Volume one

Mouth rehabilitation

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Clinical and laboratory procedures

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Dedicated to my beloved wife,

Ruth,

for her ever-present help, devotion, and encouragement

Preface

To write a book on clinical and laboratory procedures in mouth rehabilitation calls for at least a clinical familiarity with most established concepts in this particular field. Experience with only one concept is not enough to evaluate properly the good or bad of the other concepts of mouth rehabilitation. I have been most fortunate to have had the opportunity to be exposed to these various philosophies long enough and to have treated and completed a sufficient number of cases in each of these disciplines so that results could be evaluated properly; that is, how did restorations function, how were they accepted by the oral tissues, what was their longevity, and so forth. It is true that clinical evaluation, which can be nothing more than opinion, can have no justification for support without controls and therefore is not scientific. However, I have been able to apply the knowledge accumulated over the years, and there is no substitute for experience and mature clinical judgment.

Although some areas of the book will deal with certain specific techniques and materials used in restoring teeth with cast restorations, a primary objective in this book is to emphasize fundamental principles that are the basis for the application of any technique or material. Since it is not feasible to assume that all readers are familiar with the techniques, in a way one should be in performing this type of work with so-called routine crown and bridge prosthodontics, details of these procedures have been included. It is advisable to learn the fundamental principles that enable us to introduce change, especially when function dictates deviation. A knowledge of anatomy, physiology, periodontics, orthodontics, and endodontics is essential to a full understanding of the problems of full-mouth treatment. Laboratory procedures must be understood (by having done them) to control the laboratory situation. Control does not mean only the date of delivery of the restoration, but also the knowledge to recognize whether all steps have been executed correctly and, if not so executed, to be able to detect the flaws and suggest or make necessary corrections.

Too much energy and effort is extravagantly wasted in futile attempts to seek an easier, quicker solution to a problem. Such an easy, single solution to a full-mouth rehabilitation is not always available, but there must be a logical, sound, clinically proved (at least) method with sequential procedures to allow for an end result commensurate with our present knowledge of the basic sciences and advanced dental technology.

There is nothing easy about restoring the oral mechanism to proper form and function. Procedural methods and instruments that appear at first to be difficult to understand and apply are not difficult if one is willing to give thought, effort, and time to their use. Shouldn't this really be part of a professional man's obligation to himself and his patients?

To rehabilitate the mouth to proper function and effectiveness it is believed that the principles of gnathology are sound for clinical purposes, even if not completely proved scientifically. The function of the temporomandibular joint, a major and unalterable factor in diagnosis, treatment planning, and therapy, gives us the information as to condylar guidance. It is necessary to comprehend the fixed biologic factors, as well as those subject to change by the dentist, that are involved in the occlusion of the teeth. The cusps, ridges, grooves, and fossae of the teeth that will function properly in any given mouth are the result of these fixed and variable factors. It is our job and responsibility to record them and to make restorations accordingly, if the restorations are to be successful.

I believe that one should be at the same time a believer and a skeptic and always keep in mind that, as scientific and technologic advances are made, resistance to change cannot be tolerated. Greatly increased research in the basic sciences and in clinical practice is providing the dentist with new approaches to old problems in diagnosis, treatment planning, and therapy. The practitioner should preserve the best of the old, but should try new ideas and apply current research to the treatment of the patient.

A word should be said about the format of the book. Its main purpose is to convey to the reader the chair and laboratory procedures encountered in this type of work. This is done not only by the narrative method but also by liberal use of illustrations. In some instances they are presented in detailed step-by-step sequences designed to illustrate a particular procedure. Photographs and roentgenograms of case histories are submitted as clinical evidence of the feasibility and applicability of the selected technique with which it is possible to achieve consistent, positive results that are long lasting and beneficial to the patient. The scope and needs of general clinical dental practice have been seriously considered.

Chapter 15 on emotional aspects of extended restorative procedures is very important in full-mouth treatment. Without a good working knowledge and understanding of this subject life can become miserable for both the patient and the dentist, and the end result of treatment, however well executed, will come to naught. A few case histories are included in this chapter.

Human life has only such ends as we set up for it, individually and collectively, and these are dependent on good health, on joy in our work, and on an intelligent appreciation of the durable values of life.

Max Kornfeld

Acknowledgments

I wish to express my thanks and appreciation to those individuals from whom, over the years, I have obtained bits of information from lectures, by word of mouth, and from articles that are incorporated in this book, but whose names and exact source of reference I cannot remember so that proper credit by name and source could be given.

I also wish to express my great indebtedness and appreciation to the contributors to this book:

Victor O. Lucia, an excellent dentist, a serious student, and a very capable teacher in the field of mouth rehabilitation, whose method of recording centric relation is of inestimable help in full-mouth treatment.

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Anthony J. DePietro, who contributed Chapter 12 on mandibular physiology and whose background as a dentist and a student of the science of engineering, coupled with a fine mind, has qualified him to write this excellent chapter, which it is hoped will clarify many things in this particular field and stimulate further research and debate.

In addition to those who have written chapters, I benefited over the years from the teachings and counsel of the following:

Arne Lauritzen, who gave me my first insight into gnathologic principles.

Ernest R. Granger, a most able person, whose friendship, advice, and teachings from the beginning of my serious interest in problems of occlusion cannot be adequately expressed in words, but will always be remembered with the warmest of feelings and appreciation.

Charles E. Stuart, whose advanced methods of gnathologic procedures and knowledge of the science of occlusion have helped many serious students of occlusion.

Harvey Stallard, whose ability to express his philosophy of occlusion by means of the written word is masterful.

Peter K. Thomas, an extremely talented person and fine teacher, who I refer to as a master in the art of dentistry.

Morton Amsterdam, an excellent dentist, exceptionally well trained in the basic sciences and fields necessary for the type of work being discussed in this book, to whom I owe a debt of gratitude for making me cognizant of prosthetic-periodontal interrelationships and the vital part that periodontics plays in our work.

Frank Celenza, a friend and knowledgeable dentist, who was the first to call my attention to, and explain the principles of, geometrics, which was sorely needed at the time.

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William R. Dykins, a man of integrity and principle, whose knowledge of the problems of centric relation and their solution inspired and stimulated others to work in this field.

Russell C. Wheeler, my friend and former teacher, who allowed me the privilege of observing and discussing the importance of anatomy and physiology in the dynamic relationship of teeth—it took many years for the profession to recognize the importance of his keen observation dealing with the "cervical third."

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And my warmest thanks and appreciation to my wife Ruth, whose understanding of the many problems involved in this undertaking not only helped me in the writing, art, and photographic work, to which she contributed many fine photographs, but whose counsel, encouragement, devotion, and steadfastness made the completion of this task possible.

Max Kornfeld

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Chapter 1

My philosophy of practice

As I seriously considered the subject of mouth rehabilitation I vividly recalled the many conversations that I had with my father during my early youth and adolescence which have helped me so much in the development of my philosophy of practice.

He stressed the importance of humility—the ability to really feel and to practice it. He taught me to assume responsibilities without complaint, to be patient, conscientious, understanding, and sincere, and to never compromise for second best if one's capabilities and knowledge point toward the best. He felt that to realize independence one must be a creative man. One must be stimulated to independent learning, to be a continuous student, and to work hard to keep out in front, accomplishing this without harm to, or disrespect for, your fellowman.

In other words, what he truly wanted me to know is that through study, reflection, and the development of interests in the arts, sciences, and humanities, I would develop into a good citizen, would be self-sufficient and feel worthy, and thereby would do a good job at anything that I undertook. He urged the widest development possible and, above all, the broadening of my intellectual horizons. He always stressed the fact that success was not always measured in material worth, but rather in self-expression and personal excellence.

This was a lot of philosophizing, and I have sincerely tried to follow his advice. Being somewhat self-effacing, I leave how successful I have been for others to judge. But wholeheartedly I can advise my friends and colleagues to do their best to measure up to these human factors.

Percy Phillips has aptly said: "To fulfill its responsibilities to society and to survive as a profession, dentistry must call on all its priceless ingredients—honesty, integrity, professional independence, maintenance of the high quality of dental service, continuing study, expansion of dental research, the clinical application of the findings of research, and observance of our code of ethics."*

It does not take very much imagination to know that these basic ingredients are the heart and soul of the practice of dentistry and must be taken seriously. In fact, we must live and practice by them.

Today's changing socioeconomic conditions present many perplexing problems and, with them, responsibilities. In dentistry we must assume these responsibilities in relationship to ourselves, to our colleagues, and to our public.

Our patients are only interested in a longer and healthier life. For our profession to exist as a private enterprise we must have moral and professional responsibility. We must start to think positively and to do something about solving these socioeconomic problems that face us today. Otherwise, instead of our own efforts and initiative, some governmental agency will solve these problems for us.

In my travels around the country attending

*From Phillips, Percy T.: The priceless ingredients of our profession, J.A.D.A. **60**:282-284, 1960.

meetings and conferences, giving lectures and clinics, and studying with individuals and groups, I am appalled at the apathy and ignorance of many men in our profession, especially as to the scientific and technical advances in dentistry. I am really concerned because ours is a most noble and honorable profession rendering a service of great physiologic and psychologic value.

My creed always has been to be a perpetual student, to perfect myself in the latest proved techniques, and to conduct, study, and apply basic and clinical research in my practice. I have never been interested in any narrow individual aggrandizement or the development or pushing of one's own narrow ideas. Also I have felt the necessity to know myself, my inner drives, motivations, etc. so that I could have the ability to understand the peculiarities of people whom I am called upon to serve, turning their oddities into an asset of goodwill. Since it is always necessary to deal with the human equation, an intimate knowledge of the varying temperaments of people is very important for application in practice. By developing myself to the best of my abilities along cultural and professional lines, and by being able to have more rapport with patients, I am able to fullfill the aforementioned basic ingredients of our profession and also to help my patients to a longer and healthier life. One must be a teacher and a friend as well as a good technician.

Another cardinal factor in conducting a dental practice is that of the most scrupulous and constant cleanliness.

I am known as a perfectionist, but by knowing myself, my drives and motivations, I can afford to be a perfectionist without injury to my soma or psyche and thereby be of beneficial help to my patients.

It is argued that more and more dental services for more people are needed and that there should be more personnel and better trained personnel who are legally able to render services to the patient. It is true that more dental services for more people are needed, but only well-trained dentists should do any operative or restorative work for the patient regardless of the nature of the operation. The inherent dangers of the legalizing of auxiliary help is great. Following the specific duties that are indicated by the nature of her training, the dental hygienist is the only exception to this rule. Delegation of authority to legalized auxiliary help, even types of procedures considered somewhat simple, can get out of hand, and many operations that are not in their realm of authority will be performed with or without the consent of the dentist.

Auxiliary personnel are of the utmost importance in a busy dental practice, but their functions must not include any operative procedures in the mouth.

The dentist must be knowledgable, and he must learn to be efficient and skillful. By so doing he will become more productive. A profitable dental practice cannot be conducted without making the minutes count, and truthfully there is altogether too much waste motion in the average practice. The basis of time conservation is efficiency and precision of technique and also the training and experience to know precisely what to do and the most expeditious manner of doing it. We must follow the old adage "plan your work, and then work your plan." And, above all, we always must remember that patients must be taught a greater respect for the value of dental services, and they will never be taught this until dentists assume a greater respect for their own service. We must always keep in mind the quality, not the quantity of our services.

Although the business side of dentistry is very important, professional competence must come first. The selling of dental services in the same manner that is used in Madison Avenue advertising cannot be condoned—it is deplorable. The new fad of "time and motion" has a lot of merit, provided this form of automation is not carried to the extreme that the dentist and his staff become some kind of a machine or automaton. We must not sacrifice any of the fine details of operative procedures and even of remakes when indicated because of the factor of time. It is not necessary to constantly want to make our gross income larger and larger since the net return because of the higher percentage of overhead costs does not warrant an ulcer, a coronary, or an anxiety neurosis.

Before any professional man can exact a just fee for his services he must first have the conviction in his own mind that his training warrants this fee.

A certain amount of confidence is necessary, but overconfidence is fatal. One must have humility—must be able to say "I don't know," when necessary, or "I would like for you to consult with Dr. X who has had more training or experience in this or that type of work." The greatest majority of dentists seem to be reluctant to admit these facts, but until this is done we will not reach the true status of professional men.

We must not have narrowness of vision and always must be willing to experiment with new ideas and new equipment. A willingness to listen and to have an open mind and a keen appreciation of the other fellow's ideas and beliefs is also worthy of consideration.

We must attend dental meetings regularly. We must take graduate and postgraduate courses and read the dental literature—and, in fact, be an avid reader and a continuous student. We must serve organized dentistry in whatever capacity we can. Service and consideration of the patient must be a guiding principle. We must fight legislation that endangers the health of the public.

All of us—practitioners and dental educators—must make a determined effort to attract many more of the dedicated type of student who is being lost to the engineering profession, to research, and to public service. We have been accused of attracting more of the business type of person.

To be successful professional men in the true sense, we must make at least a limited study of affairs outside our profession and be able to discuss intelligently some of the important issues of national and international policies. We must participate in community affairs and have an interest in the arts.

We must surely take cognizance of the need of accumulating material worth, but this, in itself, does not necessarily mean success or happiness. We must involve ourselves in a type of development that will give us a breadth of vision and in the culture, ethics, and morals that will not overlook the finer aspirations of life. A successful dentist must be more than a fine operator.

Chapter 2

Diagnosis and treatment planning

Diagnosis

GENERAL CONSIDERATIONS

To treat the dental patient completely a thorough oral diagnosis is the first order of business. A thorough examination of the patient and an evaluation of all available data are the essential elements necessary for comprehensive diagnosis and treatment planning, and they determine the success or failure of extensive restorative procedures. In other words, the most meticulous techniques may fail if the case is not correctly diagnosed and is not properly planned.

It is necessary to make a detailed study of the physiologic and pathologic conditions of the masticatory mechanism to determine how, if necessary, to intercept any pathologic processes or to eliminate conditions conducive to disease or injury. By so doing, a plan of treatment can then be instituted, which, incidentally, can be successful only if the diagnosis is correct.

Diagnostic data is obtained by (1) visual and digital examination of the oral cavity and associated structures, (2) medical and dental histories, (3) a complete series of roentgenograms, and (4) properly oriented casts on an adjustable articulator.

The data obtained by these means must be all-inclusive and detailed both in observation and in recording because with this information the dentist may proceed to definitive treatment planning and therapy. No dental service can be of value unless the entire mouth is studied and treated as an integral unit.

Consideration of the total personality makeup of the patient is also essential, especially if mouth rehabilitation procedures are being considered, because of the possibility of a psychotherapeutic component, the importance of which must never be overlooked.

DIAGNOSTIC PROCEDURES

Medical and dental history

The first appointment with a new patient should consist of what may be designated as the interview and preliminary examination. The chief complaint, if any, is ascertained, and the asking of questions pertaining to the medical and dental histories brings to the fore, among other things, the mood, manner, and anxiety of the patient. Close observation of the patient at this time points up the chances of rapport between the involved individuals and also any semblance of the presence of psychogenic factors. During the interview it is usually possible to determine if the patient's teeth are really important to him, if he is willing to undergo extensive therapeutic treatment, if he desires to devote sufficient time in home care, and if he is willing and able to spend the time and money for this type of treatment. A history of any unusual reactions to local anesthetics or medicaments of any kind should be obtained at this time.

If a complete medical history is available, many unfortunate situations can be prevented. Oral manifestations of systemic diseases—allergies, metabolic disturbances, nutritional disturbances, blood dyscrasias, and many others—may be insiduous factors often overlooked as the reason for prosthodontic failures. The oral cavity is an accurate mirror of systemic health or disease. Do not overlook the fact that many a beautiful and well-executed biomechanical dental result has not maintained itself because of failure to obtain a good medical history. Such history should include the patient's age, occupation, drug intake, information concerning cardiovascular diseases, blood dyscrasias, bleeding time, nutritional or metabolic disturbances, endocrine dysfunction, pain in or around the face, head, and neck, if any, history of a neurosis or psychosis, and other pertinent information. Question the patient concerning systemic conditions that might affect the mouth or his ability to respond well to dental procedures. The type of diet is and always will be of such importance that it cannot be overlooked. This detailed, general health history allows one to ascertain possible correlations that may exist between oral symptoms and a medical problem. Consultation with the patient's physician is the best source of the desired information.

Several well-worded questions will bring out (1) possible reasons for excessive attrition of the teeth, if present, or parafunctions such as bruxism, clenching, picking on teeth, tongue, lip, or cheek biting, and chewing on foreign objects, (2) success or failure of past dental restorations, (3) feelings about former dentists, (4) acute or chronic infections about the mouth, and (5) professional and home-care oral hygiene procedures. A detailed history of the patient's dental and periodontal complaints are recorded.

Oral examination

If the patient is desirable from the therapist's viewpoint or amenable to treatment, the oral examination is now undertaken. The dental and oral tissues are examined visually and digitally. A meticulous scrutiny of the oral tissues by inspection and palpation is very important. Make a study of the oral mucosa, which includes the soft tissues immediately adjacent to the teeth and the tissues remote from the teeth. Unusually large freni and tori are recorded since they can influence appliance design. Aberrant manifestations such as deviations from normal gingival form, color, and pocket depth and fistulas or neoplasms are important findings. Dentists must be stimulated to observe oral lesions so that a greater number of patients with early symptoms of oral cancer will be guided toward accurate pathologic diagnosis and specific early treatment. Every effort should be made to detect oral neoplasms long before subjective symptoms appear. Any departures from the normal in this area should be referred to the physician for definitive diagnosis.

Transillumination is a fine adjunct in the oral examination (Fig. 2-1). It consists of the passage of light through tissues by interposing the object to be examined between the light source and the examiner.

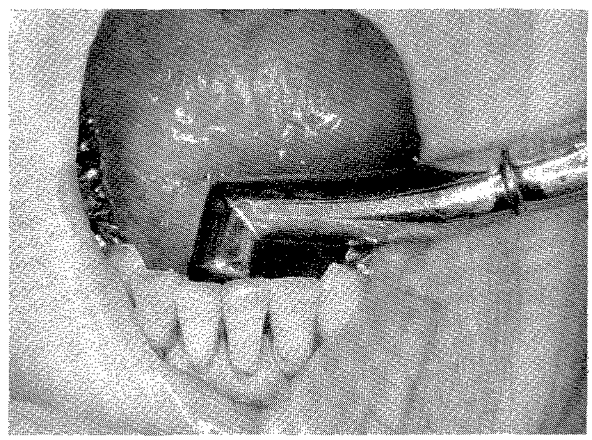


Fig. 2-1. Transillumination—an adjunct in oral examination.

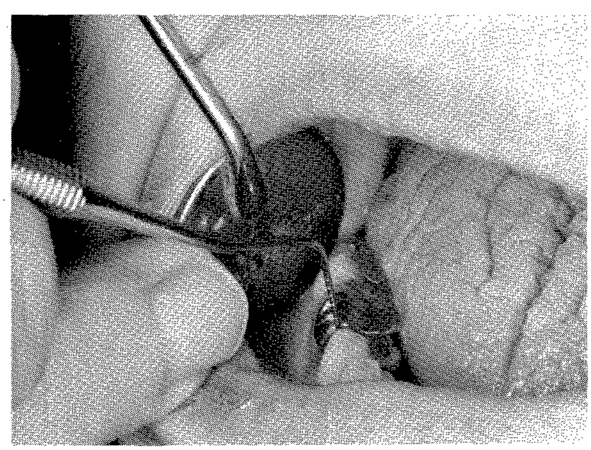


Fig. 2-2. Calibrated periodontal probe for measurement of pocket depth.

Examination of the gingival tissues requires detailed inspection and probing to determine its health status. Be alert to changes in gingival color, texture, and form. The calibrated periodontal probe for measurement of pocket depth is an important tool in our armamentarium (Fig. 2-2). The depths of all periodontal pockets are measured with this millimeter probe and are recorded. Detection of bifurcation and trifurcation involvements are also noted. The periodontal condition also must be studied in relation to the function of the mouth.

Observe and evaluate the following:

1. Swallowing pattern—whether it is a closed or open one. It ideally occurs with even distribution of pressure and maximum interdigitation of cusps with the condyles in their terminal hinge position. If this pattern does not occur, perverted movements are precipitated.
2. Chewing habits—whether unilateral or bilateral.
3. Diastemas and migrations.
4. Physiologic rest position.
5. Free-way space (distance between occlusal and rest vertical dimension).

Laboratory tests

Specific additional clinical or laboratory procedures should be performed, when indicated. These may include urinalysis, blood chemistry, and bacteriologic and pathologic examinations. At times it has been advisable in advanced periodontal disease to secure complete blood count, blood calcium, blood phosphorus, alkaline phosphatase, sugar tolerance test, and urinalysis.

Examination of hard tissues

Next examine and record the condition of the hard tissues. The skillful use of the mirror and explorer point should not be overlooked. Note any malformations of the teeth, missing teeth, and edentulous areas. Also note suspectibility to caries and character of dental work in the mouth, carefully observing marginal fit, contact areas or loss of proximal tooth contacts, form, and function. A dietary survey may be essential in patients who have had extensive caries; the results will determine the need for dietary correction. Observe if there is any unusual amount of sensitivity to hot or cold. Any temporomandibular joint disturbances causing soreness, clicking, or "popping" in the region of the joint should be investigated carefully and thoroughly. Observe presence or absence of inhibited mandibular movements that may be caused by degenerative or inflammatory changes in the temporomandibular joints.

Tests are made for pulp vitality, either by means of an electric pulp tester such as the Vitalometer* or by thermal tests making use of a pointed piece of ice. Percussion or tapping is used to gain valuable diagnostic data, and it may show pulpal involvement. In many instances it is necessary to make a differential diagnosis between causes originating in the pulp and those emanating from severe inflammatory periodontal lesions.

A record of tooth mobility is of great importance in diagnosis as well as in observation of the progress of treatment. Carefully test the mobility pattern of teeth in all directions and record degrees of mobility such as 1, 2, or 3 degrees (some skilled clinicians use half degrees for a more accurate evaluation of mobility). The operator should do it instrumentally rather than with the fingers.

A mobility of 1 degree means that the tooth is just barely movable. Its most facial position is about 1 mm. from its most lingual position when it is rocked from the labial or buccal side to the lingual side with the instrument. Two degrees means that the tooth has a 2 mm. range of movement and that it must be considered a problem tooth. Three degrees means that the tooth has a 3 mm. range of movement and carries with it the connotation that the tooth is very loose.

Observe the presence or absence of simultaneous, even contact of the teeth in terminal hinge closure. Look for premature contacts when guiding the patient into terminal hinge closure.

Evaluation of nonfunctional movements

Observation and evaluation of tensional or pernicious habits, if present, is of the utmost importance in making a diagnosis and in evaluating the treatment plan. Patients under emotional stress clench and grind their teeth for hours at night and some even carry out this damaging habit during the day. When it is practiced during their sleeping hours, they awaken in the morning with soreness of the teeth and the masticatory muscles.

*Burton Medi-Quip Co., Van Nuys, Calif.

Besides the patient exhibiting these grinding and gnashing habits, there is the patient who develops biting habits. Tongue, lip and cheek biting, biting on fingernails, and foreign objects such as bobby pins, toothpicks, and pipes are common to this type of patient.

Such habits (nonfunctional movements) as just mentioned may transmit light or heavy pressures, depending on the hardness or softness of the intermediate object, but the constant application of these forces can and do cause migration of the teeth, temporomandibular joint difficulties, and periodontal destruction.

Other habits such as mouth breathing and tongue thrust warrant close observation.[1]

Mouth breathing may be caused by inadequate nasal passageways, which need the attention of the E.N.T. (ear, nose, and throat) physician, or it may be because of habit, which may have a psychologic component.

Tongue thrusting is the child's way of using the tongue as a nipple and of sucking on the tongue. This leads to abnormal swallowing habits.

In normal swallowing the teeth are brought together in centric relation, and the tongue is pressed against the palate in the area of the anterior palatine papilla. In abnormal swallowing the tongue places heavy pressure on the anterior teeth or may even be forced between them, causing an open-bite condition in this area. Myofunctional therapy methods may be used to treat these patients, but this type of condition calls for a bad prognosis.

Photographs

Black and white or color photographs should be taken to document the preoperative and postoperative conditions (Figs. 2-3 to 2-7).

Fig. 2-3

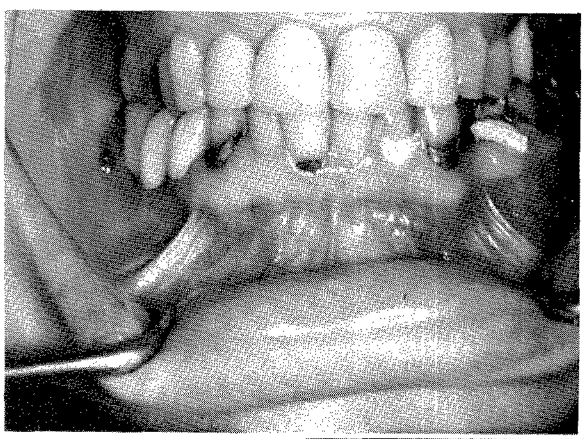


Fig. 2-4

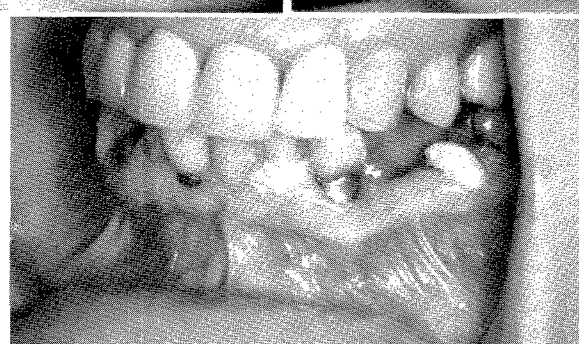
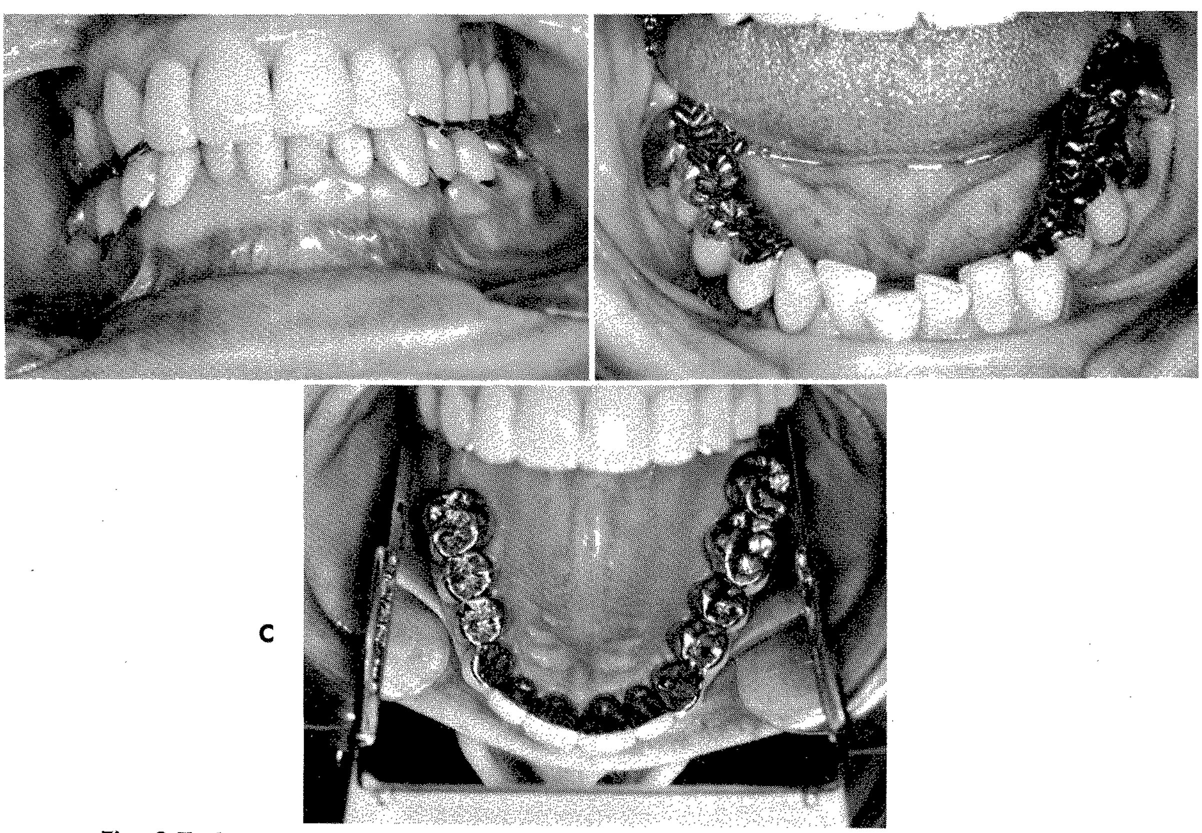


Fig. 2-5

Figs. 2-3 to 2-5. *Preoperative centric relation views.*

Fig. 2-6. Preoperative occlusal views of upper and lower teeth.



A

B

C

Fig. 2-7. A, Postoperative centric relation view. **B** and **C,** Postoperative occlusal views of lower **(B)** and upper **(C)** teeth.

Roentgenographic examination

A complete set of roentgenograms, including bite-wings, are taken at the first appointment, and, although this procedure is an adjunct to diagnosis, it must not supplant it. Roentgenograms help in recognizing pathologic conditions, which must be either removed or restored to a state of health capable of supporting normal function.

The roentgenograms must be good from a diagnostic as well as a photographic standpoint (Fig. 2-8). In the roentgenograms the teeth *should never be elongated or foreshortened,* and they should be clear, well angulated, and properly processed.

They must be studied and related to the patient being examined because they are meaningless unless correlated to the clinical findings in the oral cavity. Observe carefully if any destruction has accrued in the area that receives the force in the form of a rebound from prematurities which prevent the occurrence of a normal path of closure of the mandible. The following information will be revealed:

1. Extent of carious lesions
2. Type and amount of alveolar bone
3. Presence or absence of apical infection
4. Furcation involvements
5. *Root resorptions* or *appositions*
6. Size, shape, and position of the roots
7. Condition of the supporting structures of the teeth

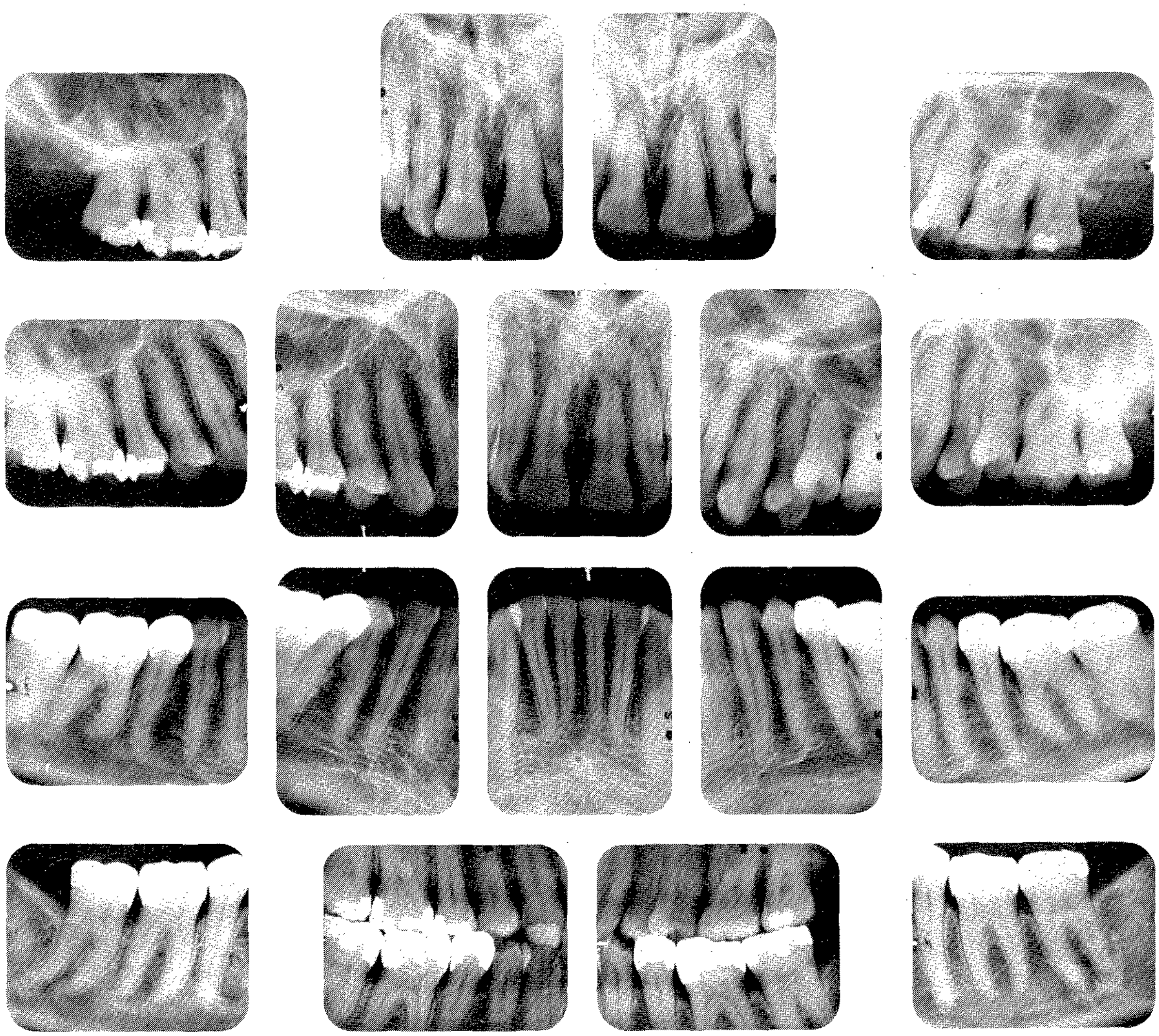


Fig. 2-8. *Good roentgenograms from a diagnostic and photographic viewpoint.*

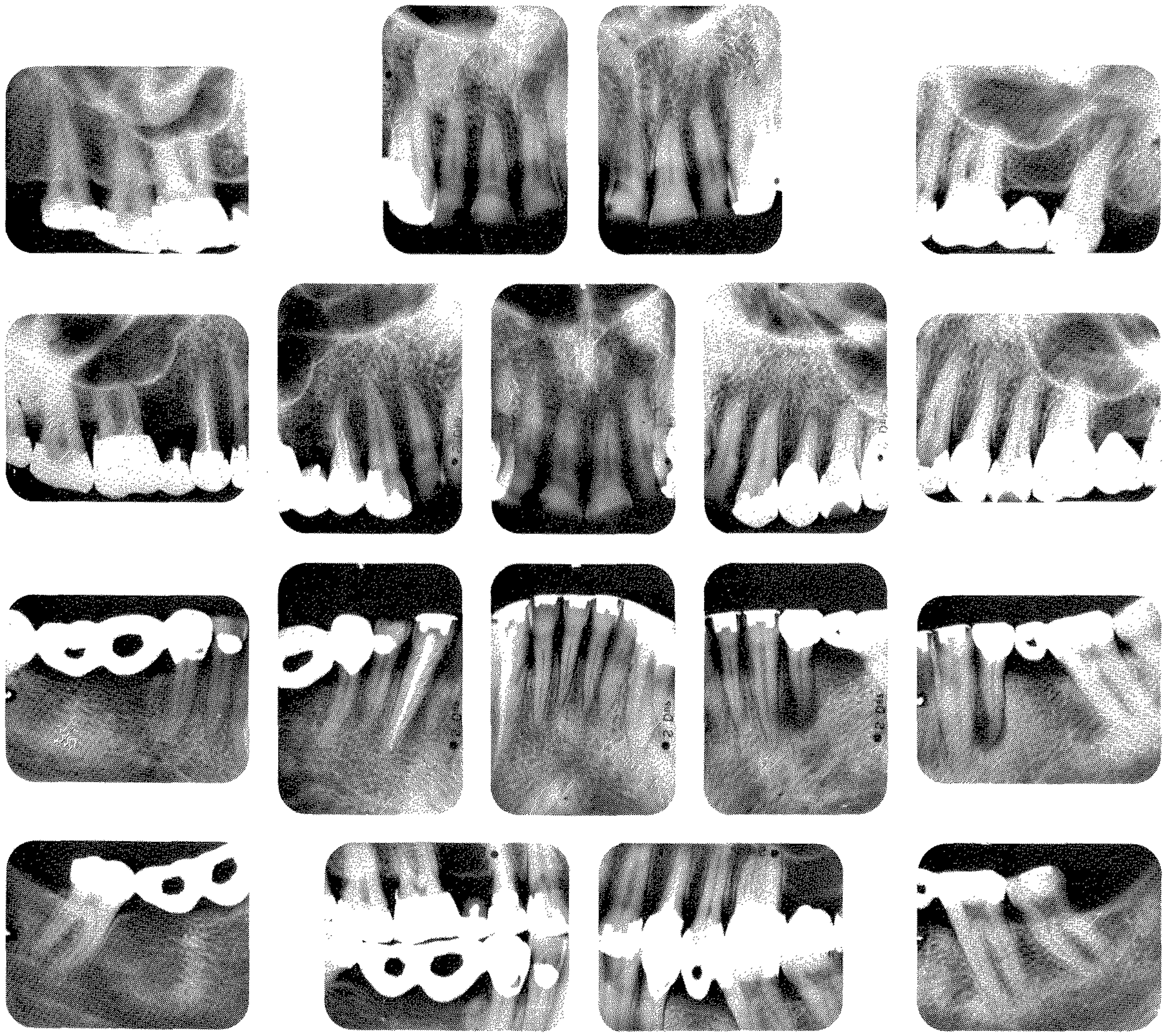


Fig. 2-8, cont'd. For legend see previous page.

8. Impactions and retained roots
9. Cysts and granulomas
10. Status of any endodontically treated teeth
11. Ratio of remaining alveolar bone to the length and width of the roots; stress-bearing ability of the periodontium
12. Crown-root ratio
13. Conditions of the coronal portion of the teeth
14. Pulps of the teeth
15. Periodontal ligament space
16. Lamina dura
17. Vertical bone loss

The bite-wing roentgenograms provide much needed information relative to carious lesions and the proximity of these lesions and of old restorations to the pulp, the gingival marginal fit of restorations, and often the crestal bone involvement attending periodontal inflammation.

Since the basis for therapy is a comprehensive diagnosis established on the accumulation and the evaluation of all pertinent information, complete roentgenographic documentation is an essential part of this information. This documentation is important, preoperatively and postoperatively (every year or two), for evaluation of whether our diagnostic, treatment planning, and therapeutic techniques are adequate to restore functional requirements within the metabolic activity of the bone for the patient. Will *his stomatognathic system* be relatively immune to disease or will there be a return of pathology?

Cast orientation

The proper use of study casts in diagnosis and treatment planning is of the utmost importance in the evaluation of the patient's occlusion and also in the determination of necessary occlusal changes, if any.

For a functional diagnosis casts must be mounted on an adjustable articulator with some semblance of order. Unmounted casts are of limited value because they may reveal centric occlusion, but not centric relation, and because tooth contacts in working and balancing positions cannot be determined. This points up the importance of a careful mounting of the patient's dental casts on an instrument that copies his mandibular movements so that a diagnosis of the functional relations may be made by studying them in connection with clinical findings and roentgenograms.

Mounted casts on an articulator must reproduce proper mouth relations to reproduce the correct movements of the mandible. Stallard aptly said, "What should be expected of an articulator is the individual expression of the condylar movements of a patient, something that may differ from all other patients."* In other words, we must refer to the controlling mandibular axes, and only by so doing can diagnostic models be of any value in arriving at a diagnosis and correct plan of treatment.

Impressions and casts

In cast orientation accurate study casts of the patient's mouth should be made from well-taken impressions making use of an elastic impression material such as alginate, hydrocolloid, silicone, or rubber base. This type of an impression should be poured immediately for accuracy, using a hard artificial stone. (See Fig. 2-9.)

If possible, two sets of impressions are taken to provide the following:

1. A set of preoperative casts for the study of occlusal relations for diagnosis, treatment planning, and method of therapy. This set should be preserved as a permanent preoperative record for future documentation.
2. A set for the construction of clutches, which are necessary in the location of the hinge axis and in the recording of a three-dimensional pantographic tracing of the controlling mandibular axes.
3. A set for preoperative study—for the determination of types of tooth preparations, and location and amount of tooth structure to remove and for the development of the articulation in wax, which is required to properly restore the patient's mouth to good function.

However, with great care, a second and third set of casts can be poured from the original impression when alignate material has been used. Be very careful in the removal of the first or second set of casts so that tears and distortion are avoided.

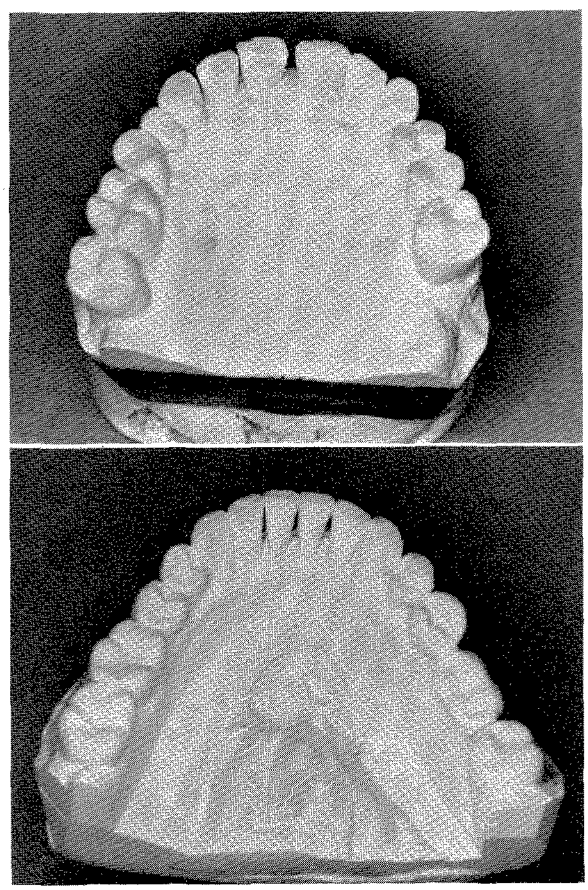


Fig. 2-9. Preoperative study casts made from alginate impressions.

*From Contino, R. M., and Stallard, Harvey: Instruments essential for obtaining data needed in making a functional diagnosis of the human mouth, J. Prosth. Dent. 7:66-77, 1957.

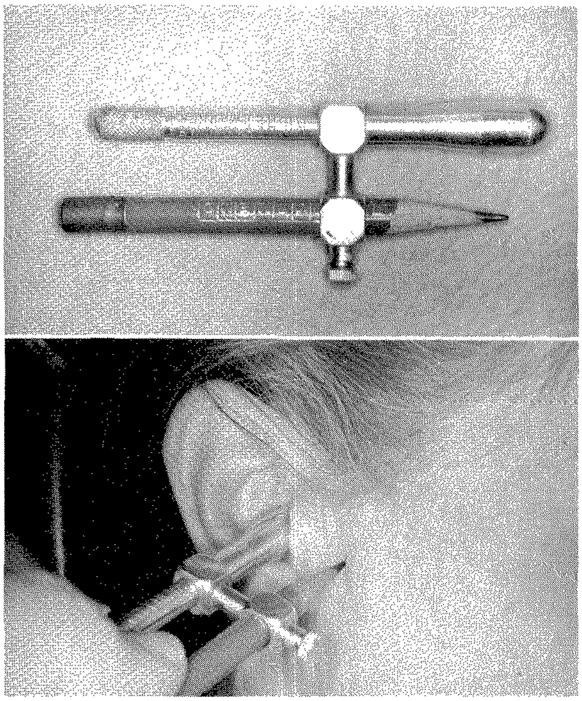


Fig. 2-10. Location of arbitrary axis points, making use of Ritchey pencil.

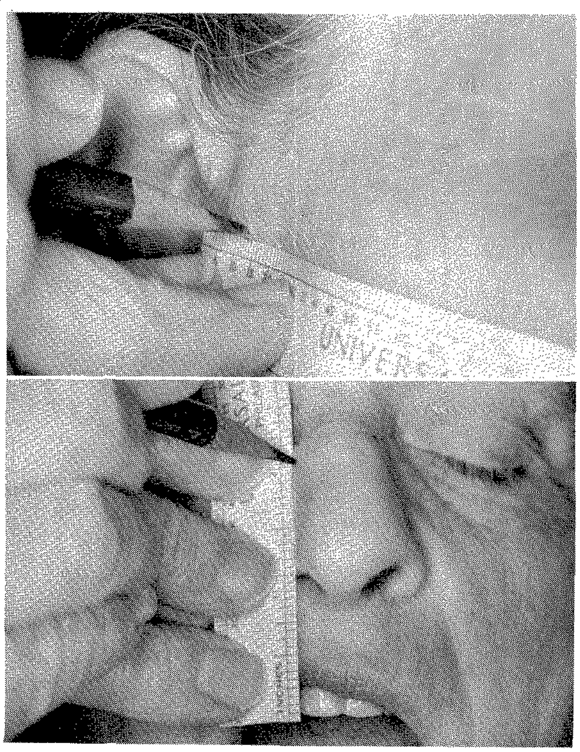


Fig. 2-11. Location of arbitrary axis points and of third reference point on nose by means of millimeter rule.

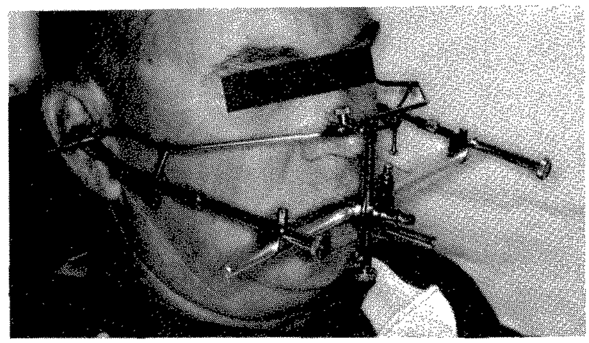


Fig. 2-12. Face-bow transfer for orientation of upper cast on articulator to same plane of occlusion as found in mouth.

Face-bow transfer

In addition, a conventional face-bow mounting and a centric relation record for mounting the study casts in a fairly accurate relationship to each other must be taken. The face-bow transfer is taken so that the upper cast on the adjustable articulator can be oriented to the same plane of occlusion as is found in the patient's mouth. A simple method for locating the arbitrary axis points is to locate the ala-tragus line on both sides of the face and, making use of a Ritchey pencil or flexible millimeter rule, to mark a point 13 mm. from the tragus (Figs. 2-10 and 2-11). To use the face-bow transfer properly we must have a third reference point to establish a plane of reference, the axis-orbital plane. This third point is marked on the right side of the nose at a distance 2⅜ inches from the incisal edge of a central incisor tooth or by locating the inferior border of the orbit on the right side and, for convenience, recording a mark on the same plane on the side of the nose. (See Fig. 2-12.)

Centric relation record

The next order of business in this preliminary diagnostic procedure in cast orientation is the conditioning of the patient for a centric relation record. This conditioning can be done by means of a Cohen trainer or the use of some form of anterior resistance, which tends to overcome the translating contractions of the external pterygoid muscle (Fig. 2-13).

The centric relation record must be registered at an increased vertical dimension (within the limits of pure rotation of the condyles) so that the guidance provided by the teeth is removed.

Some form of anterior resistance must be provided. This resistance tends to act as a fulcrum, which aids in obtaining a registration of the condyles in the posterior and superior positions—rearmost, uppermost, and midmost.

In all preliminary diagnostic procedures a wax form (made with Sure-Set wax*) is accurately adapted to the occlusal surfaces of the upper cast (which has been lubricated) and down the facial and lingual surfaces to the height of contour of the teeth. This makes a wax form that can be seated firmly and definitely on the upper teeth (Fig. 2-14). Use is then made of a piece of "air chamber metal."* It provides the anterior resistance and acts as a fulcrum, thereby preventing penetration of the wax by the teeth and interference from habit patterns and also allowing for enough clearance in the posterior region for the recording material. Breaking the reflex pattern of closure will permit a normal closure. Only a few lower anterior teeth contact this piece of air chamber metal. (See Fig. 2-15.)

During the exact positioning and adjustment of the metal form to the wax form for proper contact with a few lower teeth and posterior

*Kerr Mfg. Co., Detroit, Mich.

*Dixon Mfg. Co., Newark, N. J.

A

B

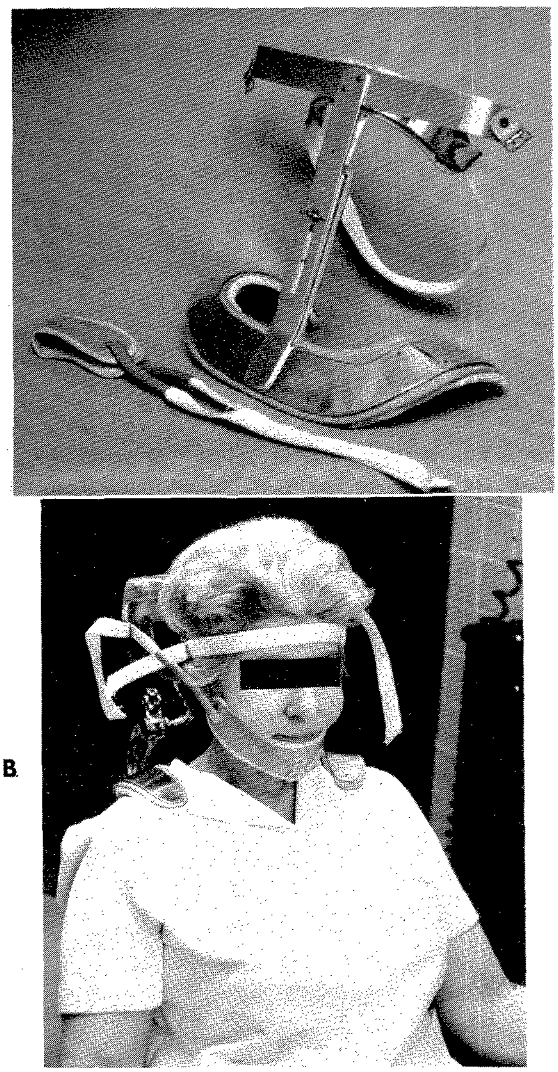


Fig. 2-13. A, Cohen trainer. **B,** Cohen trainer left on patient for five to ten minutes to prevent protruding of jaw.

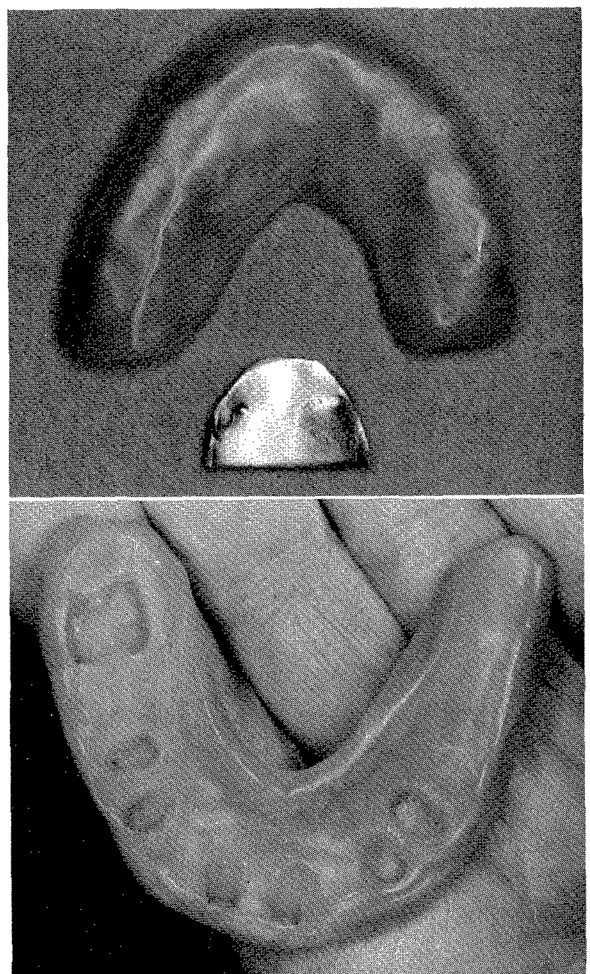


Fig. 2-14. Prepared wax form and "air chamber metal" form. This form can be definitely seated on upper teeth, and with provision made for anterior resistance to act as a fulcrum, it serves well as a preliminary interocclusal record.

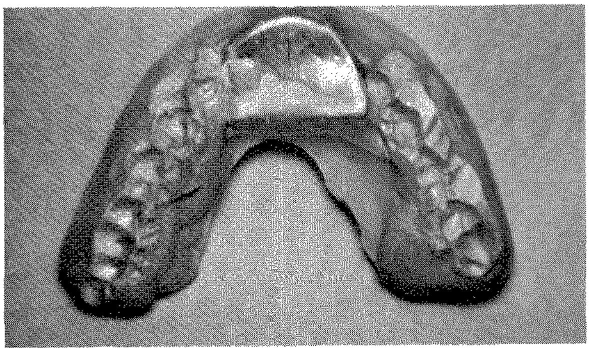


Fig. 2-15. Completed preliminary centric relation record.

Fig. 2-16. Use of right thumb on chin to guide patient into terminal hinge closure.

clearance for the recording material, the patient is not allowed to bring his teeth together to keep blocking out the proprioceptive reflex. A saliva ejector is inserted into the mouth every time the wax form is removed for adjustment of the metal form.

Use is made of a soft wax, Aluwax,* for the recording of shallow occlusal indentations. With the softened Aluwax on the underside the well-adapted wax form is seated on the upper teeth and is held in place with the left thumb and forefinger. With the right thumb on the patient's chin the operator guides the patient into the terminal hinge closure (Fig. 2-16). The mandible is guided, not pushed or forced, into repeated closures. The wax record is removed and placed in cool water. The excess wax is removed with a Bard-Parker† knife, leaving only the cusp tip indentations so that the cast may be accurately

*Hickok Specialties Co., Grand Rapids, Mich.
†Bard-Parker Co., Danbury, Conn.

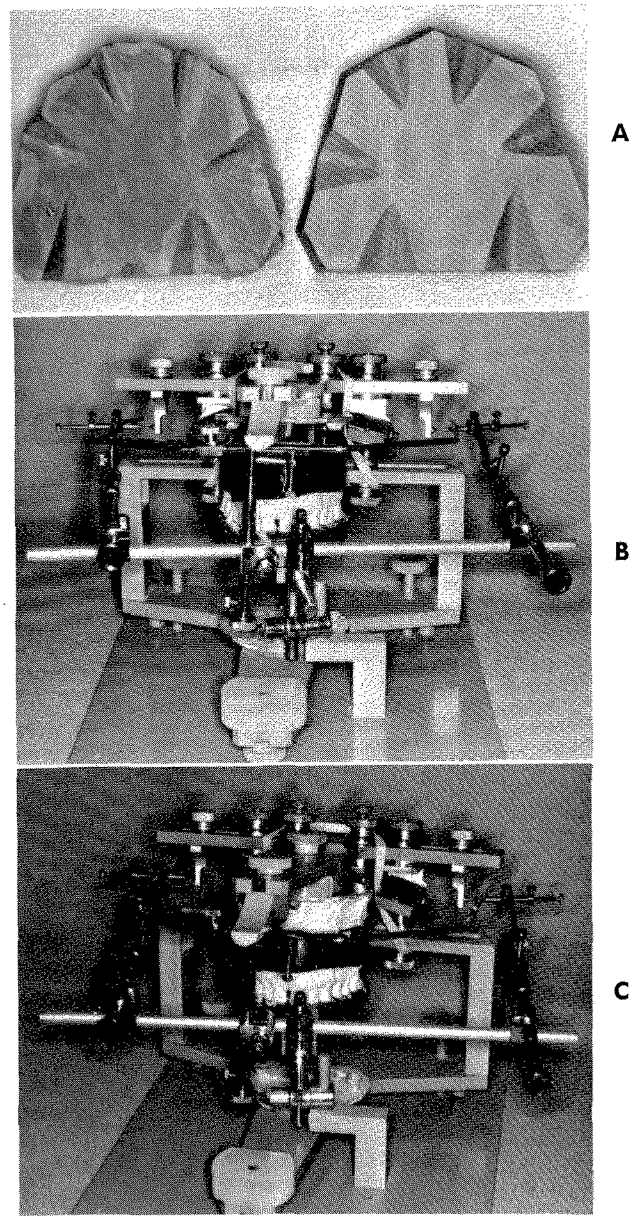


Fig. 2-17. A, Upper cast prepared for split-cast method. **B,** Upper cast being readied for mounting to upper frame of articulator. **C,** Upper cast mounted to upper bow of articulator.

seated when the mounting is made. This wax record is again seated on the upper teeth, and the patient closes the mouth once again. The operator guides the mandible to position to eliminate any warpage that may have resulted from the chilling in cool water or from the trimming of the excess wax. If no distortion can be detected on closure, the record is accepted. Two other centric relation records are taken to check

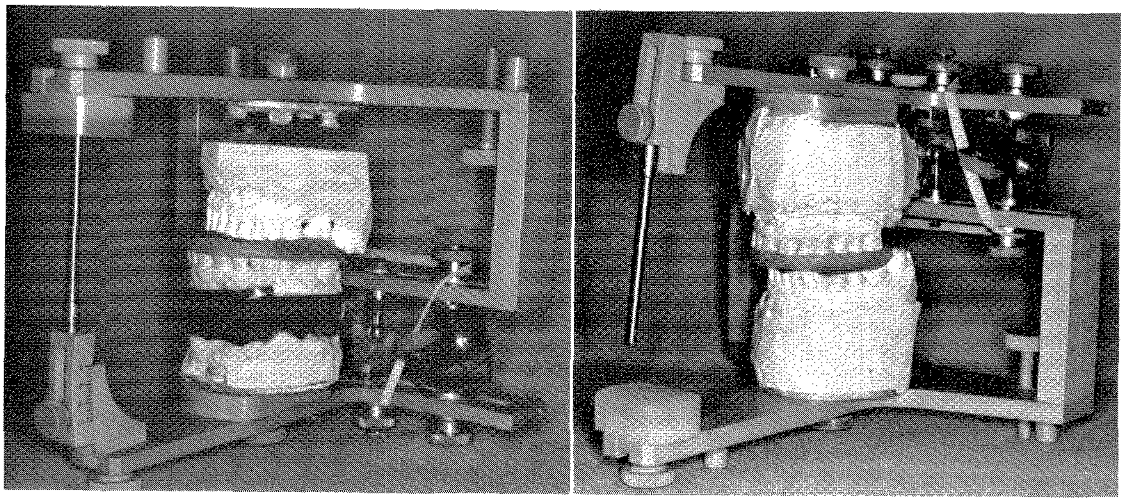


Fig. 2-18. Articulator inverted, centric relation record positioned, and lower cast then attached to lower bow of articulator.

the accuracy of the records by checking one record against the other, making use of the Lauritzen split-cast method (for detailed accounts of technique see Chapters 3 and 13).

Mounting the casts on articulator

The upper cast, which has been prepared for the split-cast method, is mounted on an adjustable articulator with the face-bow transfer record (Fig. 2-17). After this step has been completed the articulator is inverted on a mounting block, and the centric relation record is placed on the occlusal surface of the upper cast. Then the lower cast is placed on the centric relation record, and held firmly in this record and against the upper cast, and attached by means of a stone, with a low setting expansion, to the lower bow of the articulator. The upper and lower members of the articulator must be in centric relation. (See Figs. 2-18 and 2-19.)

The second and third centric relation records are verified by separating the grooved upper primary base cast from the secondary base cast, which is attached to the upper member of the articulator, placing the primary base cast into the second or third record, which is carefully held in position, and closing the secondary base cast against and into the primary base cast. If the secondary base fits accurately into the primary base and no discrepancies are visible, the centric relation records have been proved to be correct, and the casts are correctly mounted in terminal hinge relation. (See Figs. 2-20 and 2-21.)

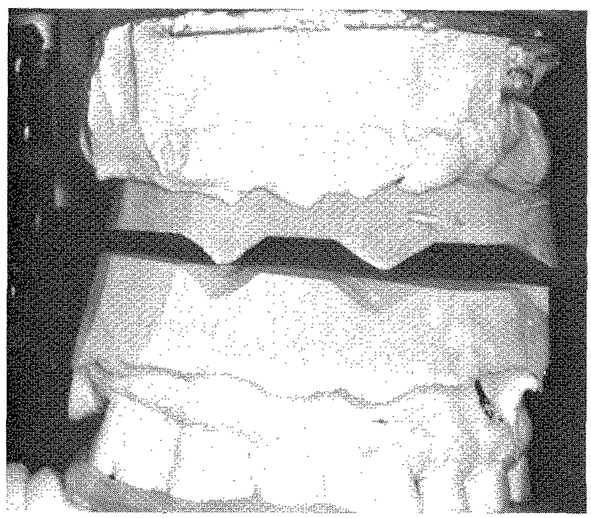


Fig. 2-19. Verification of centric relation records: separation of grooved upper primary base cast from secondary base cast, which is attached to upper bow of articulator.

In this type of cast orientation, where an arbitrary axis has been located for preliminary study of occlusal relations and the construction of clutches for the recording and the transferring of mandibular relations, some discrepancies will result. However, the discipline that is required in the making of a hinge-bow transfer, centric relation records, and mounting procedures by the split-cast method will be very helpful in the steps that are to follow. (See Figs. 2-22 to 2-28.)

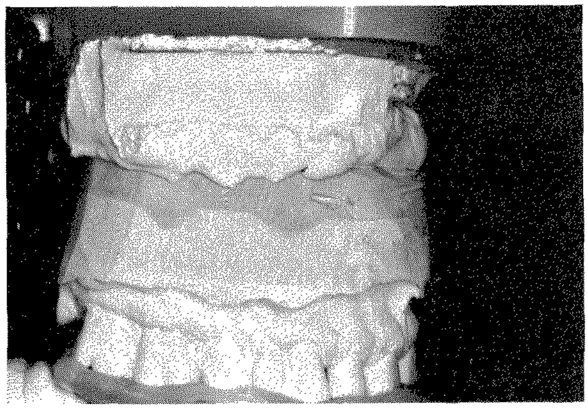


Fig. 2-20. Verification of centric relation records completed: secondary base fits accurately into primary base; no discrepancies are visible.

A

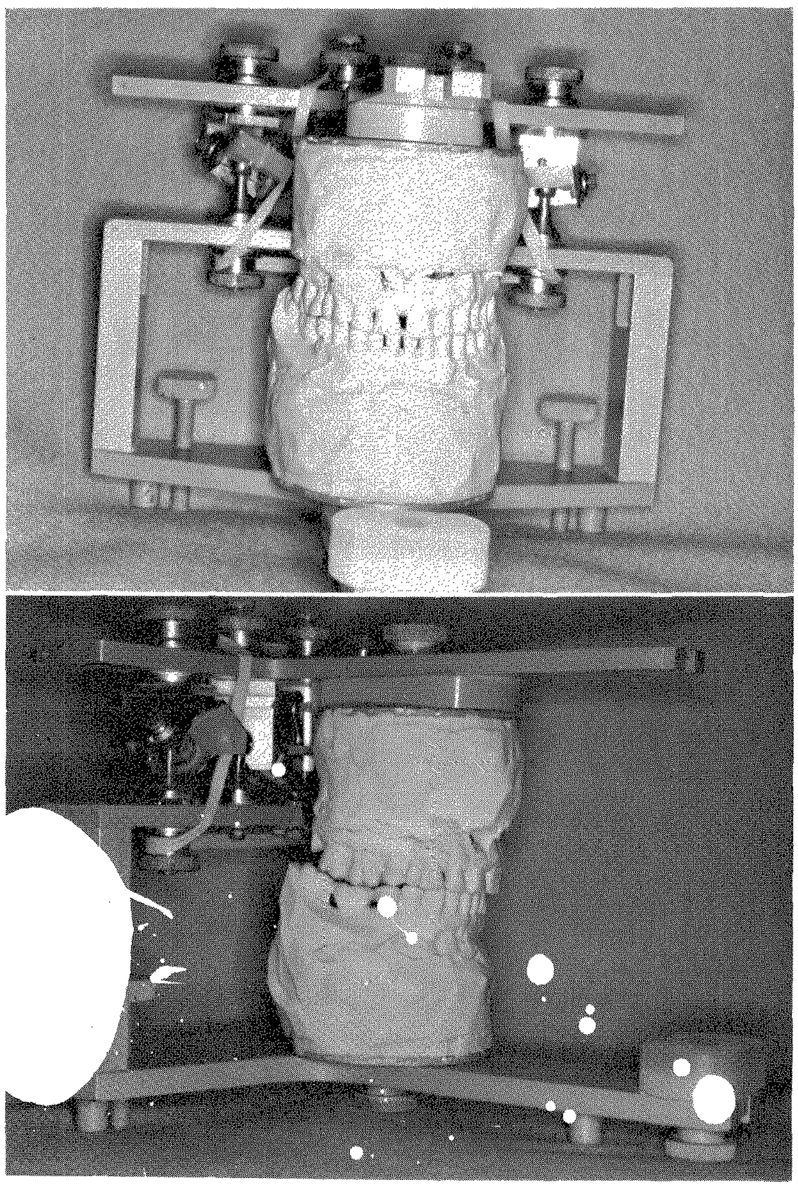


Fig. 2-21. A, Mounted casts in centric relation, anterior view. **B,** Mounted casts in centric relation, right posterior view.

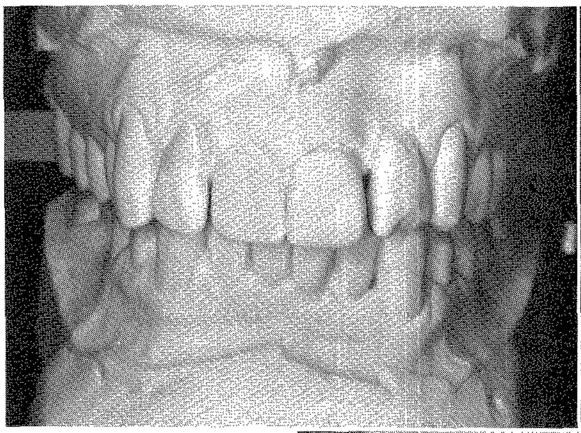


Fig. 2-22

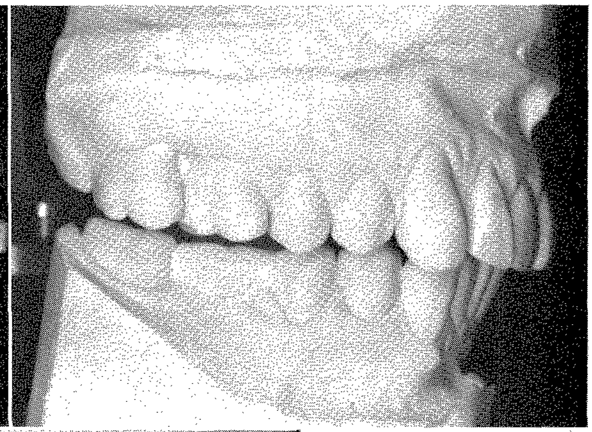


Fig. 2-23

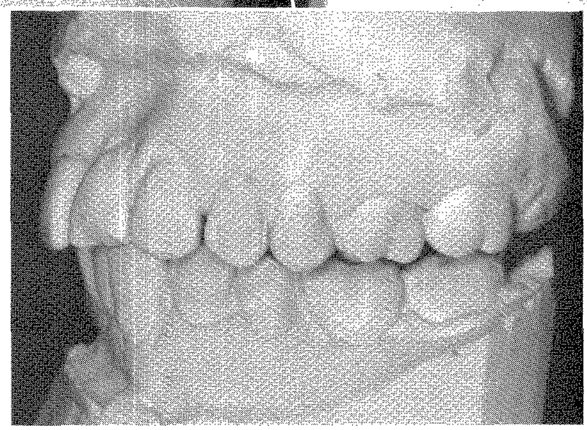


Fig. 2-24

Figs. 2-22 to 2-24. Cast orientation on arbitrary axis for preliminary study of occlusal relations, construction of clutches, and preoperative wax-up.

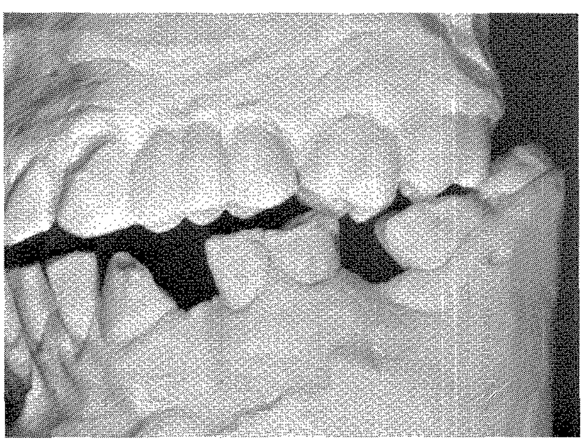


Fig. 2-25. Diagnostic casts correctly oriented on adjustable articulator revealing initial occlusal contacts.

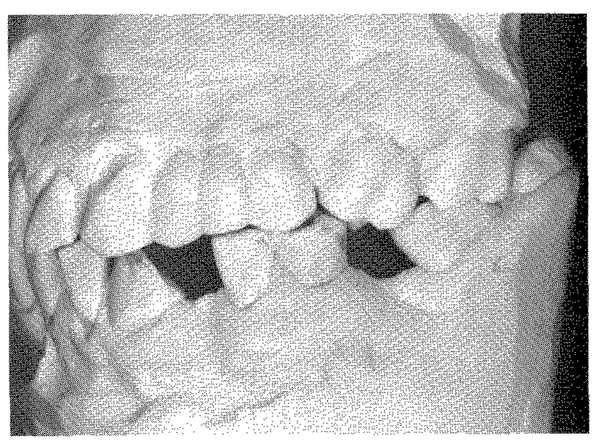


Fig. 2-26. Diagnostic casts forced into maximum occlusal contact (acquired centric occlusion) by displacement of condyle forward (see Figs. 2-27 and 2-28).

A

B

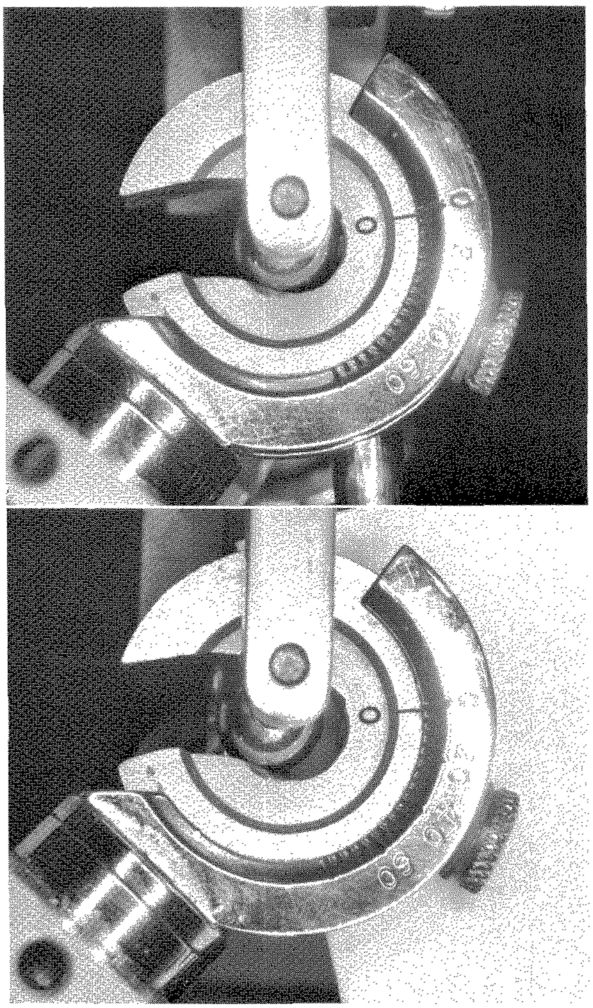


Fig. 2-27

A

B

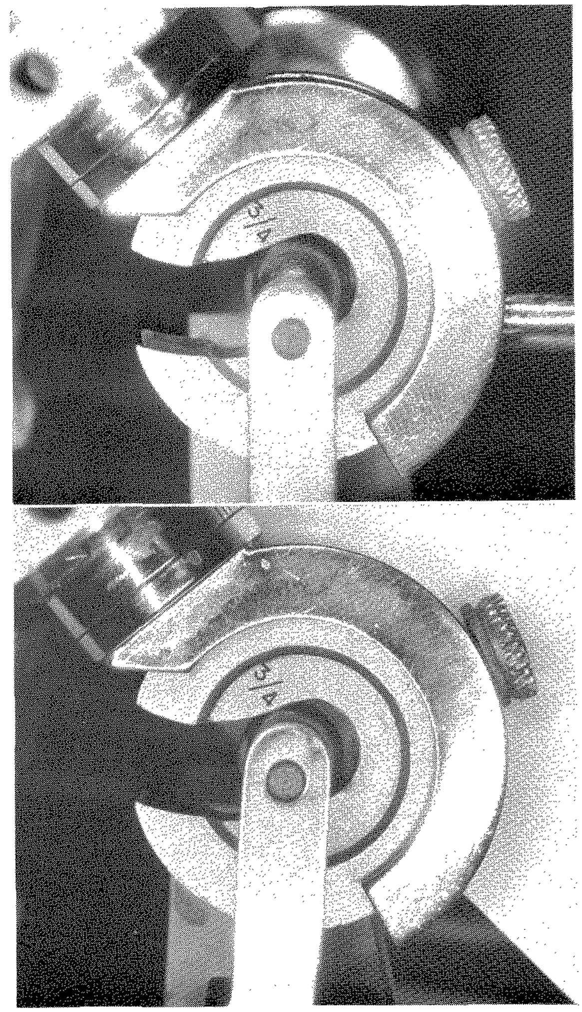


Fig. 2-28

Figs. 2-27 and 2-28. A, The condyle (ball) when teeth are occluded in centric occlusion. **B,** The condyle (ball) pulled forward to allow meshing of occlusal surfaces out of centric relation.

Recording and transferring of mandibular relations

Importance of mandibular relation. Function is the prime object of restorative dentistry. The proper care and treatment of the oral organ should be the concern of all practitioners of dentistry, and of necessity this requires a knowledge of the form and function of this organ—its parts, how it can be, at least figuratively, taken apart and put back together, how it is made, and how it works in health and disease. In other words, a complete knowledge and understanding of the anatomy and physiology of this most important organ is a "must."

The accurate recording and transferring of mandibular relations is possible now, provided certain principles are understood and executed carefully.

The ability to treat and save mouths is directly related to the ability to capture and transfer jaw function to the restoration.

Although I am thoroughly in accord with the modern concept of periodontics, I also firmly believe that complete pocket elimination, as important as it is, comes to naught if stability in function is not attained.

We must concern ourselves with a *center* that can be easily located and useful for our procedures—a *center* that will enable us to reproduce the patient's movements on a suitable articulator.

The dentist must be able to recognize and distinguish between normal and abnormal occlusion and joint function. It is therefore necessary (1) to have a knowledge of mandibular function since the temporomandibular joint bears an almost unbelievably precise relation to the teeth and (2) to keep in mind that there must be a harmony between centric occlusion and centric relation, which can only occur if the occlusal surfaces of the teeth can be brought into maximum contact without cuspal interference as the mandible assumes its terminal hinge position.

Existing conditions must be analyzed by means of a functional method. The mere relation of teeth to each other is not enough. Unless the relationship satisfies the functional requirements of the whole mouth, it becomes a destructive function, creating a metabolic demand in excess of the normal requirements of the mouth. Functional relations that will make it possible for the natural metabolic processes of the body to come to our aid must be created.

We now have the instruments and knowledge to make good functional examinations and diagnoses leading to proper treatment planning, prognosis, and therapy.

We must be able to duplicate the variety of patterns of mandibular motion, realizing that the musculature motivates the movement of the mandible and the temporomandibular joint determines the nature of the movement. To generate a proper occlusal form it is necessary to know how and why the mandible moves. Casts must be oriented properly upon an adjustable articulator so that occlusal relationships will be reproduced correctly. The determinants of mandibular movement that dictate the occlusal morphology must be possible of attainment. But how can all this be accomplished?

To begin with, a set of clutches must be made using the casts of the preliminary mounting. With these clutches, a hinge-bow, and a pantograph the hinge axis can be located, registrations or "jaw writings" taken, the articulator adjusted to these registrations, and the study casts remounted to the correct axis.

The first step is the accurate location of the hinge axis of the mandibular articulation. Many investigators have shown that a hinge axis does exist and can be precisely located in its terminal position with the use of mechanical aids. A fixed point of rotation can be obtained clinically and utilized in restorative procedures.

In vivo the only axial centers that can function independently in mandibular motion are the horizontal axial centers of rotation. In a limited degree of mandibular opening (about 12 degrees) the condylar element, because of the limiting effect of the superior and anterior slopes of the glenoid fossa and the temporomandibular ligament, can brace itself superiorly, medially, and at its posterior limit. Thereby the condylar element can enable the horizontal centers of rotation to be located. An imaginary line connecting both horizontal axial centers of rotation is termed the *horizontal axis*. This may be referred to as the hinge axis, or the transverse axis (Chapter 12).

Tooth relations on the articulator will not be the same as in the mouth unless the opening-closing hinge and centric relations are the same on the articulator as in the patient's mouth. We must reproduce on the articulator the same relation of the casts to the axis of the instrument that the teeth have to the axis of the mandible. Unless casts can be occluded by closing them on the same arc of closure as that exhibited by the patient, erroneous conclusions may be drawn concerning existing occlusal patterns and the need for restorative procedures for the patient.

The rotational centers of the condyles can be determined and transposed to the rotational centers of an adjustable articulator. Therefore, we must locate the hinge axis and record and transfer the three basic paths that it follows. These paths can be recombined to create every possible movement of the teeth and mandible, that is, we must reproduce on the instrument the paths of motion of the axis.

Granger[3] so aptly pointed out that "we cannot deal with one compartment of the temporomandibular joint by a simple hinge-axis mounting or a centric relation record and ignore the paths of motion of the axis, because this is something the patient cannot do. The patient is compelled to use both compartments of the temporomandibular joint every time he moves the jaw. Therefore, we cannot ignore the precise location and paths of motion of the center of rotation."*

*From Granger, E. R.: Functional relations of the stomatognathic system, J.A.D.A. **48**:638-647, 1954.

Why use the hinge axis?* Use of the hinge axis permits us to accomplish the following:

1. It provides a definite point of reference (a constant) for all procedures necessary in reconstruction. This permits a similar relation of the parts as they are constructed and corrected.

2. By recording the various relations of the axis and by transferring these to an adjustable articulator we are able to reproduce the patient's mandibular movements with *fidelity.* If we wish to work on a laboratory instrument that is a mechanical and relational likeness of the mouth, we must have it open and close on the same axis as the mouth.

3. It permits us to accurately *record* and *check* the centric relation of each patient.
   a. Then we can arrange the cusps of the teeth so that the closure can be made in centric relation without striking opponents on the way.
   b. We can then register our centric relation with enough opening between the teeth to avoid any deflective malocclusion that might be present in the dentition, and we can diagnose it.

4. It affords us the privilege of being able to alter the vertical dimension on an articulator with the certainty that any such alterations will be identical to such changes in the patient's mouth.

5. Adjustments (remounts) that may be necessary in the completed work can be accomplished on the articulator. This permits the completion of an extensive restorative procedure on an articulator without the need for very much adjustment in the mouth.

6. The hinge axis is a component of every masticatory movement of the mandible and therefore cannot be disregarded. The hinge axis of the articulating instrument must be a duplicate of the hinge axis of the jaw, or there can be no mechanical reproduction of jaw motions.

7. The hinge axis permits duplication of all the arcs of closure of the mandible on an instrument, and thus the cusps can be tailored to harmonize with these arcs.

8. If we do not locate an axis, we ignore the laws of geometry, physics, and mechanics.

9. a. If we could transfer the centric relation to articulated mounted casts and could finish our work without changing the opening component, then we would not need an axis.
   b. If we have no cusps on teeth around and over which closures are made, we would need no axis determination unless we want to diagnose the ills of the occlusion.

Because of the previously mentioned reasons, the location on a patient and the transference to an articulator of the hinge axis are well worth the effort involved.

We feel the hinge axis is imperative—yes, mandatory.

Mandibular movements are three dimensional in character, and a competent articulator is a three-dimensional pantograph. Therefore, a primary law of mechanics must be satisfied—to pantograph in three dimensions one axis must be duplicated—in this case, the hinge axis. In mandibular movements there is a fourth dimension of time sequence; that is the amount and character of movement in one plane in relation to the other two planes.

Instantaneous axes. When rotation and translation are combined, there is no constant axes of control. Picture a body rotating about an axis and then translating. As soon as translation takes place the axis changes; then when rotation begins again, a new axis is in control, and this goes on and on. *The axis that changes is called the instantaneous axis of rotation.* It is only in control for an instant and can be located only when motion is stopped and then only mathematically. In the physiologic function of the mandible this is precisely what is happening. Because we cannot locate the instantaneous centers, we have no way of plotting the functional envelope of motion. Therefore, we are forced to use the border paths of the complete envelope. Much of the confusion of the profession centers about this area. When we masticate, we do not do so with the hinge axis in control; instead it is the instantaneous axis or more properly axes. Also when we close from physiologic rest to centric, again it is the instantaneous axis in control. This is why we must avoid *rest* in taking our records, and also why we do not need it. The hinge axis then has control only along the border paths.

What I am trying to emphasize is that many axes having to do with mandibular motion can

*With the assistance of Charles E. Stuart and Harvey Stallard.

be plotted. However, most of them cannot be used, and so we must utilize only those with which we can work. Because of some inaccuracies in our technical procedures, we must use an axis more than once. Therefore, we must choose one that is constant. We use the axis that is in control in the terminal position. Because this is also centric relation, the hinge axis is not only convenient but mandatory.[4]

Unless the opening-closing hinge and centric relation are the same on the articulator as in the patient, tooth relations on the articulator will not be the same in the mouth.

The mandible should be allowed to reach all its border limits freely without any restrictions by cusp interference.

Locating the hinge axis. The hinge axis can be located accurately by trial and error with a hinge-bow, which is rigidly attached to the lower teeth by an aluminum clutch or clamped to the edentulous ridge. The side arms of the bow are adjustable, horizontally and vertically, and carry pointed styluses, which are directed at the positions of the condyles. The patient is coached to open and close the mouth with a pure hinge movement, using the thumb and index finger to guide this movement and avoiding translation of the mandible. Attention is directed to the action of the *tip of the stylus* as the patient executes the hingelike movement. The tip of the stylus will arc in a definite direction, depending upon its relation to the actual centers of rotation. By close observation of the arc scribed by the stylus, an adjustment is made to approach the center of rotation. The nature of the adjustment is determined by the direction and the size of the arc. Use is made of the geometric principle that, if a secant intersects an arc of a circle, its perpendicular bisector will coincide with the radius of the circle. In other words, when the tip of the stylus describes an arc, the axis will always be toward its radius. By trial and error and repeated adjustments it is possible to arrive quite readily at the exact center of rotation (as the patient executes the pure vertical rotational motion of the condyle on the meniscus), which is indicated *when the tip of the stylus will no longer arc; it will merely rotate.* A magnifying glass is now used to help see that the stylus tip is definitely rotating.

This procedure is carried out on both sides simultaneously, and the points so located are transferred to the skin. The dental practitioner must remember to move the patient's head out of the headrest, which will eliminate any possible skin displacement that would occur from pressure against the headrest. The stylus tip is rubbed with an indelible pencil and gently pushed against the face to transfer the point to the skin, after which the hinge-bow and clutches are removed. (See Figs. 2-29 to 2-38.)

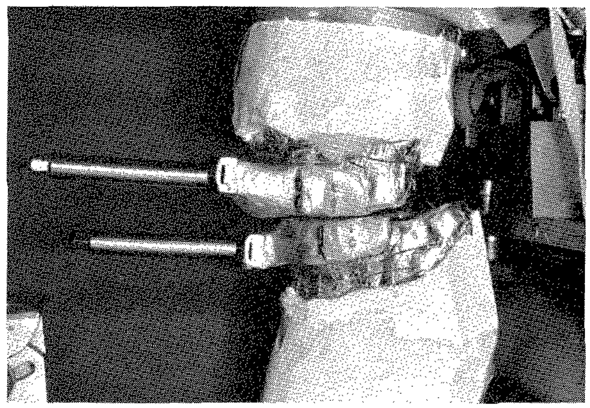


Fig. 2-29. Clutches on casts on articulator and center bearing screw adjusted so that no contact exists in centric, protrusive, and lateral positions except on screw.

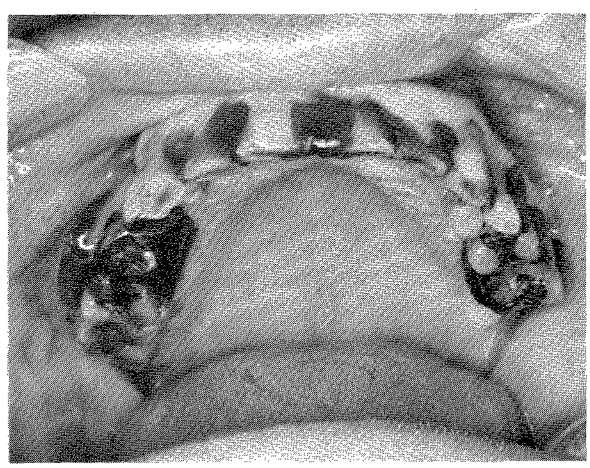
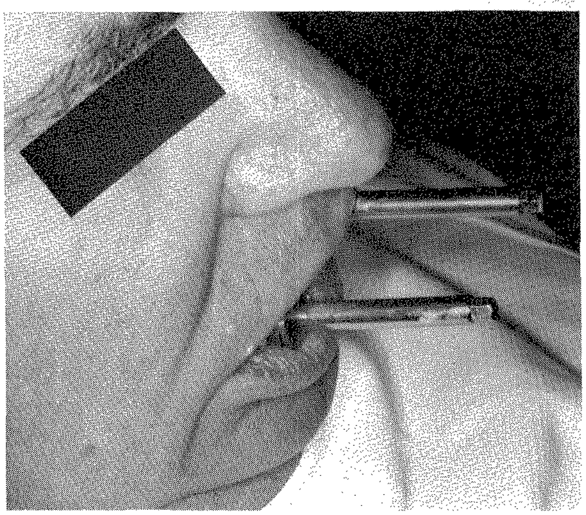


Fig. 2-30. Interproximal spaces and undercut areas around restorations and under pontics are blocked out with a soft wax before cementation of clutches for ease of removal. Be careful to have enough relief around teeth showing a high degree of mobility.

Fig. 2-31

Fig. 2-32



Figs. 2-31 and 2-32. Clutches cemented. Observe alignment of separable studs from both front and side views to "eye" the studs properly for parallelism to each other during cementation of the clutches.

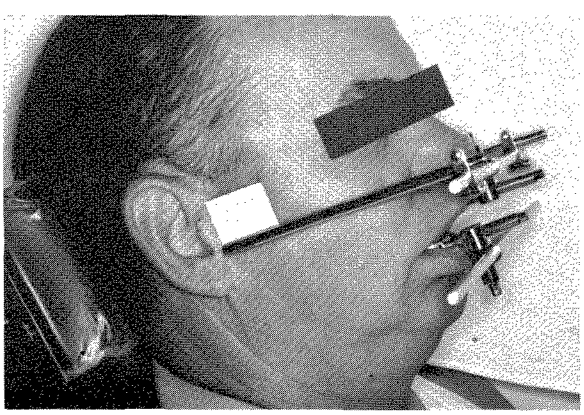


Fig. 2-33. *Front bars and sidearm with graph paper on flag positioned to provide a stationary background against which axis can be located.*

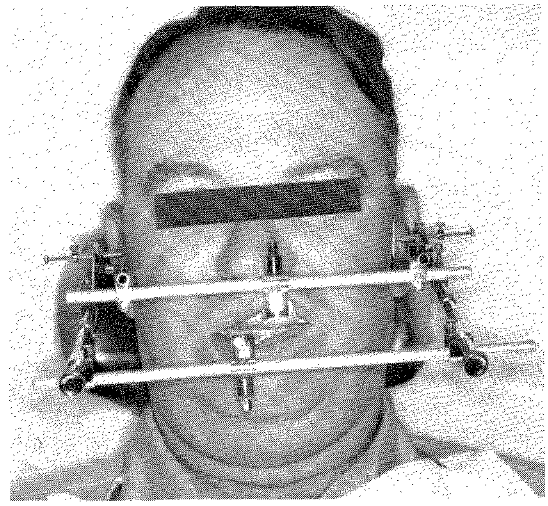


Fig. 2-34

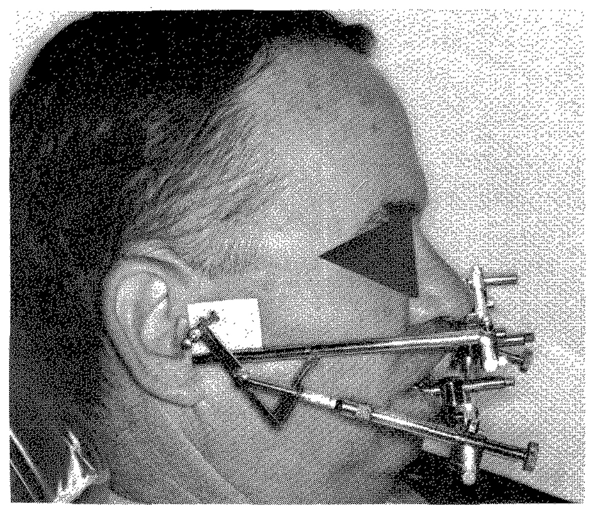


Fig. 2-35

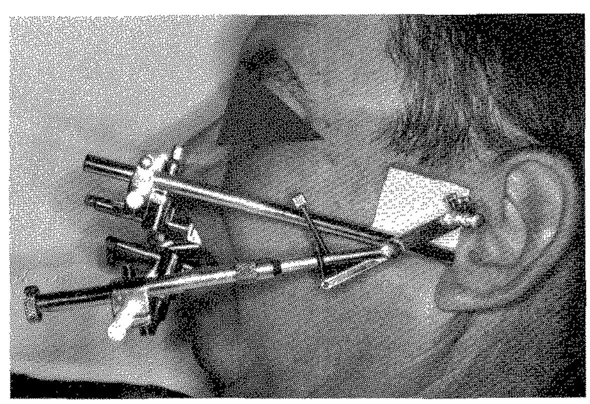


Fig. 2-36

Figs. 2-34 to 2-36. Stylus arms (adjustable horizontally and vertically) placed on lower front bar with stylus in vicinity of condyle.

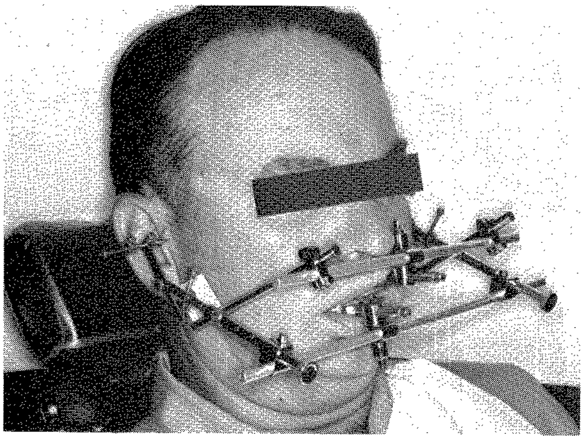


Fig. 2-37. After tip of stylus will no longer arc but merely rotate (carried out on both sides simultaneously) upper arm is dropped and points so located are transferred to skin.

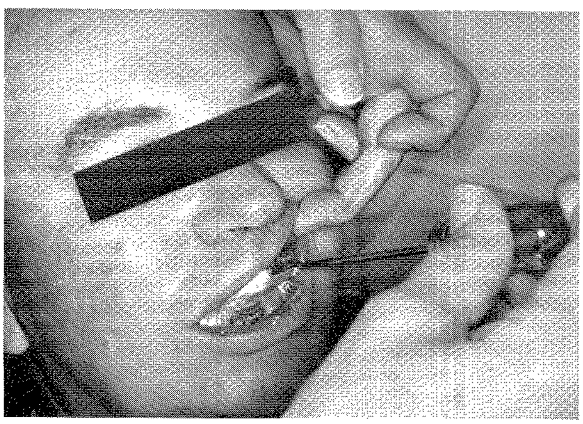


Fig. 2-38. Removal of clutches—removal of screws holding two parts of clutch together and positioning screwdriver in "pry slot" for easy displacement of anterior section.

By locating the center of rotation for each condyle and joining these with an imaginary line, the hinge axis is located.

Also keep in mind the following:

1. Use the Cohen or Hickok trainer for five to ten minutes before positioning the hinge-bow for location of the axis.
2. The hinge action actually is being located in the facial plane (on the side of the face).
3. This is not the true center of vertical motion for that is located in the condyle.
4. A point on a line that has been extended from the centers of vertical motion is being located.
5. Centers of hinge action can be located only when the condyle is in a position where it can repeatedly scribe these arcs —when it is in the most retruded position in the glenoid fossa.[5]

The axis points are now related to a third point on the side of the nose. This point is usually placed on the right side of the nose 2$\frac{3}{8}$ inches from the incisal edge of a central incisor tooth or by locating the inferior border of the orbit on the right side and, for convenience, recording with a mark on the same plane on the side of the nose. These three points are on the axis-orbital plane, which is a plane of reference. They are used to make a conventional face-bow transfer so that the casts will be oriented on the articulator in the same relation to its axis as the jaws are to the hinge axis.

This axis-orbital plane will give a constant position for the upper jaw, and a correct interocclusal record will establish the position of the lower jaw to the constant upper jaw. In this way repeated mountings will have a constant relation to the records and the patient's centers of rotation.

The three points (marks) are made permanent by using a special tattoo needle and a little pink marking dye (sulfide of mercury) (Figs. 2-39 to 2-41). India ink, which is used in conjunction with a disposable hypodermic needle, is also used very successfully. Remember to examine tattoo marks at intervals, and re-ink if any of them start to fade out.

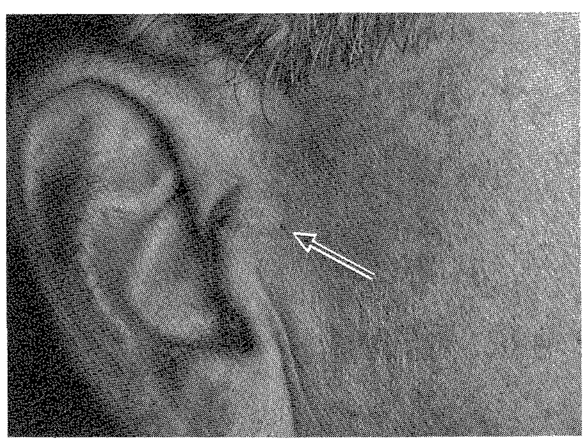


Fig. 2-39. Axis point on right side made permanent by using a special tattoo ink.

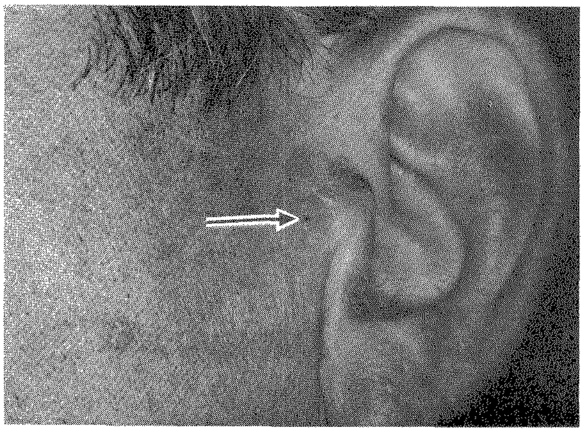


Fig. 2-40. Axis point on left side made permanent by using a special tattoo ink.

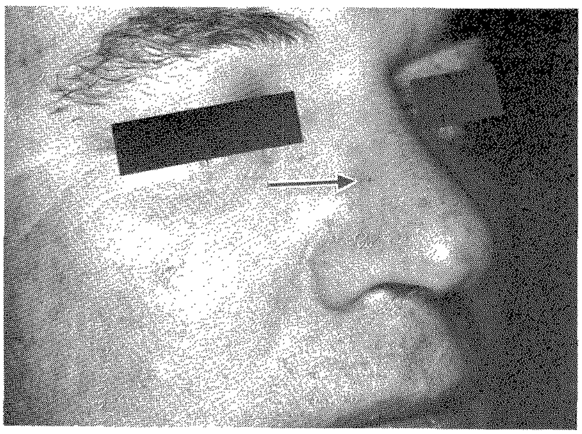


Fig. 2-41. Nose reference point made permanent by using tattoo ink.

The axis is constant to the mandible, and it determines the arc of closure upon which the cusps of the teeth meet in any contacting position. For convenience, the hinge axis is located and reproduced in centric relation. It can be said therefore that the hinge-axis position is a physiologically acceptable maxillomandibular relationship.

Use of pantograph in recording of jaw movements. The procedure so far permits the correct apposition of the casts on an instrument in the opening and closing component, but only in the terminal hinge position. It is necessary to transfer the centers of lateral motion to an articulator if the other movements of the mandible are to be faithfully reproduced. This is accomplished by the use of twin Gothic arch (needle point) tracings. On a suitable articulator that can be adjusted for intercondylar width, the centers of lateral movement are located from the twin Gothic arches. All that remains now is to duplicate the paths of these centers, and all possible jaw relationships will have been duplicated. It can be used as a means of creating occlusal forms that will be in harmony with the joint and also the supporting structures of the teeth.

The most accurate practical method of recording jaw movements is the use of an extraoral tracing device. Actually this is a pantograph, which consists of two face-bows with six recording slides and six styli (Fig. 2-42), that scribes the paths of the centers of rotation of the mandible. The tracings are made in three dimensions simultaneously.

Pantograph registrations should be used for the following reasons:

1. They permit us to accurately record the border movements of our patients and to duplicate these movements on an articulator. This makes it possible to conveniently design and construct the occlusal surfaces of the restorations so that they will be in harmony with the patient's jaw movements.
2. Copying mandibular movements on an articulator is necessary if we are going to produce an organic occlusion that fits the masticatory organ.
3. The direction, shape, and depth of the occlusal grooves can be carved accurately so that the cusps that travel in these grooves can arrive at their destinations (fossae) without trauma. They can be on the right "track," or let us put it this way:
   a. The ridge and groove directions are determined as a resultant of the movement of the condyles.
   b. In the main, the cusp height and fossa depth are determined as a resultant of mandibular movements.
   c. The proper concavity of the lingual surface of the upper anterior teeth is determined by the movements of the condyles.

(These determinants can be applied in the fabrication of the occlusion of the teeth if we will record the mandibular movements of the patient and then cause the articulator to reproduce the same border and intermediate movements.)

4. Cuspal elements (cusps, marginal ridges, triangular ridges, developmental grooves, supplemental grooves, fossae) are necessary to

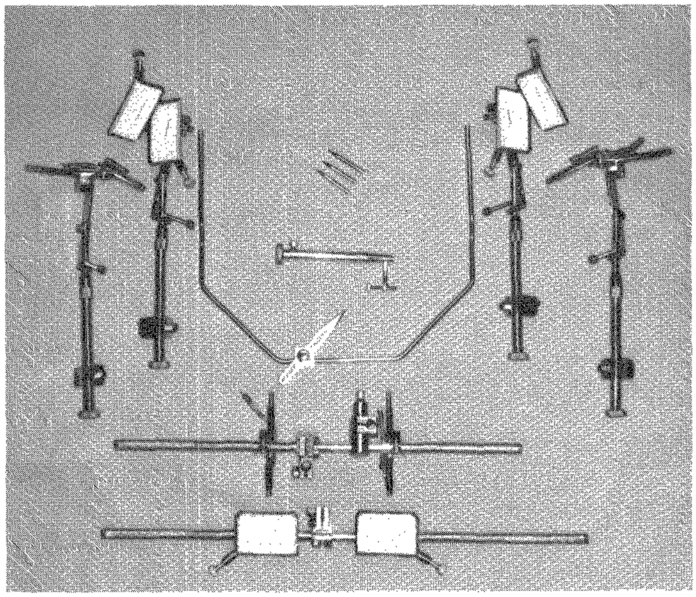


Fig. 2-42. Various parts of a pantograph. It consists of two face-bows with six recording slides and six styli.

maintain the vertical stability of the teeth by distributing the forces of occlusion in the long axis of the teeth.

(Pantograph registrations permit us to accurately determine the height, position, and relation of the cuspal elements so that they will efficiently perform their functions without creating lateral stresses on the supporting structures.)

5. The centric relation intercusping is built by first consulting the eccentric paths of mandibular travel. If we do not consult the eccentric travel, the cusps will not be free to travel in and out of centric relation closure without conflict. The resultant will be trauma, wear, and loss of the centric relation contacts.

6. *So, by logic we feel the only way we can work accurately and measure our work is to use a faithful substitute for the jaws, an articulator in which all the occlusal determinants and the opening and closing axis relations are precisely incorporated.*

This method of employing the pantograph graphically records the various positions and movements of the mandible. These graphs are then utilized to adjust the articulator to reproduce the same relations and the actual path of the movements found in the patient.

In making these records the clutches have to be separated vertically so that there will be no tooth guidance during the registrations and the minimum amount of separation that will ensure this is desired.

When an accurate and complete record of the jaw movements has been registered and the orbital guide set (if this step is forgotten, the registrations will be useless), the upper and lower arms of the pantograph are firmly locked together with a fast-setting stone making use of four vise grips. (See Figs. 2-43 to 2-55.)

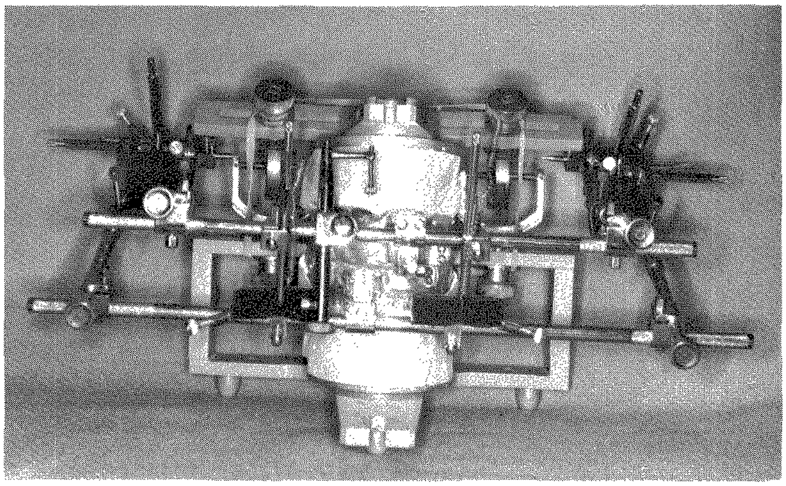


Fig. 2-43. Alignment of pantograph on articulator for ease of positioning when carried to the patient.

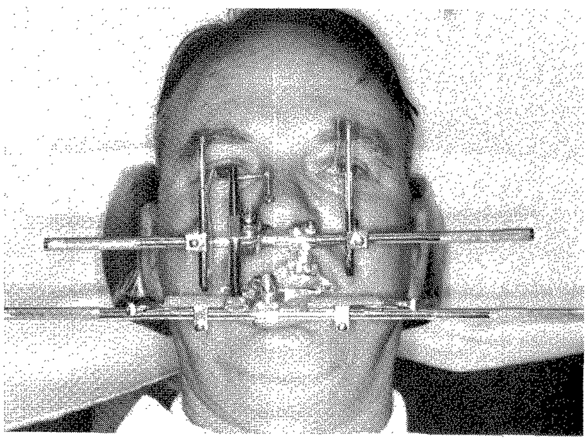


Fig. 2-44. Upper and lower crossbars of pantograph positioned.

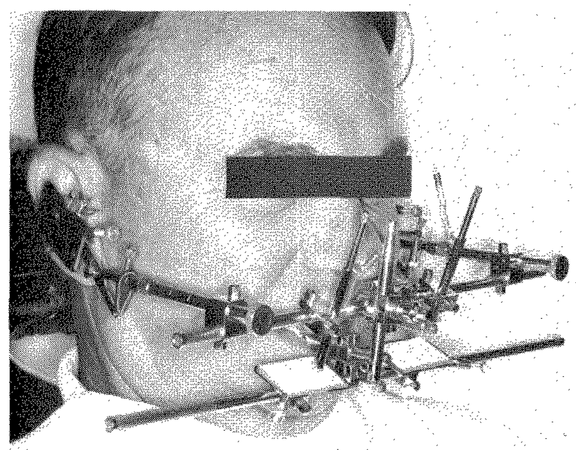


Fig. 2-45. Sidearms with slide holders placed on each end of upper crossbar. Position axis stylus pins on axis tattoo marks, barely touching skin.

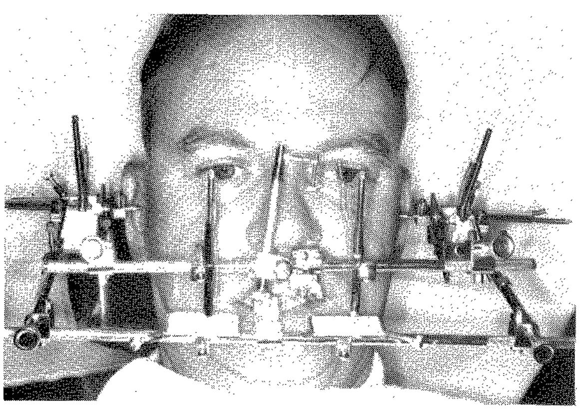


Fig. 2-46. Lower lateral arms placed on lower front crossbar. Adjust them so as to put horizontal styli on hinge with patient in centric relation.

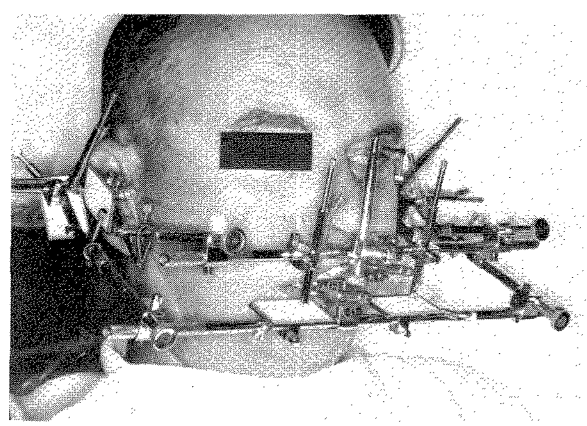
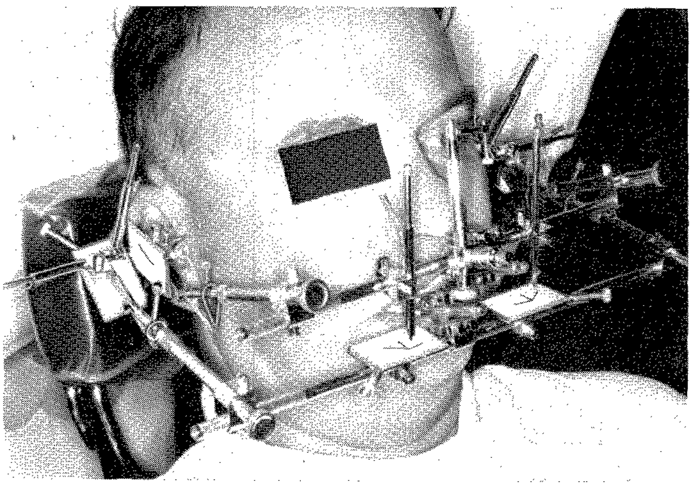


Fig. 2-47. Vertical styli placed about ¼ inch inside horizontal recording plate.

Fig. 2-48



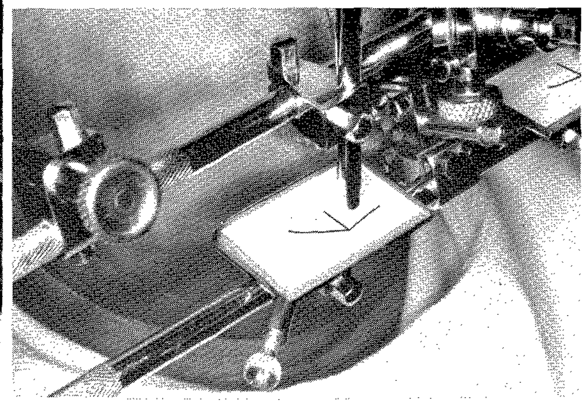
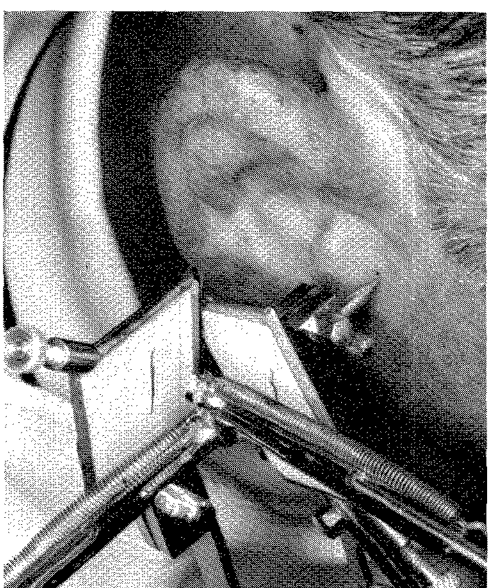


Fig. 2-49

Fig. 2-50



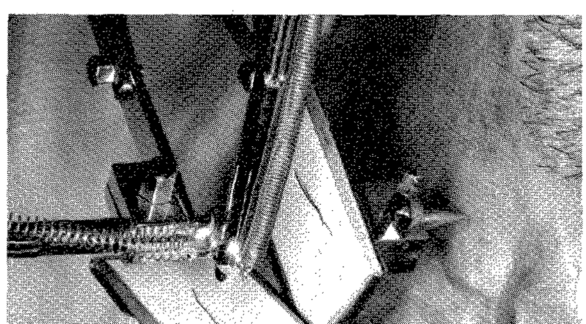


Fig. 2-51

Figs. 2-48 to 2-51. A series of completed tracings—centric, protrusive, and lateral.

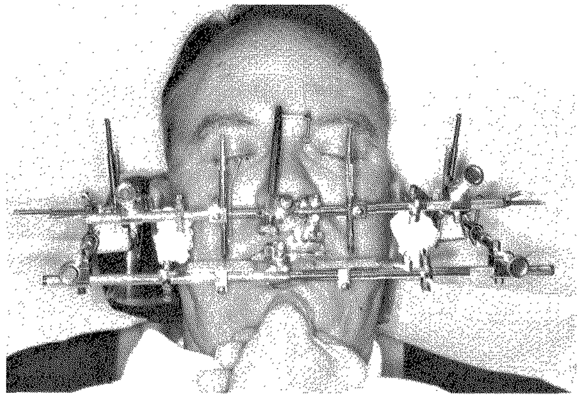


Fig. 2-52. Fast-setting stone applied around crossed studs of vise grips. Patient held in centric position until stone sets.

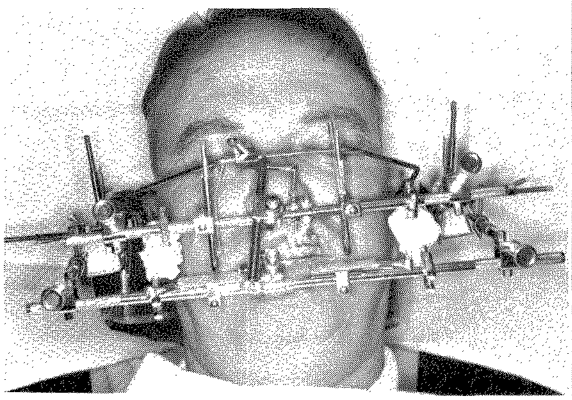


Fig. 2-53

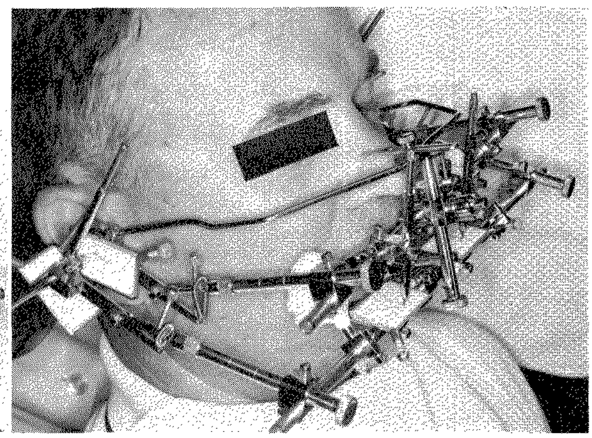


Fig. 2-54

Figs. 2-53 and 2-54. Axis-orbital indicator bow placed on support. Lays across axis indicator pins posteriorly and indicator point on bow is on nose tattoo mark. Don't forget this step!

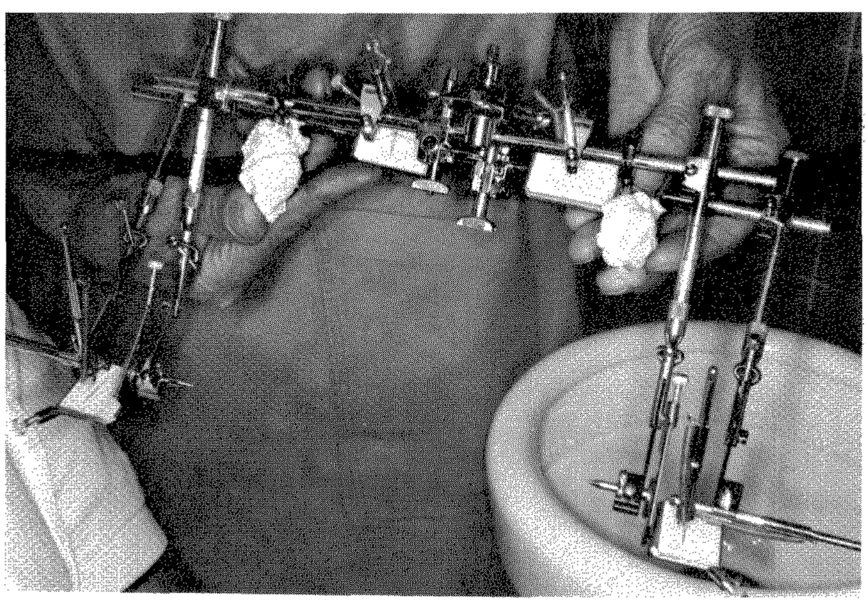


Fig. 2-55. Pantograph removed intact from patient and ready for mounting on articulator.

Transference to an adjustable articulator. The entire assembly is removed intact from the patient (not including the clutches, which are subsequently removed) and is transferred to the mounting frame. The mounting frame is a jig that conveniently holds a face-bow in proper relation to an articulator. It permits accurate relationship of the clutch or cast to the articulator while the attaching stone sets.

The leveling device is in position on the front of the upper bow and rests on the axis-orbital plane. This arrangement automatically makes the upper bow parallel to the axis-orbital plane. (See Fig. 2-56.) The lower clutch is attached to the lower bow, the vise grips are removed, the articulator is adjusted or set, and the adjustments are recorded on a suitable card (Figs. 2-57 to 2-68).

By means of a face-bow transfer and a correct centric interocclusal record, study casts, working casts, and remount casts can be mounted on this set adjustable articulator, which is capable of duplicating the patient's jaw movements (Figs. 2-69 to 2-77).

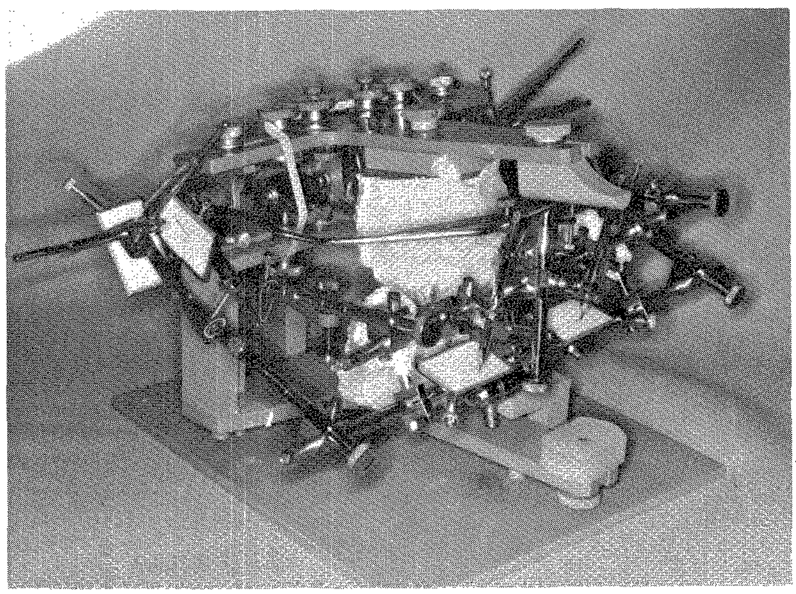


Fig. 2-56. Pantograph mounted on articulator. Leveling device in position on front of upper bow, resting on axis-orbital plane (making upper bow parallel to axis-orbital plane).

Fig. 2-57

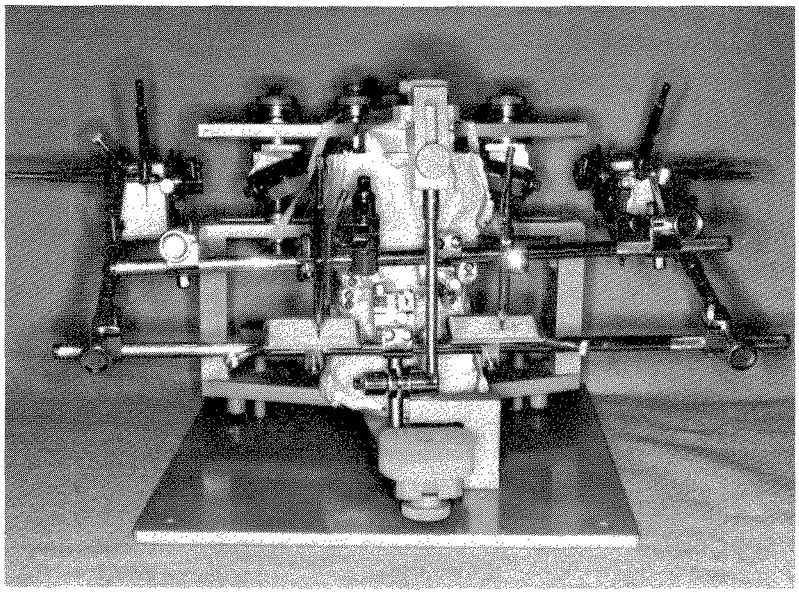


Fig. 2-58

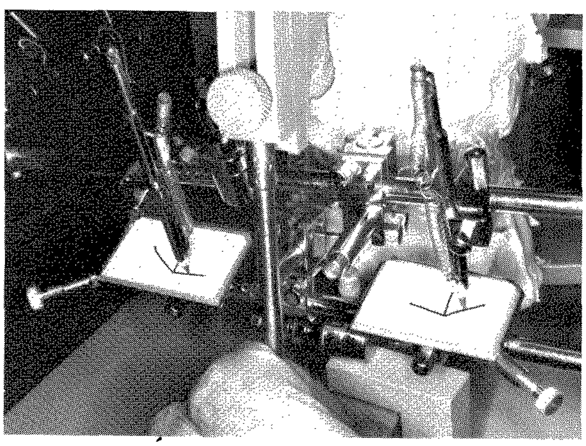


Fig. 2-59

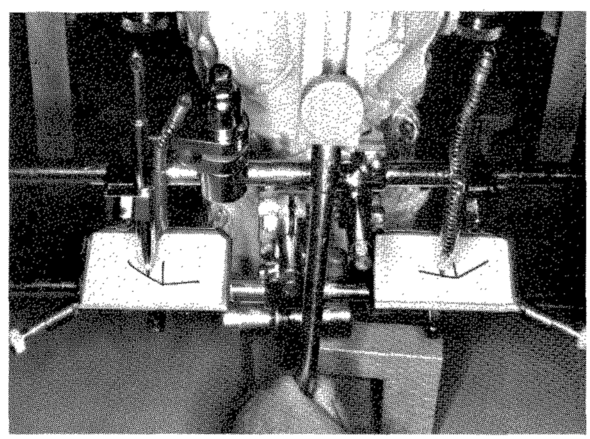


Fig. 2-60

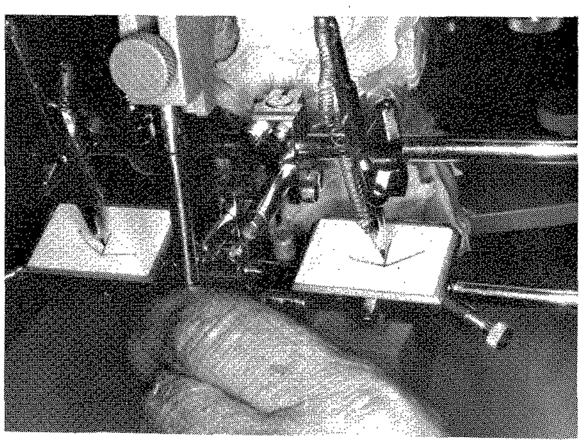
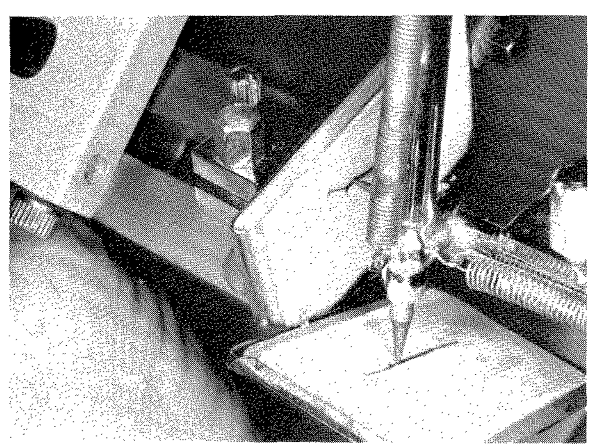
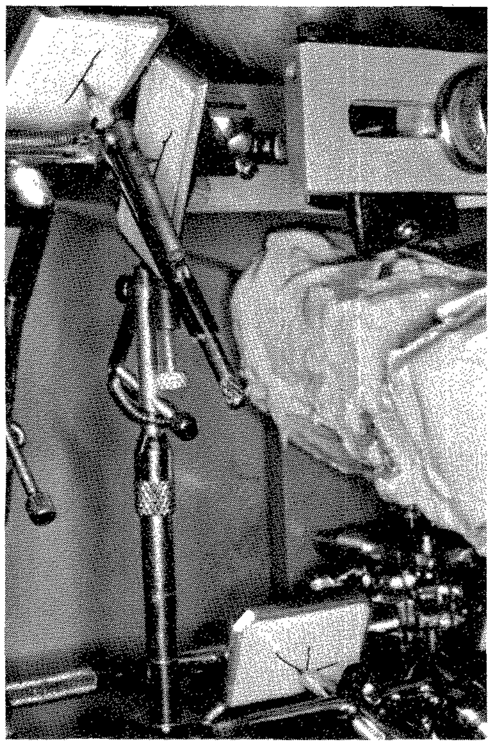


Fig. 2-61



Figs. 2-57 to 2-65. Vise grips removed and articulator set to recorded registrations. Styli following tracings in all mandibular excursions.

Fig. 2-62



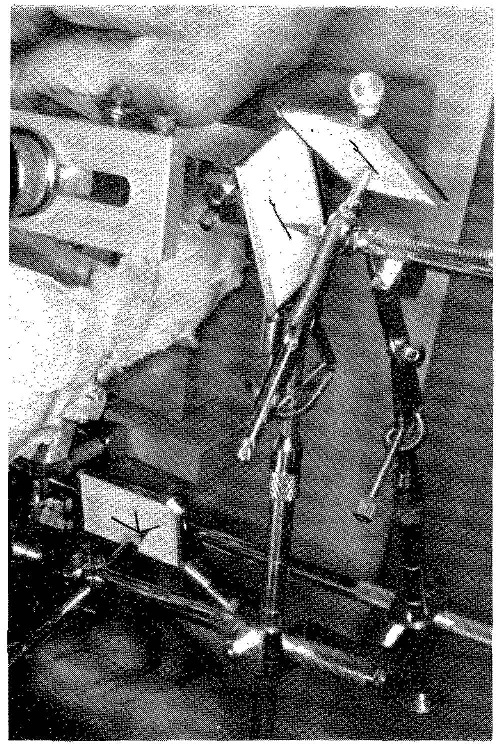
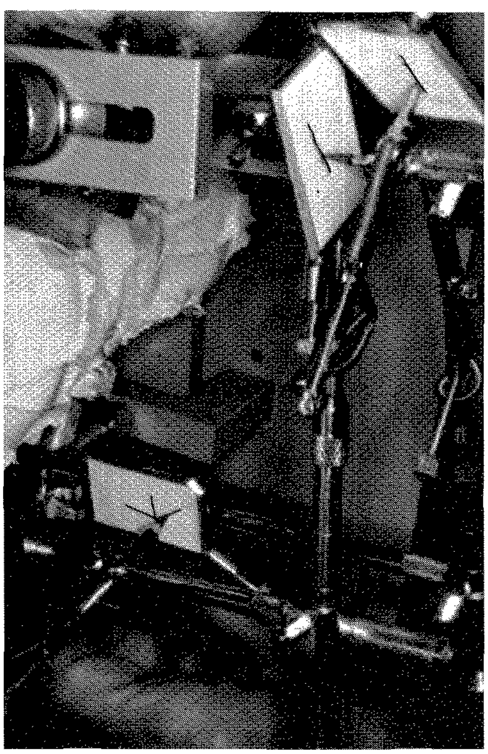


Fig. 2-63

Fig. 2-64



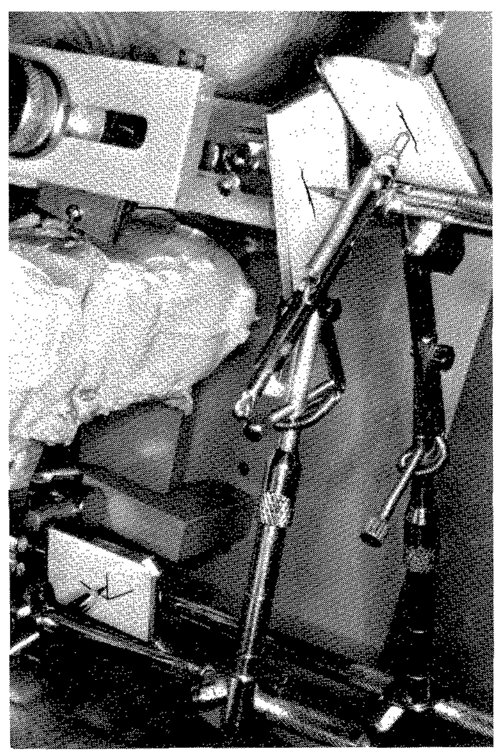


Fig. 2-65

Figs. 2-62 to 2-65. For legend see opposite page.

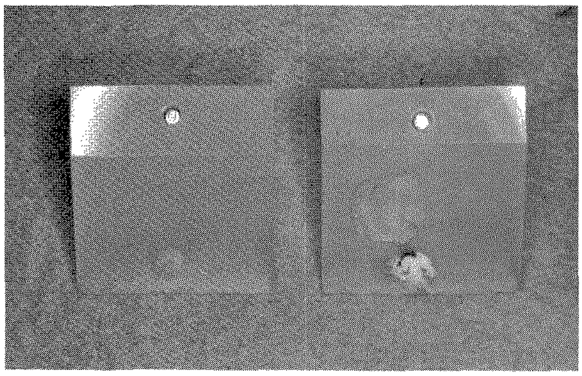


Fig. 2-66. Ground eminentiae.

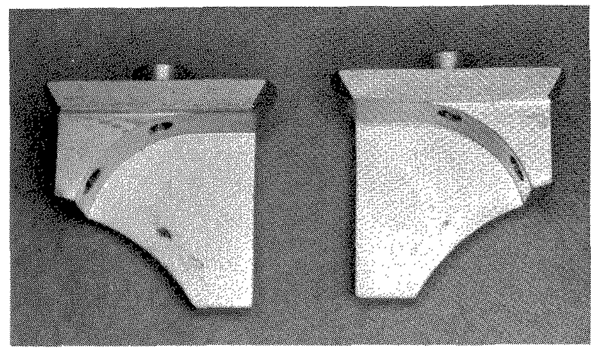


Fig. 2-67. Side shifts (in this case, straight or unground).

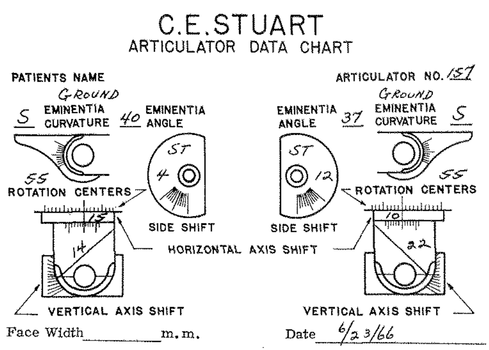


Fig. 2-68. Adjustments recorded on a suitable card.

Fig. 2-69. Face-bow fork showing tips of cusp indentation of maxillary teeth.

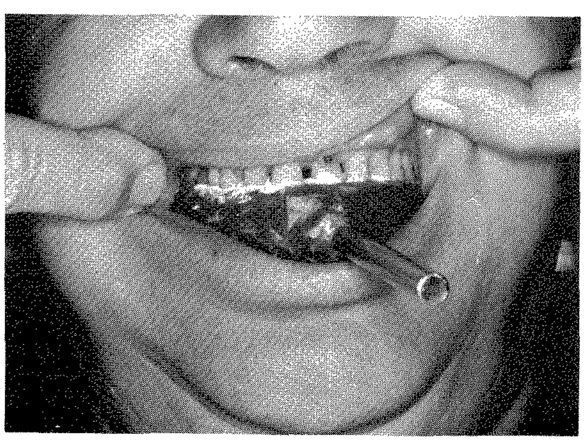


Fig. 2-70

Fig. 2-71

Figs. 2-70 and 2-71. Bite-fork cusp tip indentations rebased with Kydac (zinc oxide–eugenol paste) for greater accuracy in cast positioning and avoidance of rocking of cast.

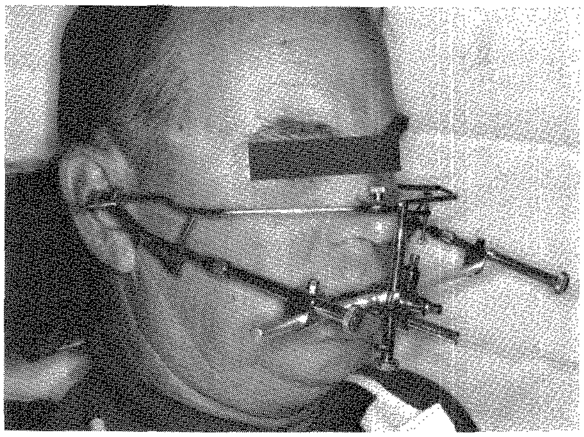


Fig. 2-72. Hinge-bow transfer for mounting casts to correct axis.

Fig. 2-73. Hinge-bow and bite fork removed.

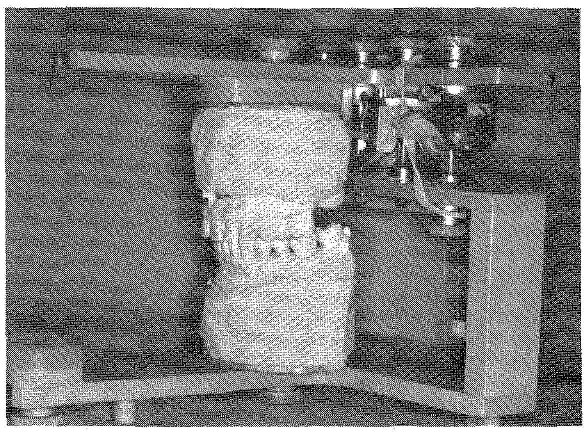


Fig. 2-74

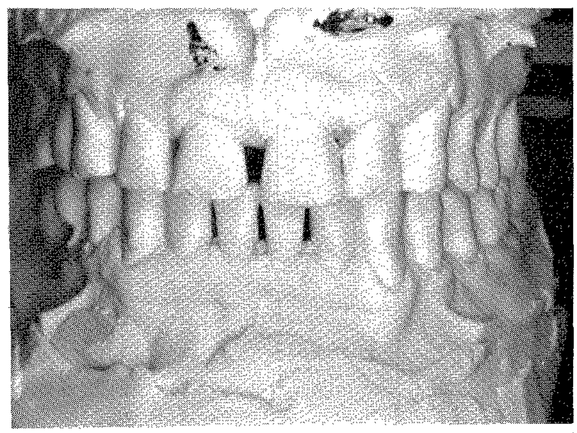


Fig. 2-75

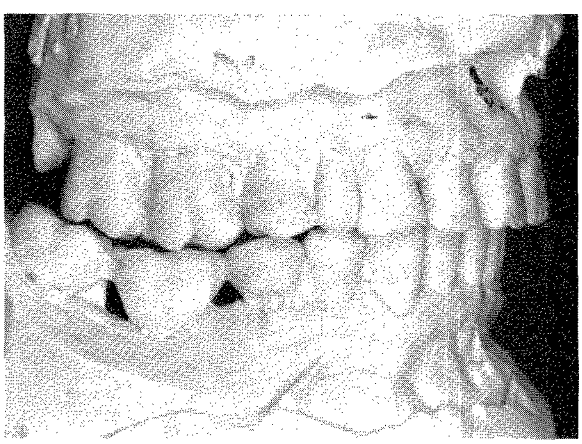


Fig. 2-76

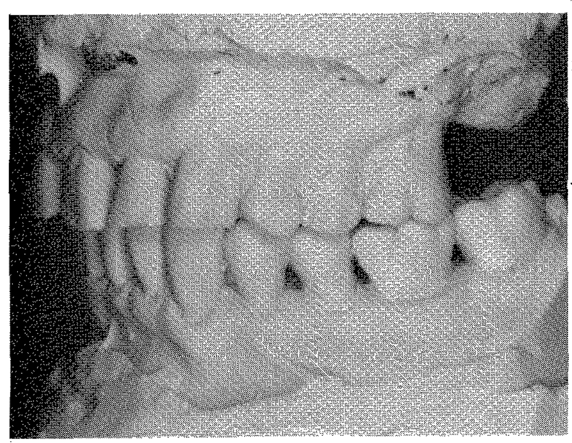


Fig. 2-77

Figs. 2-74 to 2-77. Study casts mounted to correct axis, anterior and right and left posterior views.

Fixed and variable factors of occlusion

The factors utilized in properly orienting the casts were all *fixed factors of occlusion,* which were accurately recorded and reproduced and which cannot be changed or altered. These factors are Bennett movement, lateral angulation and curvature, protrusive angulation and curvature, intercondylar distance, and horizontal axis. They exert the greatest amount of control in the posterior region, and the effect of the fixed factors diminishes gradually toward the anterior portion of the arch.

There are other factors, not anatomically fixed, that can be altered to restore the mouth to normal function. These are known as the *variable factors of occlusion* and are anterior guidance, plane of occluson, curve of Spee, cusp height, etc. This effect manifests itself primarily in the anterior region, and there is a gradual diminution of this control toward the posterior region. They can be altered, provided one knows how they are related to the fixed factors of occlusion, giving us the possibility of a physiologic articulation. Under any given fixed set of factors of occlusion only one set of cusps can function in harmony with jaw movement.[11]

The fixed and variable factors of occlusion functioning simultaneously form the complete spaciotemporal continuum in all excursions that directly influence the morphology of the occlusal forms to be constructed (Chapter 12).

Centric relation

Dykins has said that the most important task in dentistry is to get the two jaws to come together correctly.

Granger has said that regardless of our beliefs with respect to cusps, articulators, materials, or methods, there is no single factor in all dentistry equal in importance to centric relation.

Therefore, a thorough understanding of centric relation is essential to the proper practice of dentistry.

Centric relation defined. Despite the fact that some authorities contend that there is not such a thing as "centric relation" and that maybe, from a purely scientific standpoint, they are right, dentists doing clinical procedures must have it defined and must have a method of correctly registering jaw relations. This condition must exist until such time that a truly scientific approach is given to the profession.

"Centric relation of the mandible is its rearmost, midmost, untranslated hinged position. It is a strained relation as are all border relations. It is the only maxillo-mandibular relation that can be statically repeated."*

"We may define temporomandibular centricity as that terminal hinge fossae relationship necessary for the establishment of a fulcral seat toward which the condyles rotate and translate in the dynamics of function. Or it may be expressed by saying the opposing occlusal surfaces of the teeth bear a reciprocal dependence to the temporomandibular joint. Centric relation denotes both condyles in their firmest bracing contact and the only motion possible in this relationship is vertical rotation."†

Actually, establishing centric relation is the orienting of horizontal centers of motion, which are identical with the vertical centers of rotation to the maxilla. When the exact centers of lateral rotation have been located and this has been done in conjunction with the location of the centers of vertical rotation (hinge action), then we have truly found centric relation.

The following must be done: (1) location of the hinge axis, (2) location of the centers of lateral rotation, and (3) transference of the casts to the axis, which entails face-bow transfer of the upper cast to the axis and relation of the lower cast to the upper cast by a correct centric relation record. *The lower cast must be oriented to these centers.*[8]

In other words, *geometrically,* the problem of centric relation is one of relating the position of the hinge axis and rotational centers to the maxilla.

Anatomically, the problem of centric relation becomes one of employing ways and means whereby the physiology of the involved anatomic parts is utilized to establish a correct joint-fossae relationship.[9]

It can be said that the criteria of centric relation acceptability is its capability of reproduction.

Reproduction of centric relation using the Lucia method. Fundamentally, the problem of joint-fossae relationship involves directed joint positioning, application of patient bilateral

*From Stuart, Charles E.: Personal communication.
†From Dykins, William R.: Personal communication.

muscular effort, and means of joint stabilization.

Operator guidance serves as the means of orienting the posterior relation of the condyles to the fossae, while the musculature is interpreted as the factor in placing the condyles in their correct superior relationship. To utilize bilateral muscular balance an anterior stop, as suggested by Victor O. Lucia of New York, must be provided as close to the desired vertical dimension as possible. An absolute requirement of the stop is that it must not be capable of any movement for constancy in its relation to the supporting teeth; neither should it be designed so that the backward and upward movement of the condyles is influenced. For convenience and form it is fabricated from quick-setting acrylic on models mounted on an articulator by means of a preliminary centric bite.

One or more layers of Sure-Set wax is the vehicle that is employed to carry the recording medium, such as Kydac, between the teeth. The wax wafer should not be in contact with the posterior teeth when the jaw is closed against the anterior stop. If it comes in contact, it may invite displacement because of the stretching of the ligaments.

Two or more wafer recordings are necessary. The criteria of acceptance of correct condylar centricity is their capability of reproduction demonstrated by the split-cast idea as presented by Lauritzen. With this technique the objective of recording centric relation at a predetermined, vertical dimension can be fulfilled.[7]

A step-by-step description of *Lucia's method* is in order. A small anterior self-curing acrylic bite plane is first constructed on the maxillary master model of the patient; the design of which can be seen in Fig. 2-78.

The bite plane is then placed in position in the patient's mouth and the teeth closed in centric onto the plane. In this position there must be enough lingual extension of the plane to allow firm contact with the lower anterior teeth, and there must be enough height or thickness to the plane to allow a 1 to 3 mm. clearance of the posterior maxillary and mandibular cusps.

After any necessary preliminary corrections are made the plane is again placed in the patient's mouth. A piece of articulating paper is placed between the plane and the lower incisors, and the patient is guided into protrusive, centric, and lateral movements. The plane is then removed from the mouth, and the resulting Gothic arch tracing is observed. Any interferences on the plane are corrected, and it is shaped in such a manner as to render it ineffective as a lateral or protrusive guide for the mandible upon closure against the plane. In most patients this would necessitate sloping the plane's occlusal surface in a slightly upward direction, both posteriorly and laterally from a central ridge, which would now have but minimum contact with a single lower central incisor, or with, at most, two incisors. This can be better understood by referring to Fig. 2-79.

Next indentations of the patient's maxillary cusps are made in a sheet of extra-hard baseplate wax. This occlusal pattern is then cut from the sheet and trimmed to within 1 or 2 mm. of the outer edge of the occlusal indentations. A V-shaped section is then removed from the anterior part of the wax form in such a manner and of such size that the wax form and the bite-plane can be placed in the mouth at the same time with some space between them (Fig. 2-80).

Also, the corners of the wax tray are turned up in the region of the cuspids. This ensures the reseating of the wax tray in its proper position after the Kydac has been placed on the tray.

Thus a wax impression tray is formed for the centric relation record. The wax tray is then softened in warm water, enough to allow further occlusal indentations and yet not enough to cause the tray to lose its general shape while being handled. In this state the tray is positioned properly in the mouth, and the patient's mandible is guided into a centric closure and then is opened prior to complete penetration of the wax. The wax tray then is removed and chilled and is repositioned in the mouth to check for distortion.

With the wax tray still in position, the bite plane is inserted (some denture powder may have to be used to secure the plane in the mouth), and the patient's mandible is closed in the centric arc onto the bite plane. When in this position, the wax tray should be freely movable between the occlusal surfaces of the maxillary and mandibular teeth. The freedom of movement of the wax tray is most essential in obtaining the centric relation record. If it comes in contact with the posterior teeth when the jaw is closed against the anterior stop, it may invite

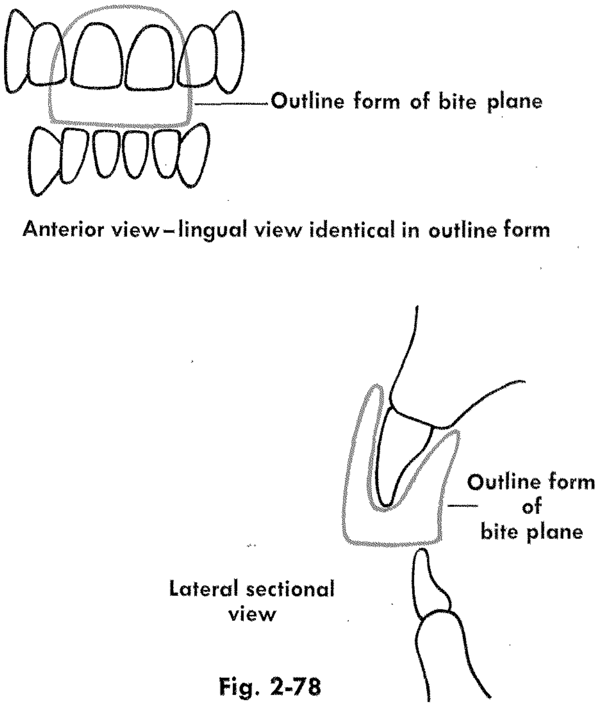


Fig. 2-78

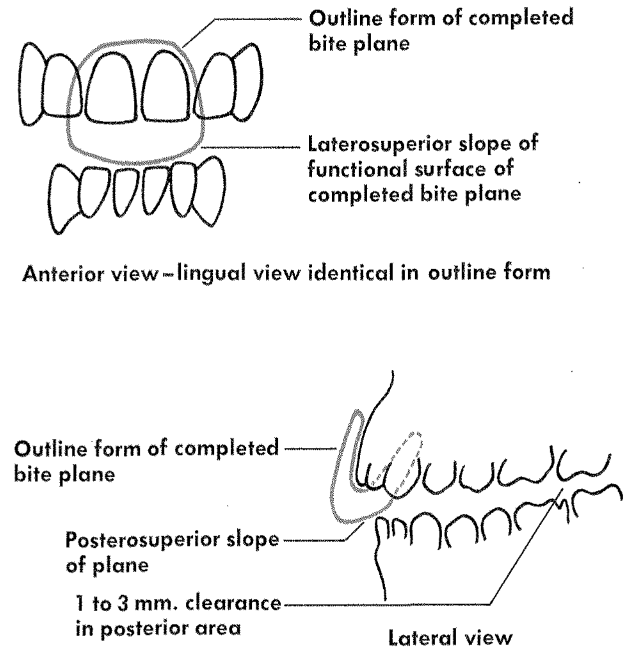


Fig. 2-79

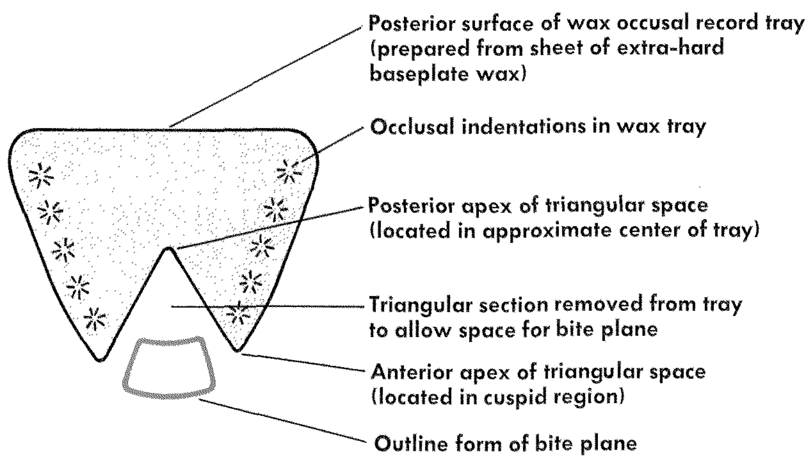


Fig. 2-80

Figs. 2-78 to 2-80. Graphic representations of principles of Lucia's method of registering centric relation record.

displacement because of the stretching of the ligaments.

After completion, the wax tray is dried thoroughly. The patient's teeth are lubricated with a petrolatum preparation, and a mix of a zinc oxide–eugenol preparation (Kydac), is prepared properly and placed in the maxillary and mandibular occlusal indentations of the tray. With the bite plane securely in position the wax tray is carried to place and the patient's mandible is guided into a centric closure against the bite plane. At this time the tray is released (i.e., no longer held in place by the dentist) and the patient is instructed to exert pressure in the closure against the bite plane and to retain this pressure until instructed otherwise. The operator should hold the patient's mandible in this centric position until the Kydac has completed its set. (See Fig. 2-81.)

The wax tray with the occlusal record is then

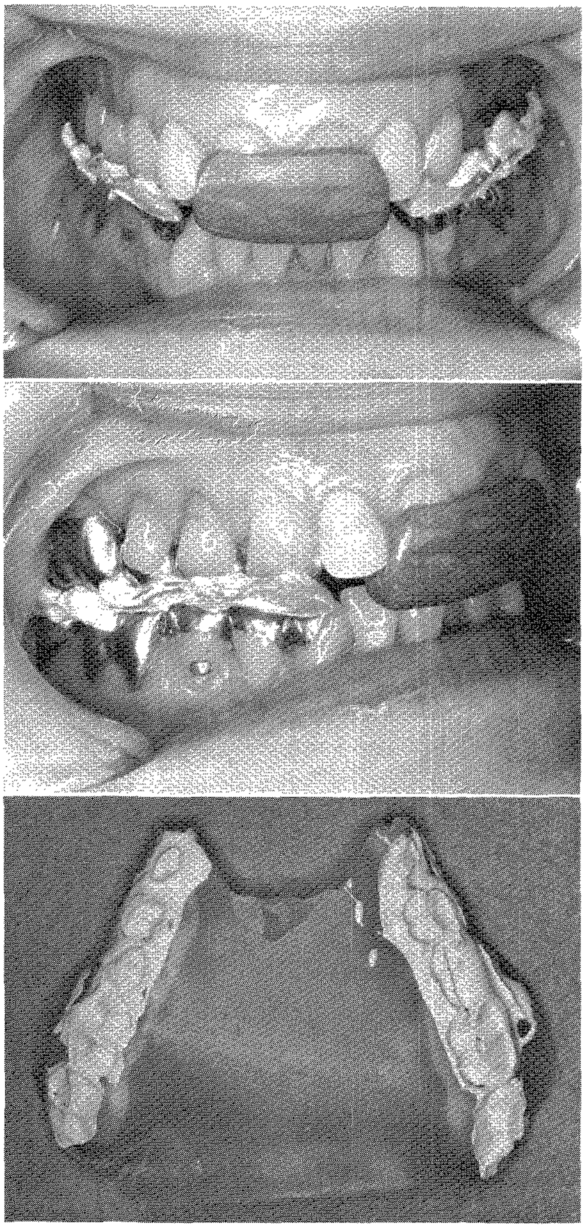


Fig. 2-81. Acrylic resin jig, prepared tray with zinc oxide-eugenol paste (Kydac) carried to place, and patient's mandible guided into centric closure against bite plane.

removed, trimmed, and checked in the mouth without the use of the bite plane.

The study casts, working casts, or remount casts now can be checked with this occlusal recording. This, as well as the subsequent articulator mounting, is done without the bite plane.

Repeating the process and using several similarly constructed wax trays with the same bite plane is essential to verify, by the Lauritzen split-cast method, the accuracy of the centric relation record on the articulator.

It has been shown that it is possible to record the true, pure, functional movements of a jaw and to transfer those records to an articulator on which they can be duplicated exactly.

The rotational centers control all the movements of the mandible, and they must be located accurately so that centric occlusion can be built at the position of centric relation.

It has been aptly said that, "The real problem is recognizing the mouth as a functioning organ, an organ whose condylar function is of such basic importance, that without recognizing it and utilizing its respective quality, restoring a mouth becomes a hit or miss proposition. Taking it into your camp as an ally, dependable and predictable, enhances success. Ignore it and its harmful potential cannot be estimated."*

Treatment planning

OBJECTIVES

The objective of a treatment plan is to restore the mouth to a healthy, functional condition. Not only must the condition and health of the supporting structures be improved upon, but also the relationship of the teeth. All of this is based on an evaluation of existing conditions and treatment potentials.

The first important consideration in arriving at a plan of treatment is whether there are definite indications for complete mouth rehabilitation and, if so, is the patient amenable to this type of treatment—physically, emotionally, and economically. Seriously consider the indications and contraindications of such an important undertaking.

The second consideration is whether the dentist has not only a good knowledge of mandibular physiology and the basic fundamentals of periodontics, orthodontics, and endodontics (the sequential integration of which is part and parcel of the modus operandi), but also basic and advanced knowledge and the necessary operative skills in the field of crown and bridge prosthodontics.

A coordinated plan of treatment is of the utmost importance. Periodontal, endodontic, surgical, and orthodontic problems should be co-

*From Sloane, Robert B.: Basic principles in mouth reconstruction, D. Items Interest **73**:1-10, 1951.

ordinated with the prosthodontics in treatment planning even though the patient is to be referred to the respective specialists in these fields. The final responsibility of the success or failure of the case, in mouth rehabilitation, lies with the prosthodontist. This makes it imperative that he know what is being done by the specialist and why and that he be in accord with the procedural objectives.

It is not only essential to be very well trained in the operative phases of prosthodontics, but also in all laboratory procedures. This holds true regardless of whether the laboratory work is executed by the dentist or by resident or nonresident technicians.

An evaluation of all assembled data must be undertaken before a treatment plan can be recommended and therapy instituted.

Clinical, laboratory, microscopic, roentgenographic, and medical and dental history findings must be studied carefully, and any recognizable pathologic conditions must be noted and categorized for treatment by self or by referral to a specialist. The length of time that the etiologic factors have been present and the degree of pathology give us some indication of the rate of breakdown.

A study of the occlusion represents a very important aspect of the examination. In evaluating this occlusion the dentist must use the primary objectives of function, form, esthetics, and phonetics as his criteria. Sufficient study of properly oriented casts saves time and effort and prevents errors in treatment planning and therapy.

The following can be noted from the diagnostic casts:

1. Discrepancies between the habitual closure pattern and the centric relation—location, degree, and influence of occlusal prematurities—can be seen.
2. In conjunction with the roentgenograms one can see if any bone destruction has occurred and if centric occlusion and centric relation are not harmonious.
3. The excursive movements can also be studied, and if worn facets of the occlusal surfaces are evident, it is certain that they are produced by stresses in lateral and protrusive mandibular movements.
4. The "why" of mobility patterns of teeth (correlated with the measurement of degree of mobility), spacing or "fanning" of anterior teeth, battered and fractured cusps, etc. are vividly pointed up for observaton and study.
5. Relation in size and position of the opposing arches.
6. Jaw-to-jaw relations.
7. Tooth-to-tooth positions.
8. Overbite and overjet relations.
9. Coronal, proximal contacts, embrasure, and occlusal forms of the teeth.
10. Plunger cusps.
11. Edentulous areas—form and size of space. Evaluation of its use for fixed and removable appliances.
12. Crossbite relations—unilateral or bilateral.
13. Degree of curve of Spee and curve of Wilson. Its effect on the final restorations can be visualized, and any necessary changes can be considered.
14. Tilted, rotated, and extruded teeth. Evaluate the degree of tipping, rotation, and extrusion of the teeth.
15. Topography of the marginal ridges of the teeth.
16. Temporomandibular malfunction—if it has to do with malrelation of the teeth.
17. Plane of occlusion. Relation of plane of occlusion to condyle path will be apparent; can alter the occlusal plane somewhat by planning of tooth preparations.
18. Vertical dimension—should it be increased or decreased?
19. Attrition and erosion patterns.
20. Axial positions of the teeth.
21. Type of bite—deep bite, loss of posterior support, prognathic, occlusal attrition, etc.
22. Fixed and variable factors of occlusion.
23. Buccolingual relationship of the posterior teeth. A study of this relationship will be very helpful in determining the type of restoration to be employed—full or partial coverage.
24. Cuspid relations. The path of travel of the lower cuspid is observed, and the complete cuspid relationship is analyzed.

When some question arises as to the successful treatment of the patient or the best method of operative approach to enable recognition of some of the problems that may be encountered, it is

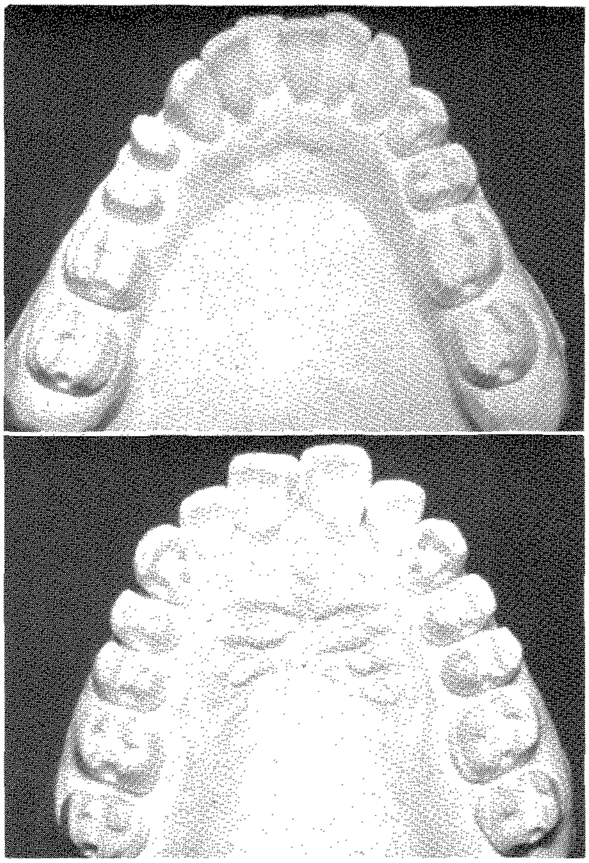


Fig. 2-82. Casts of properly prepared teeth allowing for adequate gold thickness on occlusal surfaces.

exceedingly helpful to make the anticipated preparations in a set of properly oriented study casts. Sufficient tooth structure must be removed to allow for an adequate thickness of gold on the occlusal surfaces in all mandibular excursions (Fig. 2-82).

The next procedure is to work out the coronal and occlusal surfaces in wax. It is possible to study the following determinants of occlusion: (1) the use of cusps and fossae in planning occlusion, (2) ridge and groove direction determinants (axis-orbital horizontal plane), (3) cusp height and fossa depth determinants (sagittal plane), and (4) determinants of the lingual concavity of upper anterior teeth.

Waxing of the case on the preoperative casts (and later on working casts) that were properly oriented on a correctly designed, adjustable articulator allows the cusps (in shapes, placement, and graduated heights) to bear proper relations to the axes of the mandible (Fig. 2-83).

The length or height of the cusps is influenced by the condyle path. The Bennett movement determines the position and form of the cusps. The position and form must be correct to harmonize with the lateral shift; otherwise, the cusps will bump instead of glide around each other as they should.

Where extensive therapy is indicated the aforementioned procedures creates a template of the envisioned completed result, which can also be used as a guide or blueprint during actual treatment.

With all this information available we can also determine whether the teeth in situ can be used as abutments for retainers, appraised on the basis of type of root, coronal form, position of teeth in the arch, amount and quality of supporting bone, and the health status of the periodontium. We can also determine (1) if we should resort to extraction to make the case more ideal, (2) if splinting should be instituted, and (3) if orthodontic treatment, minor or major, can place these teeth in a more favorable position for their use as abutments.

Questionable teeth that are considered clinically expendable should be removed.

Fixed splinting around the arch offsets the potentials of excessive individual tooth leverage. We know that multiple abutments are essential to offset inadequate periodontal support, tooth mobility, or an unfavorable crown-root ratio. (See Chapter 5.)

Injudicious use of splinting must be avoided. This type of therapy should never be used as a crutch for proper occlusal forms. Despite the value of fixation, optimum stability depends on the final occlusal and incisal contacts of the teeth.

Malaligned or malposed teeth should be moved orthodontically for better management of abutment teeth or for better relation to the residual ridges. It can often effectively supplement and simplify therapeutic measures. If this is not possible, elective extraction is usually indicated regardless of the periodontal status.

For minor orthodontic movement some techniques utilized are (1) wire or grassline ligature, (2) rubber dam elastics, (3) removable types such as the Hawley appliance, and (4) various modifications of this type of appliance such as the bite plate. The bite plate can be used as a prerestorative measure. (See Chapter 5.)

If indicated, consideration should be given to

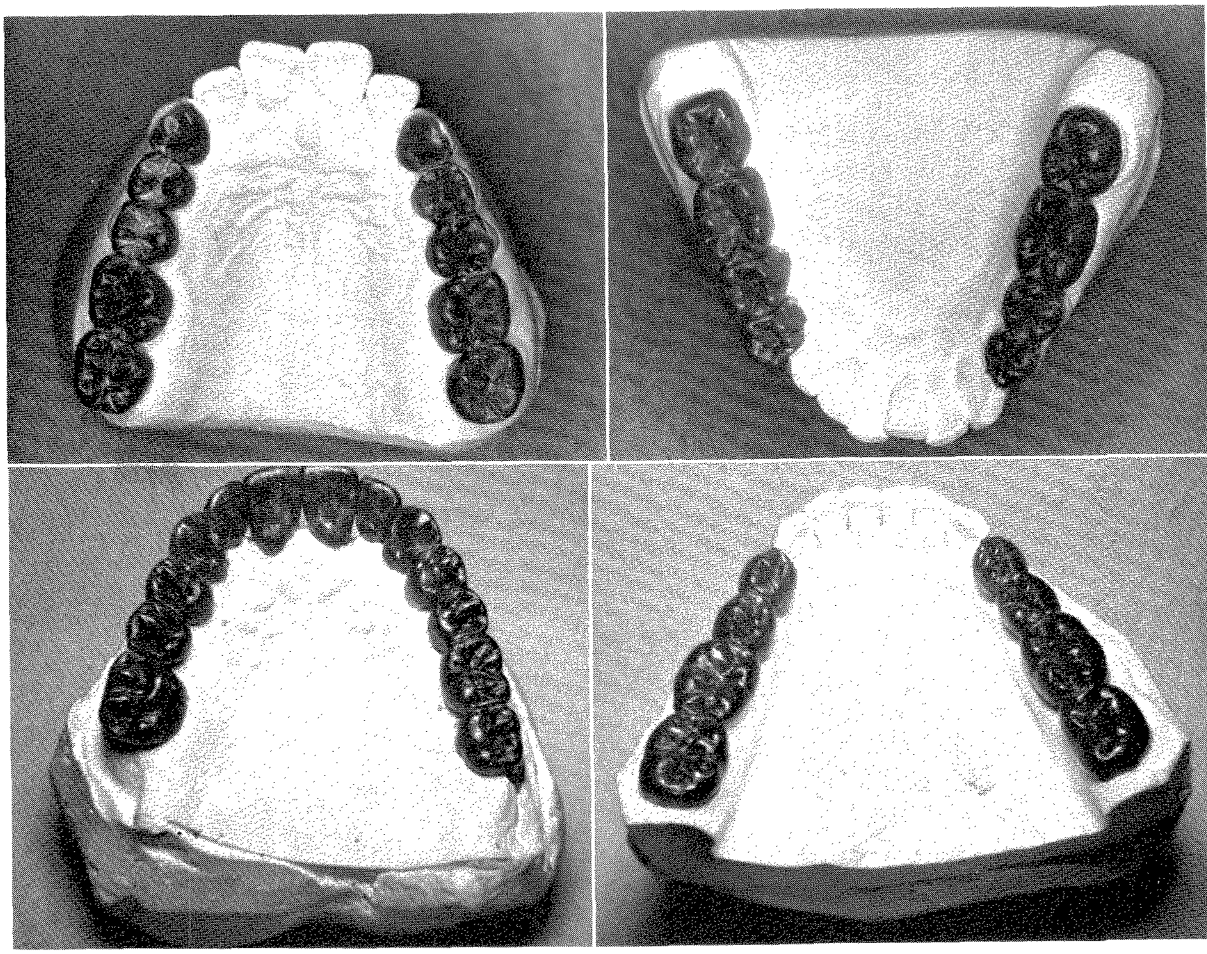


Fig. 2-83. Preoperative wax-ups.

the establishment of a closely correct vertical dimension of the dentition to enable a return to a muscularly balanced, maxillomandibular position. The free-way space should not be obliterated.

PROGNOSIS

Certain patients require some kind of compromise treatment, but it should be an intelligent compromise based on a sound evaluation of all diagnostic findings.

It is impossible to know how certain teeth will respond to treatment. Sometimes anticipated failures are resounding successes and vice versa. Inform the patient of all the inherent advantages, disadvantages, and limitations of this type of work. By all means do not allow your enthusiasm to cause you to overstep the bounds of reason by promising the impossible. We must be on guard especially against the feeling of omnipotence that the excellence of our technical skills tends to foster. The operator has to recognize that to the extent he gives the impression of omniscience, to that extent the patient has a right to call on him for omnipotence as well.

Alternative solutions must be in readiness if treatment plans do not work out satisfactorily. The uncontrolled habits of the patient, the possibilities of future periodontal and periapical involvements, and other possible eventualities must always be under constant consideration. Troubleshooting is an important phase in mouth rehabilitation procedures.

Efficient scheduling of appointments for all clinical and laboratory procedures is necessary for the preservation of physical and emotional energies of both patient and dentist and, from an economic standpoint, to make the operation a profitable one. Do not overlook the financial arrangements—inform the patient not only of the cost of the work, but how you expect him to meet his financial obligation. It makes for a more successful relationship.

Prognosis is dependent upon the skills and experience of the dentist in regard to his ability to make a careful and thorough examination and to be able to correctly interpret the findings. Technical ability, laboratory control, and patient-dentist rapport (psychologically and economically) are the other necessary ingredients.

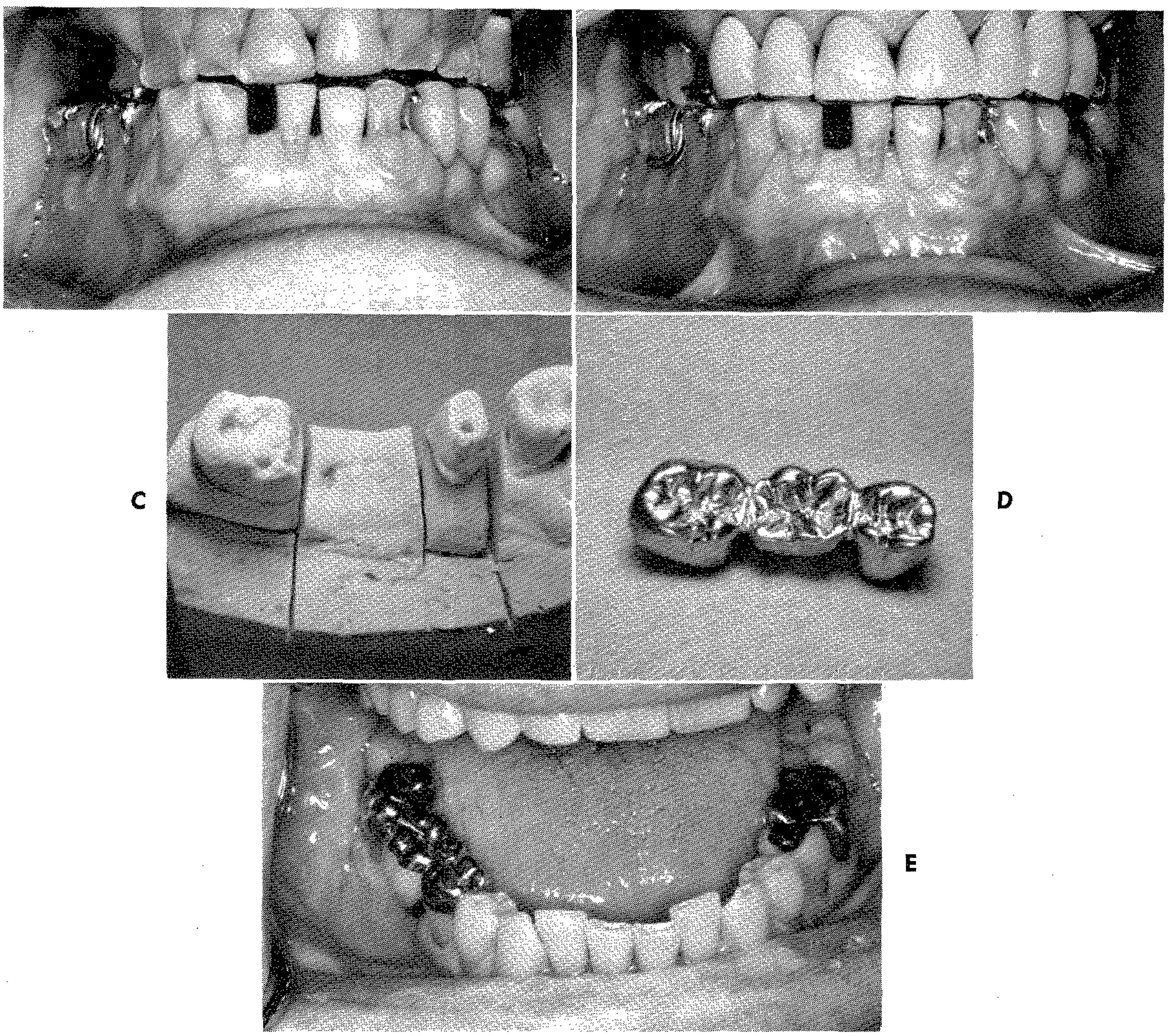
THE SENIOR CITIZEN

Statistics show that there are more older people living today than at any previous time. Everyday in the United States at least a thousand persons reach their sixty-fifth birthday.[12] Nearly 13 million, or more than 8% of the population, are over the age of sixty-five. Because of these facts, dentists have become very much interested in the problems of aging.

Our elderly patients are most eager to maintain their teeth, oral soft tissues, and jawbones in a state of health. The objective of the dentist caring for the senior citizen is to achieve this goal as effectively for the elderly patient as it can be achieved for the younger patient.

The dentist's attitude toward dental care for the senior citizen is changing. He knows now that advancing age does not necessarily mean the loss of teeth and their replacement with dentures. As a result, he directs his treatment to-

A



B

C

D

E

Fig. 2-84. Results of prosthodontic efforts in elderly patients. **A** and **B,** Patient 85 years of age. **C** to **E,** Patient 86 years of age.

ward the preservation of the teeth and attachment apparatus of the elderly patient. The dentist is attempting to look after the aged with great care, patience, and understanding. Because of the dentist's treatment and attitude, the senior citizen is grateful and appreciative. By enabling him to function adequately and comfortably, the dentist is enabling many to continue their contributions to their associates and their communities.

Ryan[13] has aptly said: "The elderly are not just 'old people'; they are structurally, functionally, and mentally different men and women than they were in the days of their youth and early maturity."*

In treating the aged we must differentiate between senescence, which refers to normal physiologic aging, and senility, which may be defined as pathologic aging. The dentist must approach the problems and the disturbances of the aged with understanding, and he must realize the important role the oral cavity plays in the health of our senior citizens.

Cowdry[14] has this to say: "Some kinds of cells are evidently replaced thousands of times in the human life span, others hundreds of times, and still others not at all. The long-lived cells which are not replaceable accumulate pigments, lipoids and various other relatively inactive materials, which suggest a diminution in physical vigor.†

In the elderly we are confronted with changes in the following:

1. Metabolism. There is a lowering or slowing down of the general metabolism.
2. Vitality of cells. There is retardation of cell division and capacity for cell growth and tissue repair.
3. Glandular balance. There is a decrease in glandular secretions. According to the physiologist, Anton Carlson,[15] "The salivary glands usually show some evidence of atrophy with advancing years; competent investigators have reported definite decrease in salivary volume and in percentage of pytalin with advance in age. To what extent the decrease in saliva or the age changes in the composition of the saliva permit or favor growth of the aciduric flora of the mouth, which in turn may enhance degenerations in teeth and gums, is still an open question.*
4. Speed and strength of neuromuscular reactions. The tonus of the muscles of mastication and deglutition is markedly reduced.
5. Nutritional patterns.

Silverman[16] cautions us not to overlook the biologic aspects of tooth care in relation to the treatment of the periodontium, the bone and muscle activity of the oral structures. These dental and oral structures depend directly on the systemic effects of the circulation, and the endocrine, neurologic, and metabolic mechanisms of the body.

Another supportive measure for evaluation is the nutritional aspect. Nutrition is the process of providing proper food elements for maintenance of health and growth. A sound nutritional program will do much to maintain the physical vitality and the nervous stability of the older patient. It is also vitally essential to the success of dental restorations.

There is a definite relationship between impaired masticatory function and general nutritive failure. It has been said that there is a definite correlation between what and how a man eats and how long he lives.[12] According to Stieglitz:[17] "We are what we are today because of our yesterdays."

Older people require less fat and carbohydrate and more protein. Many diseases and general debilitating states are the result of protein insufficiency. The minerals are also of particular importance to the aged, especially calcium since calcium loss contributes to bone fragility. A negative calcium balance is often found in our senior citizens when rapid ridge resorption is noted.

Stieglitz[17] stated: "Recent studies point out calcium requirements are greatly increased in later years. The older person needs more calcium than the young adult to maintain calcium balance. Calcium loss contributes to bone fragility. The importance of milk (as a source of both protein and calcium) for the elderly is thus once more emphasized. The nutrition of the youth affects his health in maturity, senescence, and old age, but the nutrition of each period of life pre-

*From Ryan, Edward J.: The dental problems of senescence, J. Prosth. Dent. 1:64-70, 1951.

†From Cowdry, E. V.: Factors in aging, Sci. Month. 56:370, April, 1943.

*From Carlson, Anton: Physiologic changes in normal aging. In Steiglitz, E. J.: Geriatric medicine, ed. 2, Philadelphia, 1949, W. B. Saunders Co.

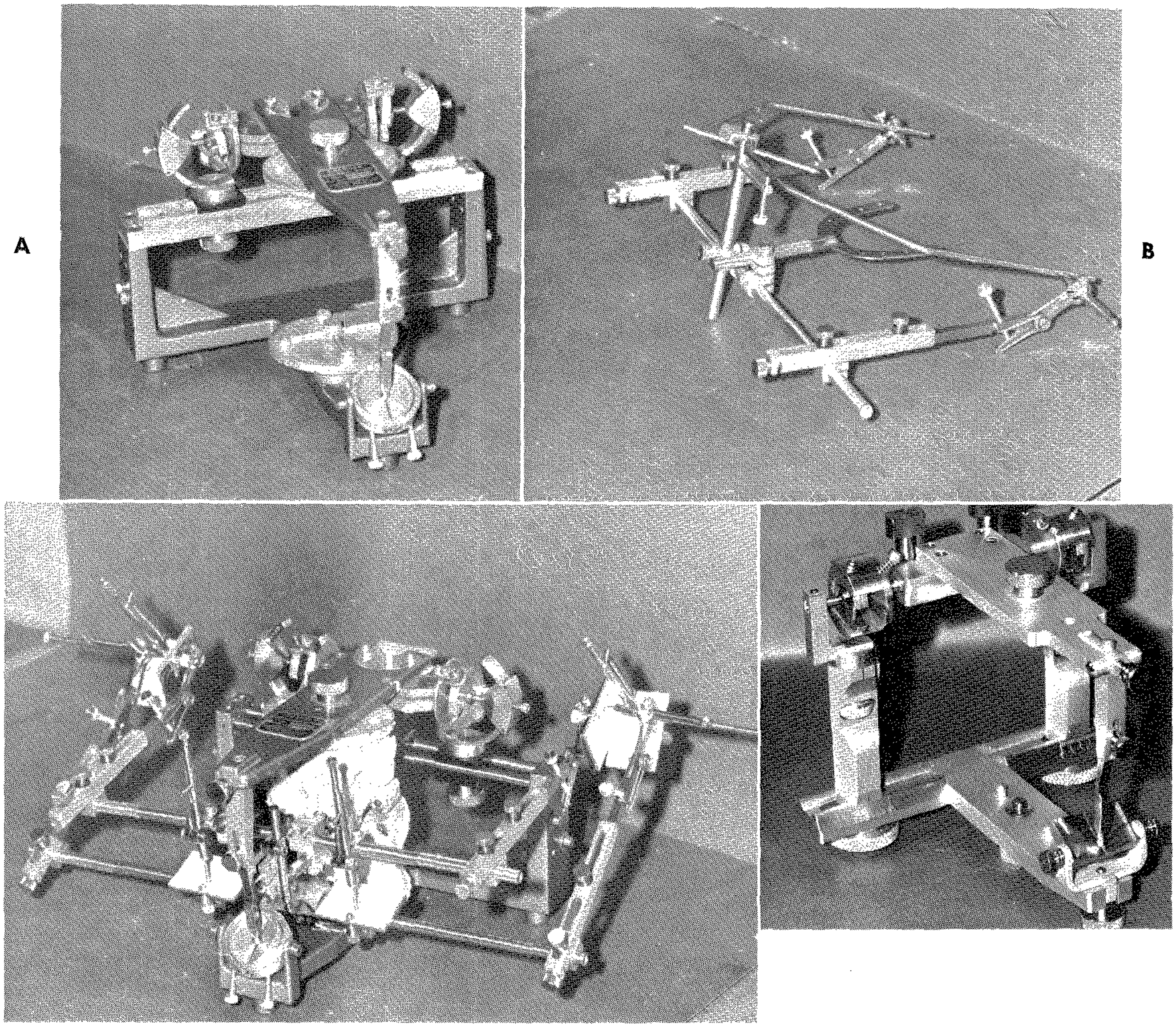


Fig. 2-85. Articulators and face-bows used in mouth rehabilitation procedures. **A,** Granger Gnatholator. **B,** Hinge-bow assembly. **C,** Granger pantograph mounted on Gnatholator. **D,** Granger Simulator.

sents problems peculiar to the period. To age is to change."*

We must not forget that the most nutritious food is of little consequence if the first process of digestion—food preparation in the mouth—is inadequate. Inadequate mechanical preparation of the food results from painful, nonfunctioning, or missing teeth or from faulty dental restorations. Without adequate nutrition the elderly patient cannot do well.

*From Stieglitz, Edward J.: Aging as a problem of nutrition, Nut. News **13**:6, Oct., 1949.

Some investigators recommend multivitamins on a supportive basis, but the possibility of the vitamin therapy masking symptoms of chronic, underlying disorders must not be overlooked.

The French have told us that "death enters through the mouth." We might likewise say that so do life, health, and long well-being.[13] We also must not overlook the fact that dental care provides not only nutritional support, but also psychologic support for the elderly patient. The desire of older patients to retain and prolong the use of their own teeth is natural and understand-

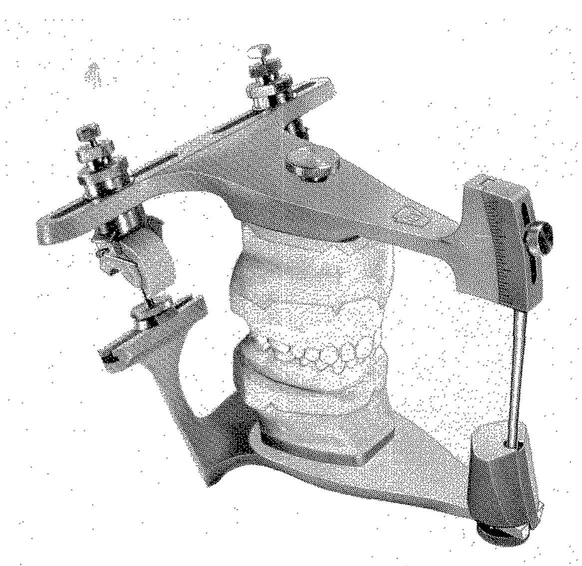


Fig. 2-86. Ney articulator.

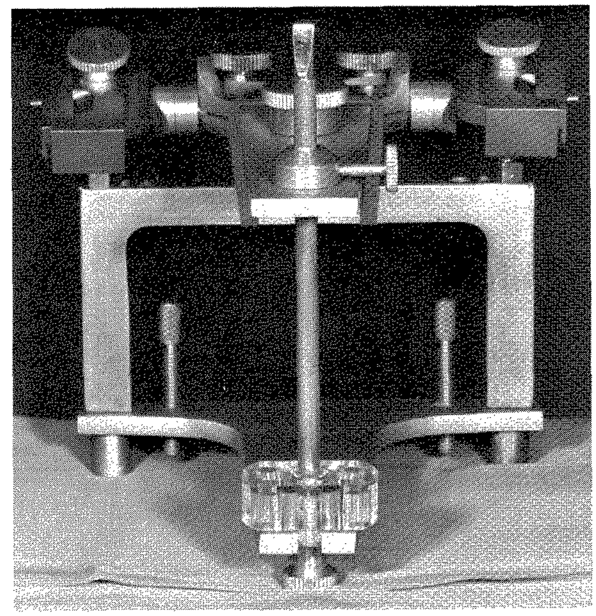


Fig. 2-87. Whip-Mix articulator.

able and in many patients must not be discouraged. Advanced age is no deterrent to the construction of limited or extensive crown and bridge prosthodontics provided the patient is in reasonably good health (Fig. 2-84).

However, the dentist must also be aware of the anxiety, depression, and hostility that many times accompany dental care for the senior citizen. Dental care for these patients should be carefully evaluated as to whether the care should be limited or extensive. By all means do not overtreat or overadjust. Patience and understanding are important to treatment. Establishing rapport with the patient can prevent many problems, but lack of concern and impatience can produce many problems. Even psychiatrists have only limited success, unless the patient recognizes his needs and is willing to cooperate.

With advancing age the vitality of the dentin is greatly decreased by sclerosis and obliteration of the tubules and by secondary dentin formation, which cuts off the tubules from the pulp. Old dentin may become entirely insensitive and impermeable. The phenomenon can result in decreased sensitivity during cavity preparation.[18]

However, we also find that many elderly patients lose their teeth from the caries of senescence. Caries in the aged is often rapid and deeply penetrating, with early pulp involvement. This may be caused by the decreased bacteriostatic power of the saliva and the atrophy of the salivary glands. In the aged we are also faced with the degenerations in the dental pulp that may be of blood-borne origin. Emboli and thrombi may affect the blood vessels in the dental pulp in the same manner they affect the vessels of other organs. Pulpitis may also be of hypertensive origin.

As a result of gathering all these findings, that is, physiologic, nutritional, psychologic, and mechanical, the total problem can be evaluated and the diagnosis and treatment plan made for the senior citizen (Figs. 2-85 to 2-87).

REFERENCES

1. Goldman, Henry M., Schluger, Saul, Fox, Lewis, and Cohen, Walter, D.: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co., p. 698.
2. Contino, Raymond M., and Stallard, Harvey: Instruments essential for obtaining data needed in making a functional diagnosis of the human mouth, J. Prosth. Dent. **7**:66-77, 1957.
3. Granger, E. R.: Functional relations of the stomatognathic system, J.A.D.A. **48**:638-647, 1954.
4. Celenza, Frank V.: Personal communication.
5. Lucia, Victor O.: Centric relation—theory and practice, J. Prosth. Dent. **10**:849-856, 1960.
6. Stuart, Charles E.: Personal communication.
7. Dykins, William R.: Personal communication.
8. Lucia, Victor O.: A technique for recording centric relation, J. Prosth. Dent. **14**:492-505, 1964.
9. Dykins, William R.: Requirements of partial denture prosthesis, J.A.D.A. **58**:232-236, 1958.
10. Sloane, Robert B.: Basic principles in mouth reconstruction, D. Items Interest **73**:1-10, 1951.
11. Kornfeld, Max: The problem of function in restorative dentistry, J. Prosth. Dent. **5**:670-676, 1955.
12. Jamieson, Charles H.: Geriatrics and the denture patient, J. Prosth. Dent. **8**:8-13, 1958.
13. Ryan, Edward J.: The dental problems of senescence, J. Prosth. Dent. **1**:64-70, 1951.
14. Cowdry, E. V.: Factors in aging, Sci. Month. **56**:370, April, 1943.
15. Carlson, Anton: Physiologic changes of normal aging. In Stieglitz, E. J.: Geriatric medicine, ed. 2, Philadelphia, 1949, W. B. Saunders Co., p. 49.
16. Silverman, Sidney: Dental care for the aged; role of the private practitioner, J.A.D.A. **64**:165-172, 1962.
17. Stieglitz, Edward J.: Aging as a problem of nutrition, Nut. News **13**:6, Oct., 1949.
18. Kronfeld, Rudolf: Dental histology and comparative dental anatomy, Philadelphia, 1937, Lea & Febiger.

Chapter 3

Centric relation—theory and practice*

VICTOR O. LUCIA, D.D.S., F.A.C.D.

Definition

Webster's *Collegiate Dictionary* defines "centric" as follows: "adj. 1. Placed in or at the center or middle: central. 2. Of, pertaining to, or characterized by a center." Is this definition in any way related to what is generally understood by centric in dentistry?

The *Glossary of Prosthodontic Terms*[1] gives this definition of centric relation: "The most retruded relation of the mandible to the maxillae when the condyles are in the most posterior unstrained position in the glenoid fossae from which lateral movement can be made, at any given degree of jaw separation."

The American Dental Association definition of 1955 is not unlike the one in the *Glossary*.

The only inference of a center may be in the phrase, "from which lateral movement can be made," and I doubt whether this was intended. However, I shall endeavor to show that the dictionary definition can very definitely be applied to the centric relation of dentistry.

With which center are we going to be concerned? There are literally millions of centers of mandibular movement. The problem depends on which movements are made and to what they are related. These centers are instantaneous and are changing constantly with each slight movement.

We must concern ourselves with a center that can be located easily, that can be useful for our procedures—a center that will enable us to reproduce the patient's movements on a suitable articulator and to execute our work more intelligently and with greater ease.

The objective of records of centric relation is to relate the mandible to the maxillae (and, in turn, the teeth) so that there can be no fulcrum on the teeth (and periodontal ligaments), but only in the temporomandibular joints. Whether many patients have this condition normally is of no consequence. The important thing is that, when the ravages of pathosis are present, the fulcrum must be in the temporomandibular joint if the destruction by the pathosis is to be minimized. This is a mechanical necessity that has biologic soundness. Many materials, methods, and devices have been used to fulfill this objective. None of these is universally effective. Yet every sincere dentist doing full mouth rehabilitation has confessed, at one time or another, either publicly or privately, that his lot would be con-

*Modified from Lucia, Victor O.: Centric relation—theory and practice, J. Prosth. Dent. **10**:849-856, 1960; and Lucia, Victor O.: A technique for recording centric relation, J. Prosth. Dent. **14**:492-505, 1964.

siderably easier if he could be sure of the centric relation record of his patient.

Significance of centric relation

Centric relation is a specific relationship of the centers of rotation of the mandible to the maxillae. There is a center of vertical arcing motion in each condyle. These centers of vertical motion are joined by an imaginary line called the hinge axis. In addition, on this hinge axis are two centers of lateral motion—one in each condyle. When the centers of vertical arcing motion and of lateral motion coincide and are in the most posterior terminal position in relation to the maxillae, the mandible and maxillae are in centric relation.

All the movements of the mandible are governed by the centers of rotation. To duplicate these movements on an articulator, the centers of rotation must be located. Moreover, when a patient chews or in any way brings his teeth together, the normal action is to seat the condyles in the rearmost, uppermost position. Unless the condyles are uppermost the restorations made will be in supraocclusion.

All normal swallowing occurs in centric relation. The resultant vector of force of the masticating muscles indicates this relationship. The anatomy dictates this.

Unless centric occlusion occurs when the mandible is in centric relation, there will be a strain on the periodontal tissues of the teeth. Teeth that have lost their supporting structures can least afford to be fulcrums of the masticating mechanism. Lateral forces will be created, and these are destructive.

When pathosis has taken a toll of the supporting structures, it becomes necessary to provide as much "bracing" as possible for the weakened teeth. One means is to set a posterior limit for the movements of the mandible. In this way weakened upper teeth cannot be rocked distally, and weakened lower teeth cannot be rocked mesially. The posterior superior limit of mandibular position, which is maintained by centric relation-holding contacts on the occlusal surfaces, makes possible the stabilization of weakened teeth. When splinting is necessary, additional stability is obtained by the posterior superior position of the mandible.

The upper teeth are like a horseshoe on an anvil. The lower teeth are like the hammer. The anvil and hammer are not damaged in use, but the horseshoe is. The upper teeth can be knocked out of the maxillae by malfunction.

Upper teeth get rocked distally as well as mesially when the mandible is out of centric relation, whereas lower teeth can be rocked only mesially.

Unless the starting point for establishing the anatomy of restorations is correct the other relationships cannot possibly be right. An improper centric relation record will cause difficulty in the preparation of teeth.

Difficulties of recording centric relation

To record the mandible's path of vertical movement in the terminal hinge position the patient must be deceived. The dentist has to block out all the proprioceptive impulses that direct the movements. The proprioceptive impulses are responsible for the awareness of the position of the mandible in space. The impulses guide the mandible in its habitual movements. The reflex actions that take place are reinforced by the proprioceptive stimuli. One of the natural reflex acts of the mandible is to close into a lateral or a lateral protruded position when something is introduced into the mouth (Fig. 3-1). This is what happens when a material such as wax is placed in the mouth and the patient is told to bite. It is necessary to obtain a relationship of the terminal hinge action without any lateral deviation. One practical way of blocking out the proprioception is to prevent the teeth from coming together (Fig. 3-2). The relationship of the mandible to the maxillae in the terminal hinge position without tooth contact must be obtained. Consequently, the patient must be trained and guided to execute the terminal hinge action.

The mechanical procedures necessary to relate the mandible to the maxillae present the problem. Our task would be simple if a magic material that would solidify at a given word could be inserted between the teeth when the lower jaw is executing a perfect terminal hinge closure. Unfortunately, we have no such material! The materials available to us are thermoplastic or chemoset. The thermoplastics have to have some "body" in order to be manipulated. The chemoset materials require some time to

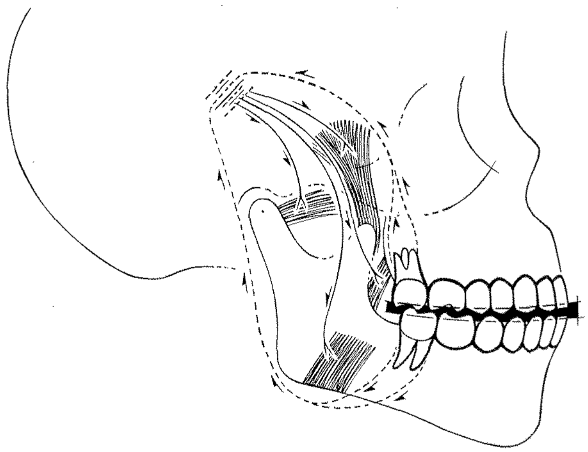


Fig. 3-1. Schematic drawing showing mechanism involved when a proprioceptive stimulus comes into play as second molars penetrate the wax and make a premature contact. This reflex act will preclude possibility of a terminal hinge closure. (From Lucia, Victor O.: J. Prosth. Dent. **10**:849-856, 1960.)

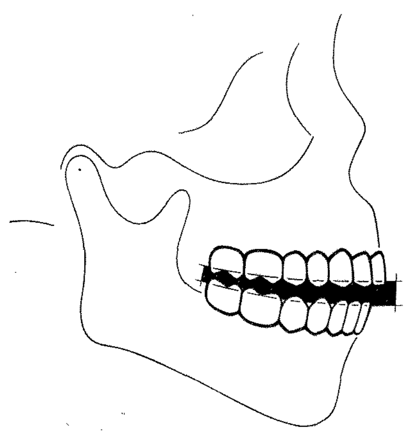


Fig. 3-2. An attempt to block out proprioception is made with a thick wax wafer. Use of such a wafer requires hinge axis–mounted casts. (From Lucia, Victor O.: J. Prosth. Dent. **10**:849-856, 1960.)

undergo their chemical change and thus set. Neither of these qualities or characteristics is at all satisfactory.

One thing should be understood. Any material could be used in some mouths, and a satisfactory result could be obtained. However, this cannot be done in many instances in which the patients are more difficult to control.

Most patients have a reflex closure, an engram, determined and guided by the teeth. The proprioceptive mechanism determines the path of mandibular closure. This "meshing" of teeth may or may not take place when the mandible is in centric relation to the maxillae. To determine if there is coincidence between centric occlusion and centric relation, it is necessary to remove the guidance provided by the teeth. The guidance is eliminated by making the recording at an increased vertical dimension. The proprioceptive reflex must be blocked out to ensure a perfect hinge closure. This is done by the recording medium. Either it is thick enough to "short-circuit" the reflex, or it offers so little resistance (or conduction) that it does not set off the proprioceptive reflex. In either case the recording must be made with the mouth open to the point that the teeth do not touch. This explains the need for a hinge axis location and transfer.

In addition to a peculiar engram, a patient may have what we call a "loose joint," one that, because of improper function, has acquired the habit of "dropping apart" whenever any suggestion of a malrelationship may exist. (This "falling apart" may be experienced when a centric relation record is made.)

Some patients have developed powerful reflexes to avoid injury to their tissues. It requires time and special manipulation to overcome these reflexes and to be able to record the correct relationship.

Unfavorable reflex action

A young patient was to be used to demonstrate a new centric relation record method. He had a full complement of teeth and a "good" centric occlusal relationship. The patient was examined by the members of our study group, and all agreed that the relationship of the lower teeth to the upper teeth was excellent.

We proceeded to make a centric relation record. In doing this we had to prepare an anterior "bite block" of cold-curing acrylic resin. It was necessary to adjust the block by having the patient slide his teeth around and bite on the block to mark it with articulating paper. The block was slowly reduced to the desired height in about twenty minutes. Then we made the centric relation records and, by means of a split-cast procedure, checked one record carefully against the other. The two records checked perfectly.

As we admired our results it was suggested that we see how well the teeth occluded on the instrument. What we observed seemed incredible! The cusps of the teeth were almost tip to tip. The contacts were entirely different from the occlusion we had seen in the mouth before we made the recording. We put the patient back in the chair for another examination, and now with very little guidance he closed his teeth together exactly as those on the casts on the articulator.

This same patient with the same guidance now exhibited a horrible centric occlusion! It looked as though we had "fractured the necks" of the condyles. What must have happened was that the strong reflex act of closing eccentrically was broken by our procedure. It fooled four experienced dentists. This experience indicated to us the importance of training a patient before examining him for the location of premature (deflective occlusal) contacts.

Location of the centers of rotation

To locate the all-important center of rotation it is necessary to reduce the jaw movements to their simplest form. The jaw can open and close in a hinge movement. This is not a normal movement, but it is one that the patient can be taught for the dentist's convenience. By teaching the patient this hingelike action one can locate the center of this action and make use of it by reproducing the same center on an articulator.

That there is a hinge axis hardly requires any defense. It is now almost universally accepted. We will try to demonstrate its importance. That there is only one axis will have to be accepted for the moment. It has been proved.

Location of hinge axis

The hinge axis points are located by means of a hinge-bow, which is rigidly attached to the lower teeth. The stylus points in the temporomandibular joint region are adjusted, while the mandible is guided in a terminal hinge closure, until there is no longer any arcing but only pure rotation by the tip of the stylus.

To bring the teeth into contact on the articulator the lower cast must travel toward the upper cast. Thus, unless the closure is made on the same arc as the patient's mandibular closure, the teeth will not contact correctly. The correct mounting of casts on an articulator definitely depends upon the location of the hinge axis of the patient and its transfer to the articulator.

The center of vertical movement of the mandible is found by locating the hinge axis. This enables us to place casts of the mouth on an articulator, which will duplicate the opening and closing component of movement (Figs. 3-3 and 3-4).

The mandible is also capable of lateral movement, and there is a center for this lateral movement. By the use of twin Gothic arch (needle point) tracings in the horizontal plane, which

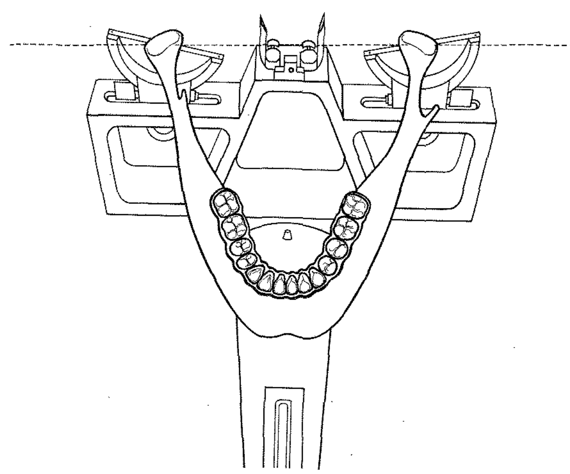


Fig. 3-3. Relation of lower teeth (and mandible) to hinge axis of articulator. (From Lucia, Victor O.: J. Prosth. Dent. **10**:849-856, 1960.)

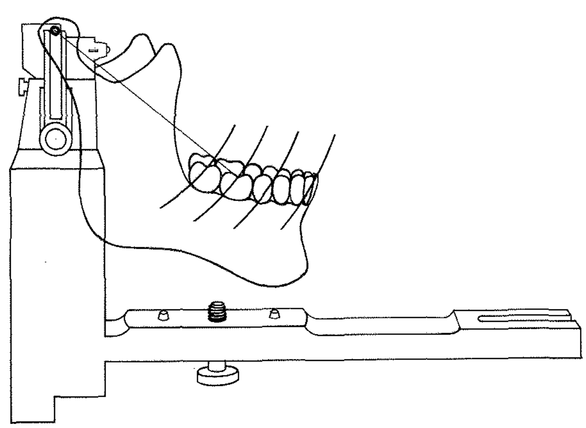


Fig. 3-4. Relation of lower teeth to arc of closure of articulator. Use of hinge axis permits these arcs to be identical with those of patient's mandible. (From Lucia, Victor O.: J. Prosth. Dent. **10**:849-856, 1960.)

are made outside the patient's mouth on either side of the midline, it is possible to locate the centers of lateral movement. These are located in the condyles and on the hinge axis. These centers can be duplicated on an articulator that has an adjustable intercondylar distance (Figs. 3-5 to 3-7).

By these two procedures the centers of rotation, both vertical and lateral, have been located and duplicated. When these centers are duplicated on an articulator and the paths of these centers reproduced, all the patient's mandibular movements can be duplicated very easily. All it now requires is a pair of hands to supply the muscular force and a mind to direct those hands.

It becomes necessary to think of the centers of rotation as made of two components, the center of vertical motion and the center of lateral motion. They are one and the same center—one in each condyle. These centers determine all the possible movements of the mandible. They are located in the condyles and travel wherever the mandible goes. They are the centers of its every movement. When these centers are in their terminal hinge position, the mandible is in centric relation to the maxillae.

After the centers of lateral motion are recorded and an articulator adjusted to these centers, the casts of the patient's mouth must be oriented to the articulator. The upper cast is easily related to the upper member of the articulator by means of a transfer bow. Certain precautions are necessary. Care must be taken that the patient is sitting in the same way as when the marks were put on the face and that the imprints of the facebow fork are accurate for seating the cast.

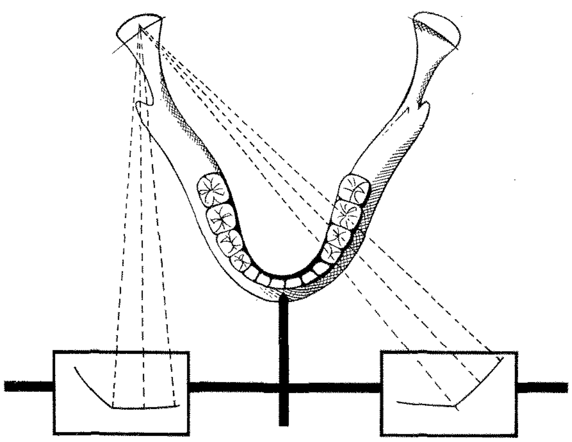


Fig. 3-5. Relation of center of lateral rotation to respective wings of the two tracings. (From Lucia, Victor O.: J. Prosth. Dent. **10**:849-856, 1960.)

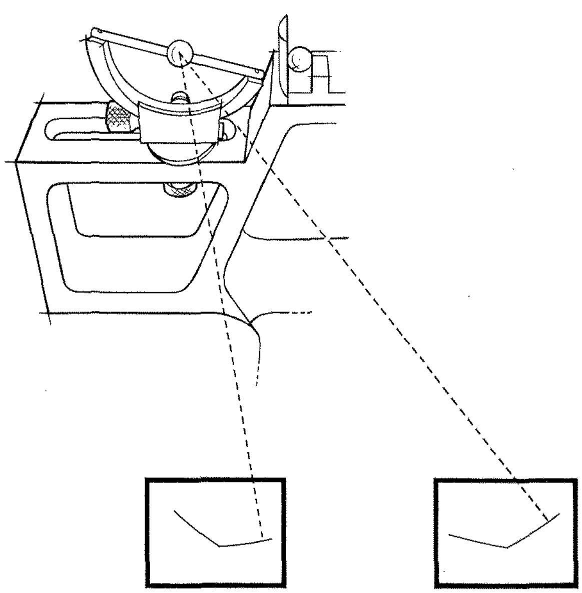


Fig. 3-6. Wings of tracings that were made on a patient are used to locate center of lateral rotation on an articulator. (From Lucia, Victor O.: J. Prosth. Dent. **10**:849-856, 1960.)

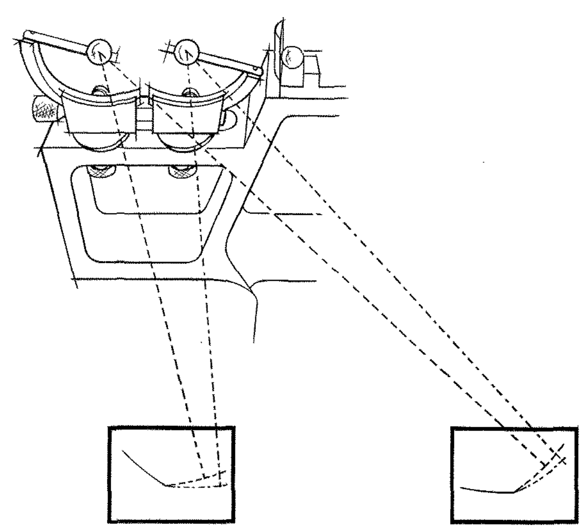


Fig. 3-7. Composite drawing to show different locations of center of lateral rotation as determined by tracings from two different patients. (From Lucia, Victor O.: J. Prosth. Dent. **10**:849-856, 1960.)

Now the most difficult part of the procedure has to be undertaken, that is, relating the mandible to the maxillae. Before we discuss the reason why this is so difficult, let us review what has been done.

1. The articulator was set for the centers of lateral rotation by means of the twin Gothic arch (needle point) tracings. (The intercondylar distance has been established.)

2. The hinge axis has been located. If we could "freeze" the *hinge action* used to locate the hinge axis at a convenient vertical relation, the centric relation would have been recorded. The hinge action used to locate the hinge axis had to be in the terminal position; otherwise, the hinge axis could not be located. Thus it would fulfill the requirements of centric relation.

Technique for securing identical centric relation records

The best way to check a centric relation record is to secure two or more identical records. Previously we would insert a second centric relation record between the casts. If the articulator parts were not displaced, we would accept it as a check on the record used to mount the casts. The split-cast technique, which was originated by Needles[2] and used by Lauritzen,[3] is a simple method for comparing interocclusal records. Many *apparently* acceptable records are not correct.

PREPARATION OF UPPER CAST FOR SPLIT-CAST TECHNIQUE

The upper cast is poured very carefully, and the initial set is allowed to occur. The impression is not inverted. The cast is not poured with a very thick base because we must add a smooth base to it. A vacuum mix of stone is made, and a bubble-free base is attached to the cast. The cast is set on a glass slab to form a smooth surface (Fig. 3-8).

When the base is set, the cast is separated from the impression and is trimmed in preparation for making the second part of the split cast. Shallow V grooves are cut on the periphery of the base of the cast—about six of them—two on each side and two in back. These grooves must be shallow and cut smoothly so that they will separate freely from the second part of the split cast.

To make the second part of the split cast we wrap some No. 33 Scotch Brand electrical tape around the prepared cast (Fig. 3-9), lubricate the cast with a separating fluid,* and pour into this form a well-spatulated, vacuum-mixed stone. Three knobs of stone are left to serve as a handle for separation after the stone sets. The tape is removed, and the second half is separated from the cast and then put together again. The knobs

*Super Sep, Kerr Mfg. Co., Detroit, Mich.

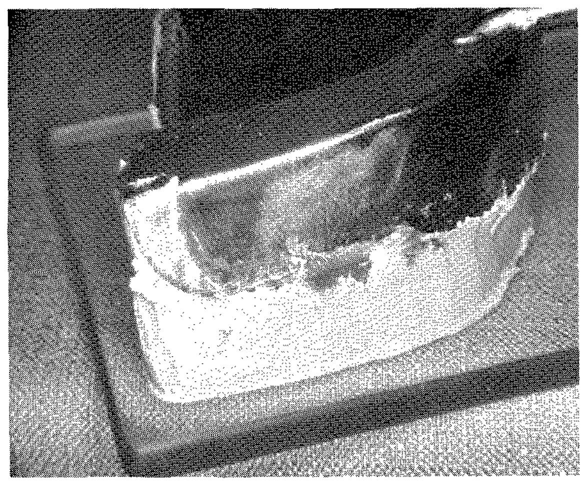


Fig. 3-8. Glass slab produces a smooth surface on base of cast. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

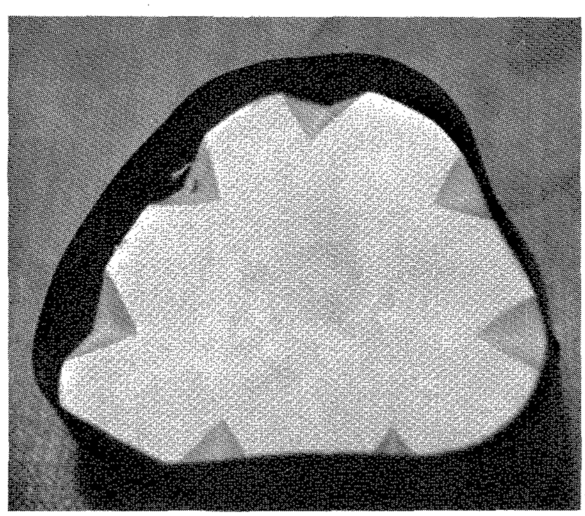


Fig. 3-9. No. 33 Scotch Brand electric tape wrapped around notched upper cast provides a form into which the stone is poured to make split cast. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

are ground down to permit clearance with the upper member of the articulator.

A face-bow transfer is made, and the cast and wafer are related carefully to the centers of rotation of the articulator. The cast and wafer are mounted on the articulator.

CONSTRUCTION AND ADJUSTMENT OF THE CENTRIC RELATION JIG

The centric relation jig is made of DuraLay,* a self-curing plastic. It should be prepared on a set of mounted casts because considerable heat is generated in its construction. If made in the mouth, the oral tissues may be burned.

Tinfoil is adapted over the upper six anterior teeth and allowed to extend beyond the gingival margin for about a half inch. The incisal pin of the articulator is set so that the bicuspids are about 5 mm. apart.

The DuraLay is mixed in a dappen dish and, when doughy, is placed on the tinfoil-covered, upper anterior teeth to cover the labial and lingual surfaces and extend onto the soft tissues (Fig. 3-10).

The DuraLay is molded to form a platform on the lingual surfaces of the upper anterior teeth. While the material is still soft, the articulator is closed so that the lower anterior teeth contact the platform established on the lingual surfaces of the upper anterior teeth. This is done while the DuraLay is still moldable. It can be adjusted approximately to the opening established by the incisal pin. The DuraLay is adapted carefully to the cast to ensure a good fit. Also, periodically, the DuraLay is lifted slightly so that it will not lock into undercuts and break the teeth off the cast. Our object is to have a well-fitting jig that can be removed from the cast.

*Reliance Dental Mfg. Co., Chicago, Ill.

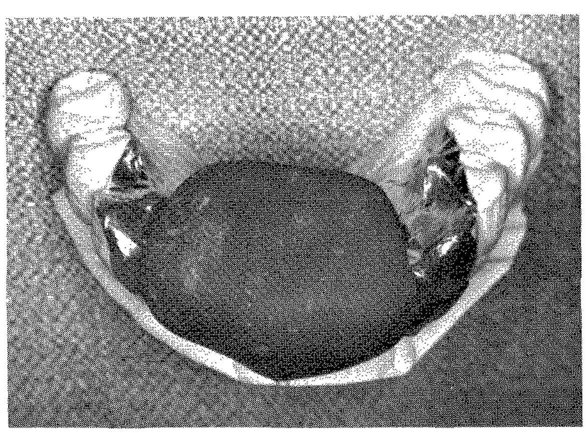


Fig. 3-10. DuraLay in "dough" stage is adapted over tin-foil–covered anterior part of upper cast to form an anterior jig. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

Variations of the jig may be necessary, depending on the number and positions of the anterior teeth as well as the relation of the lower teeth to the upper teeth. In some instances an anterior "bridge" of DuraLay may have to be made (Fig. 3-11). Other situations may call for other modifications (Fig. 3-12).

When the jig is completely "cured," it is trimmed and adjusted. With a straight carborundum disk the jig is cut buccolingually through the incisal surface just lateral to the distal margin of the central incisors (Fig. 3-13). The cut is directed at an angle so that the lingual part of the jig is considerably narrower than the labial part. The labial gingival part is trimmed and contoured until it is narrowed and rounded and does not interfere with the labial frenum. The margin usually extends 1 or 2 mm. beyond the gingival margins of the anterior teeth. This part of the procedure can be done with acrylic trimmers.

The lingual surface of the jig is trimmed to be comfortable to the tongue. It usually extends several millimeters onto the palatal tissues.

A piece of Sure-Set* baseplate wax is held against a maxillary cast to make a wax tray. With a pair of scissors the baseplate wax is trimmed until about ⅜ inch of wax extends beyond the buccal surfaces of the teeth. The wax tray is cut across just anterior to the cuspids, and a U-shaped cut is removed from the anterior part to permit the jig to seat without touching the wax tray when both are in the mouth. Three such trays are prepared by using the first one as a pattern for the others.

The wax is softened in water at 130° F. With the patient's cheeks retracted the wax tray is carefully placed on the upper teeth; one must be sure that the tray is centered as it was cut on the cast. The patient's mandible is guided

*Kerr Mfg. Co., Detroit, Mich.

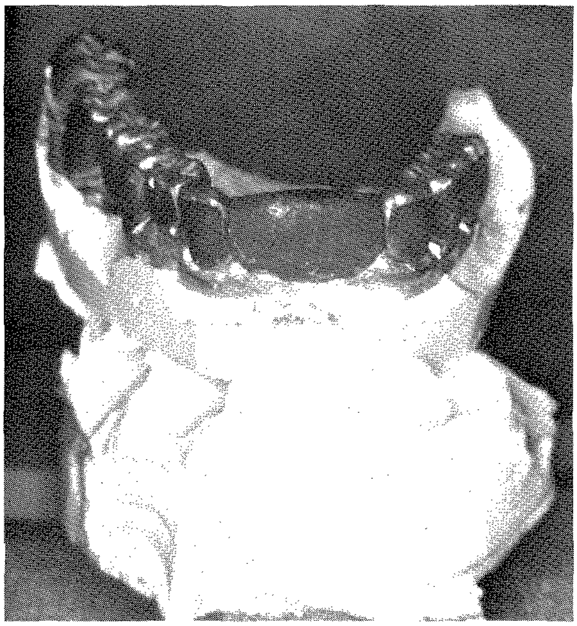


Fig. 3-11. DuraLay "bridge" joins cuspid abutments to replace lower anterior teeth that were missing. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

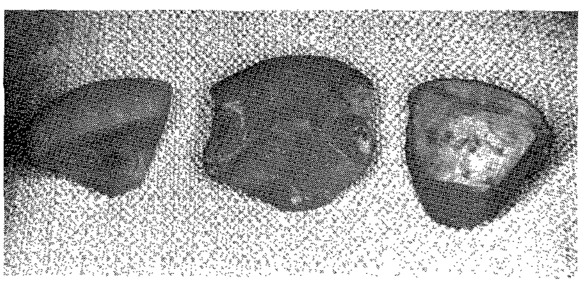


Fig. 3-12. Three variations in shape of jigs for different anterior tooth relation. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

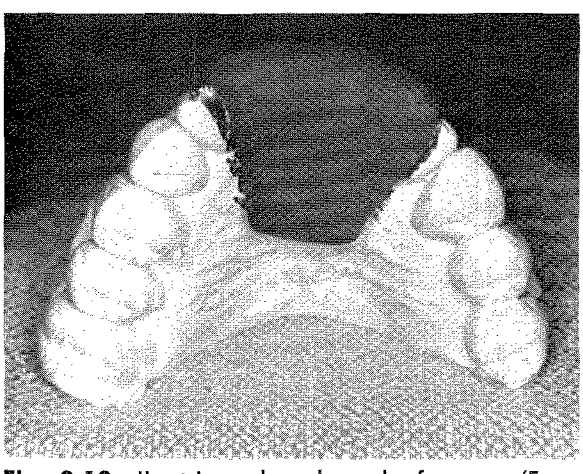


Fig. 3-13. Jig trimmed and ready for use. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

into a centric closure, and the patient is instructed to hold this position firmly for a second (Fig. 3-14).

During this time the corners of the wax tray are turned up in the cuspid region so that the tray has two little "ears"—one in each corner of the mouth (Fig. 3-15). The "ears" will help to reposition the wax tray on the upper teeth in the next step.

The wax tray is removed and chilled. This procedure is repeated with the other two wafers.

Each of the chilled wax trays is placed in position and guided by the "cuspid ears." The

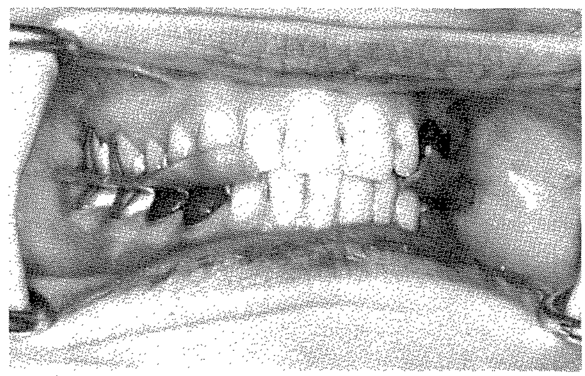


Fig. 3-14. Wax wafer is formed and thinned between teeth so that mandible is approximately in centric relation. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

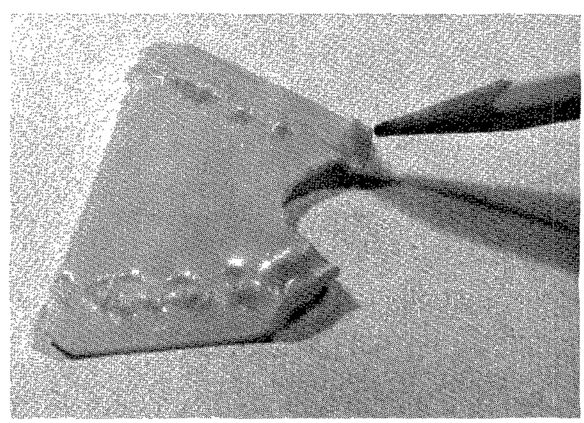


Fig. 3-15. Wax wafer is formed with turned-up corners (ears) to guide its reseating in mouth after Kydac paste has been placed on it. Wax wafer acts as a tray to carry recording medium. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

patient's mandible is guided into centric relation. This will correct any warpage that may have occurred. The wafers are stored in water.

The jig is placed in position, and its adjustment is started. *This is the most important function of the jig.* The procedures of adjustment seem to break the reflex pattern of closure, thus permitting a normal closure. It is this procedure of adjusting the jig in the mouth that differentiates this application of an anterior stop from previous methods. The adjustment procedure makes this technique work where others have failed in the past. This procedure performs the act of "training" the patient in an easy hinge closure.

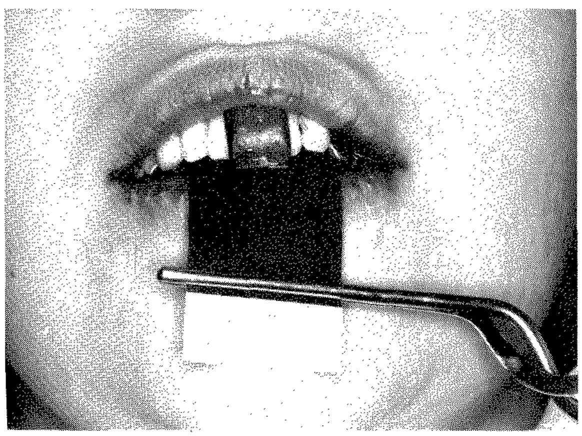


Fig. 3-16. Patient is trained to close in centric relation by sliding the teeth around and marking jig with articulating paper. Height of jig is reduced after marking and sliding motions are repeated to mark jig for further reduction. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

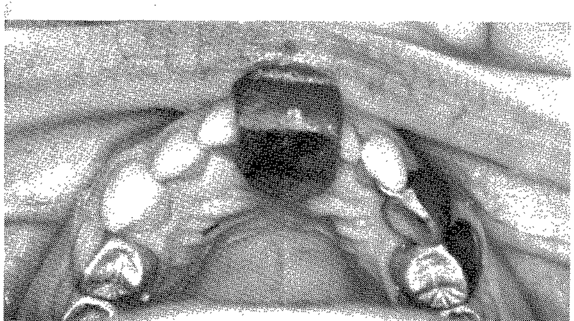


Fig. 3-17. Jig is in place after being adjusted. By the time height of jig is sufficiently reduced, patient is completely trained. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

By repeated adjustment of the jig the patient will bring the condyles to their uppermost position against the articular eminence and rearmost to the full extension of the temporomandibular ligament. The jig acts to disconnect the reflex circuit, thereby preventing the patient from making incorrect closures of long-standing habit.

The adjustment is accomplished by marking with carbon paper (Fig. 3-16) and grinding with a rubber abrasive (Cratex*) wheel. The patient is instructed to move the mandible forward and backward and to each side. In so doing he will scribe a Gothic arch (needle point) tracing. (See Fig. 3-17.) With the rubber wheel the "wings" and "tail" of the tracing are carefully removed until only a circle at the apex of the tracing (about 3 mm. in diameter) is left.

The tracing is made by the lower central incisors whenever possible. The object is to have a definite platform on the jig against which a lower anterior tooth will rest without causing any *incorrect guidance* to the mandible. The surface must not incline to the right, or to the left, or forward. We want to establish the third point of the tripod (the two condyles posteriorly and the jig anteriorly). We prefer a *slight* upward and backward slant of the surface to make it easier for the patient to hold this position while the centric relation record is made.

The patient is instructed not to bring his teeth together when the jig is removed for adjustment; otherwise the effect of the training is lost.

MAKING THE CENTRIC RELATION RECORD

A wax wafer is placed in position, and the patient is instructed to close against the jig (Fig. 3-18). *The wax tray must be entirely free of the teeth when the patient is closed in centric relation.* All wax trays are checked for this clearance.

Note: When prepared teeth are involved, as is the case when master casts are to be mounted, it may be necessary to use two or three thicknesses of Sure-Set wax. The reason is that the paste to be used for the next step will not fill too

*Cratex Mfg. Co., Inc., Burlingame, Calif.

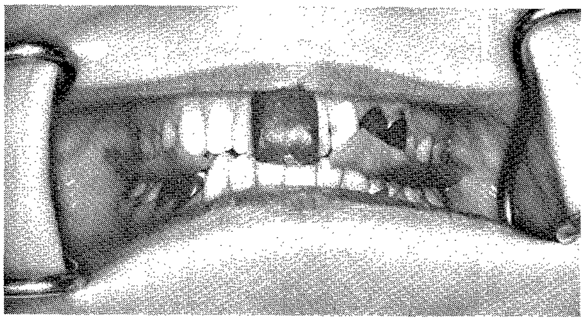


Fig. 3-18. Jig and wafer are in position. Wafer must be free of contact when lower teeth are closed against jig. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

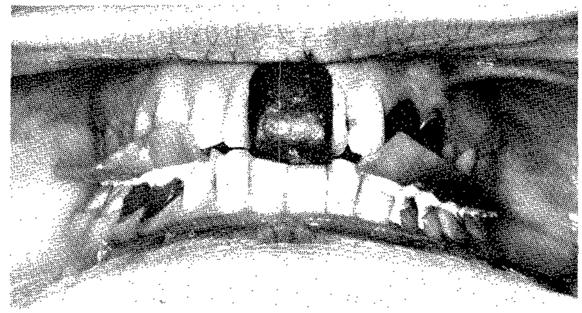


Fig. 3-19. Jig and Kydac-surfaced wafer are in position. Kydac paste makes contact with teeth to become interocclusal record. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

large a space, and, although we desire clearance between the wax tray and the teeth (or restorations), the space must not be too great. We do not want any excessive vertical opening. In other words, there must be a minimum vertical opening, definite clearance, and just enough space between the teeth and the tray.

Once the patient is trained he must not be permitted to bring his teeth together until the procedure is completed. A few closures against his teeth would reestablish his engram.

The occlusal surfaces of the teeth are lubricated with Masque.* The jig is retained in place on the teeth with denture adhesive. There must be no movement of the jig when the patient closes against it.

A small mix of Kydac† paste is made. The material is tested to determine how much, if any, accelerator is required to allow for ample working time and yet have a short setting time. The Kydac is sparingly applied to the occlusal surfaces of the wax tray. The tray is positioned on the teeth as guided by the "ears." The patient's mandible is guided into centric relation (Fig. 3-19), taking care that he closes *firmly*. The mandible is held firmly in this position until the paste has set.

In removing the centric relation record care must be exercised to avoid distortion. Both of the dentist's thumbs are placed on the patient's chin, and the index fingers are placed on the superior edges of the record. The patient is instructed to separate his teeth just slightly. At the same time a slight but firm pressure is exerted with the index fingers to keep the record in position on the lower teeth. This frees the record from the upper teeth. The patient closes again. The thumb and index finger of the left hand are used to hold the record against the upper teeth. The patient's lower jaw is steadied with the right thumb. The patient is instructed to separate his teeth just slightly. This will loosen the record from the lower teeth with a minimum of distortion.

The record is placed in cold water. Then the second and third records are made in a similar manner and placed in cold water.

The first record is trimmed very carefully with a pair of surgical tissue shears. (The one serrated edge helps to trim the Kydac without fracturing it.) All the side extensions that may have been formed by the Kydac are removed. The object of trimming the record at this time is to make it possible to detect any warpage that may have occurred in removal. Trimming is necessary to facilitate the assembly of the casts in mounting, and it also enables one to determine whether or not the casts are completely seated in the record. Only the indentations of the tips of the cusps are required for the accurate seating of the casts in the record (Fig. 3-20).

To test the record it is reseated in the patient's mouth after it is trimmed. With the jig in place the patient is instructed to close the mandible in centric relation. It is important that there are no chips of the Kydac in any of the indentations when the record is reseated. The second and third records are checked in the same manner after trimming. All records are

*Harry J. Bosworth Co., Chicago, Ill.
†Motloid Co., Inc., Chicago, Ill.

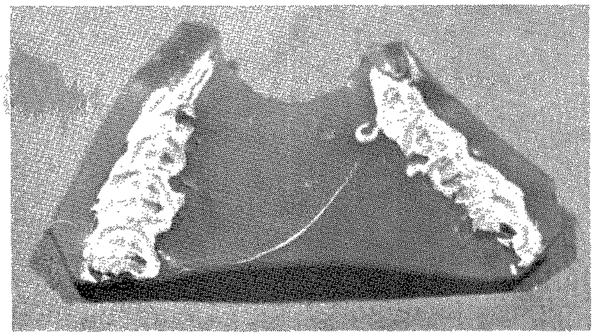


Fig. 3-20. Centric relation record on wax wafer. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

checked again after the jig is removed. Any slight distortion will be corrected if these steps are carefully executed.

Note: By changing the vertical dimension of the DuraLay jig and making additional records at the new vertical relation, the split-cast technique can be used to check the accuracy of the hinge axis location. If the axis has not been located correctly, the centric relation records, which were made at different occlusal vertical dimensions, cannot check out.

MOUNTING THE LOWER CAST

With three centric relation records having been satisfactorily made, the lower cast is mounted in relation to the upper cast, and then the other records are tested to determine whether or not they are duplicates of the first one.

The most accurate way to mount the lower cast on most articulators in proper relation to the upper cast is as follows:

1. The articulator is inverted on a mounting block.
2. The centric relation record is placed on the occlusal surface of the upper cast.
3. The lower cast is placed on the centric relation record.
4. The lower cast is held firmly in the record and against the upper cast (Fig. 3-21).

An assistant mixes the stone and completes the attachment of the lower cast to the lower bow of the articulator. The upper and lower members of the articulator must be in centric relation.

After the attaching stone has set, the inverted articulator is turned over, and the electrical tape that holds together the two parts of the split cast is removed (Fig. 3-22). The upper bow (with the upper half of the split cast) is raised. The upper cast is reseated in the centric relation record (Fig. 3-23). The V grooves of the split cast must go into place accurately (Fig. 3-24). If they do, the mounting was correctly made.

TESTS TO CONFIRM THE MOUNTING

The articulator is opened to the first centric relation record, and the upper cast is removed. The second centric relation record is placed in position, and the cast is seated on it. The articulator is closed. If the two parts of the split cast come together perfectly (as they did when the mounting operation was checked), the two records are identical. This procedure is repeated to check the accuracy of the third record. When all three records are identical, the mounting is correct.

This method will produce consistent results when different dentists make the records and tests. To be valuable a procedure must be practical. It must be one that can be performed easily by most dentists. If a technique requires a genius for its execution, then it is not useful in dentistry. By this method it is possible to build and correct restorations on an articulator and to have them check perfectly in the mouth.

Summary and conclusion

It seems logical, from the anatomy of the temporomandibular joint, that the most stable position of the mandible is that in centric relation. The origin and insertion of the muscles of mastication, the inclination of the glenoid fossae, and the function of the meniscus and synovial membranes—all indicate that any functional movements must seat the condyle in the terminal hinge position. Therefore, centric occlusion should be built to occur at centric relation. Clinical evidence substantiates this belief. The best results are obtained when we succeed in correlating centric occlusion with centric relation.

Regardless of whether we believe that centric occlusion should be slightly anterior to this terminal hinge position, this is the only constant, repeatable position that can be used to check the work as we proceed. It is the only means for accurately relating the casts of the patient so that

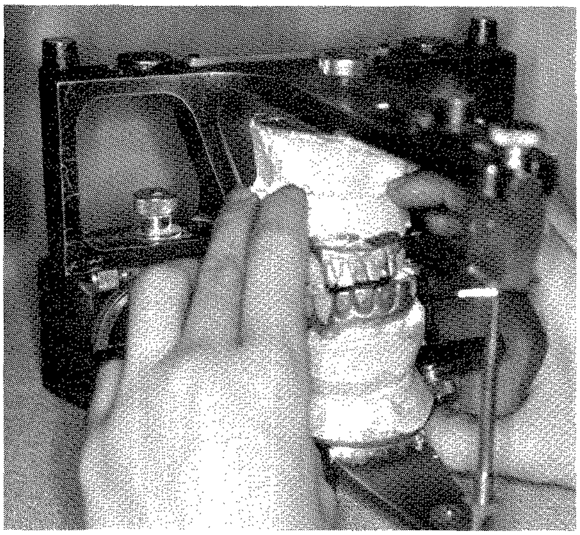


Fig. 3-21. Lower cast is held in position against centric relation record while cast is attached to lower member of articulator. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

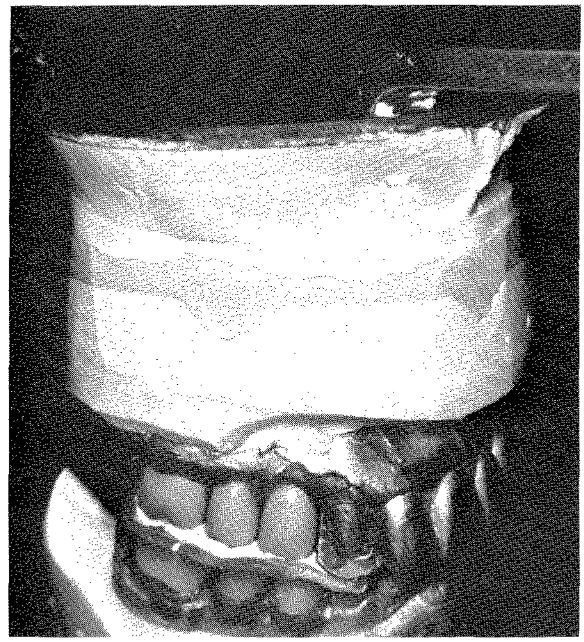


Fig. 3-22. Split cast is in position after articulator is closed in centric relation. Notches of split cast fit accurately. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

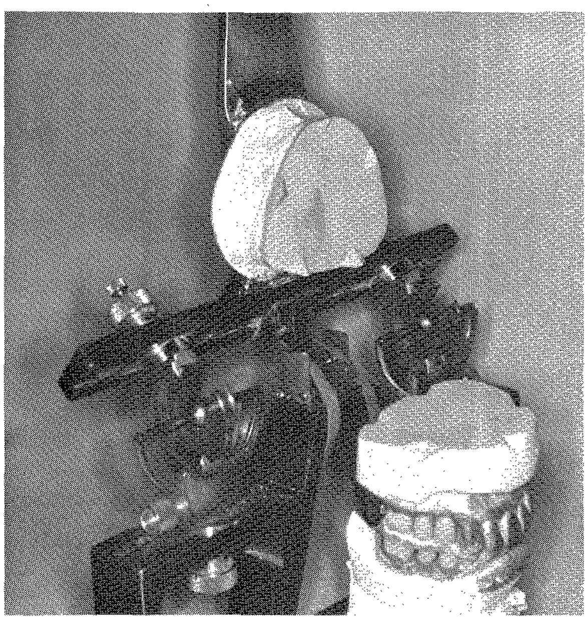


Fig. 3-23. Articulator is opened so that second centric relation record can be used to determine accuracy of records. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

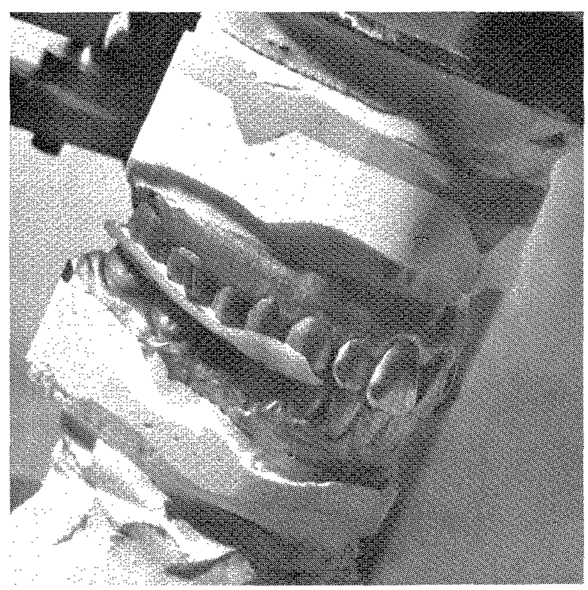


Fig. 3-24. V grooves of split cast fit perfectly together with second record in position. This proves that the two records are identical. (From Lucia, Victor O.: J. Prosth. Dent. **14**:492-505, 1964.)

they can be examined in every detail, with true relationship to each other and without encumbrances of tongue, cheeks, saliva, and the patient's distracting proprioceptive reflexes.

There is nothing new in the principle involved in this technique. Those who are seriously concerned with centric relation have tried, by one means or another, to relate the condyles to the fossae in a specific way. They may not use the same words or terms to describe it, and they may not use the same reasons for their procedures. In the final analysis, however, they want the condyles to be as far up and as far back as *the patient will ever place them when the teeth or restorations are in use;* otherwise there is no justification for being concerned with centric relation.

Many techniques have been developed to accomplish this result. Many techniques resemble the one described here. There is one major difference, however—this procedure enables any dentist to get the same accurate results repeatedly. Having made a great many centric relation records by this procedure, I am convinced that it is the most accurate method in use.

Following are the critical steps in the technique:

1. Locate the centers of rotation, hinge axis, and centers of lateral rotation.
2. Prepare the upper cast for the split-cast technique.
3. Relate the prepared upper cast to the centers of rotation by means of a face-bow transfer.
4. Form the wax wafer tray.
5. Construct and adjust the centric relation jig to interrupt the reflex action of the muscles and to permit a normal closure of the jaws.
6. Check the wafer and jig to make sure there is no tooth impingement against the wax wafer.
7. Make the interocclusal centric relation records.
8. Trim the interocclusal records with a curved tissue shears having serrations on one blade.
9. Replace the records in the mouth to eliminate any possible distortion of them.
10. Relate the lower cast to the upper cast by means of the interocclusal record and attach the cast to the articulator.
11. Check the accuracy of the mounting by using the second and third interocclusal records and observing the fit of the parts of the split cast.

This method has enabled us to consistently and accurately check one centric relation record against another. The important difference between this procedure and others in which anterior stops have been used is that the *adjustment* of the DuraLay jig is responsible for *training the patient* to place his mandible in the centric relation. No special skill is required to carry out the procedure, and it can be accomplished by any dentist.

REFERENCES

1. Academy of Denture Prosthetics: Glossary of prosthodontic terms, J. Prosth. Dent. **6**: Appendix, p. 11, 1956.
2. Needles, J. W.: Mandibular movements and articulator design, J.A.D.A. **10**:927-935, 1923.
3. Lauritzen, Arne: Postgraduate course, April, 1959, University of Pennsylvania, Philadelphia.

Chapter 4

Periodontics

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Anatomy and physiology of the periodontium

The practice of modern restorative dentistry is dependent on a knowledge of the anatomy, physiology, and function of the periodontium. Usually the periodontium is considered to be limited to the gingiva, attached epithelial cuff, cementum, alveolar bone, and periodontal ligament. The gingiva in turn is bound into a unique, inseparable complex with additional anatomic structures such as the alveolar mucosa, vestibular fold, frena, and muscle attachments. The preservation of this gingivomucosal relationship in periodontal therapy is a prime objective before restorative procedures.

GROSS CHARACTERISTICS OF GINGIVOMUCOSAL COMPLEX

The normal gingiva is light pink or coral in color, firm, and resilient (Fig. 4-1). The gingiva can be divided into the marginal (free, unattached) gingiva, attached gingiva, and interdental gingiva, or papilla. The marginal gingiva surrounds the tooth in a collarlike fashion at the cementoenamal junction, and in health it tapers to a knifelike edge at its crest next to the tooth. The marginal gingiva is demarcated from the adjacent attached gingiva by a depression—the free gingival groove—which is not always visible macroscopically. The width of the marginal gingiva is approximately 1 mm. and forms the soft tissue wall of the gingival sulcus. The gingival sulcus is the V-shaped depression that is formed by the tooth surface on one side and the wall of the marginal gingiva on the other. Its normal depth is less than 1 mm.

The attached gingiva is that portion of the gingiva that is immobile and bound tightly to the underlying cementum and alveolar bone. The width of the attached gingiva on the vestibular aspect is from 1 to 5 mm. The surface of the attached gingiva is characterized by an orange peel-like appearance, or stippling, and may be finely or coarsely grained (Fig. 4-2). The attached gingiva appears slightly depressed between adjacent teeth, corresponding to the depression on the alveolar process between eminences of the sockets.

The interdental gingiva, or interdental papilla, is that part of the gingiva that fills the space between two adjacent teeth up to the contact areas. It lies more coronal to the vestibular and lingual gingivae. It is comprised of marginal gingiva and the adjacent area of attached gingiva. The interdental gingiva is tent shaped and is characterized by a vestibular and lingual peak. The concave depression between these peaks is termed a *col* (Fig. 4-3). The shape of the col is determined by the contact areas of adjoining teeth. In the absence of proximal contacts the col area is replaced by a smooth, rounded surface (Fig. 4-4). The interdental gingiva is of special clinical importance since it is an early and accurate indicator of periodontal pathosis.

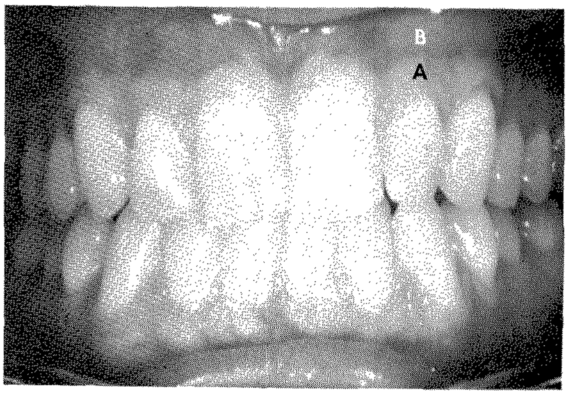


Fig. 4-1. Normal gingiva. *A*, Attached gingiva; *B*, alveolar mucosa.

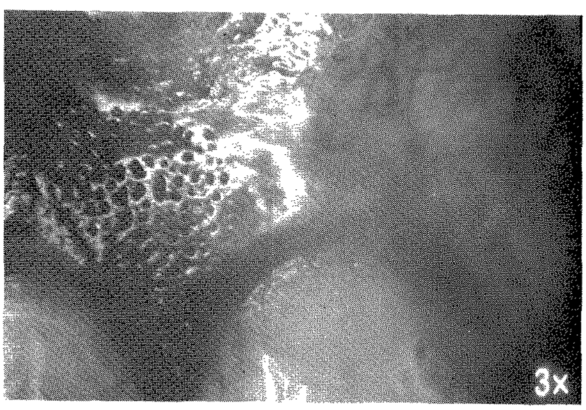


Fig. 4-2. Stippling of gingiva.

The anatomic characteristics of the teeth protect the marginal gingiva. The tooth is formed so that the cervical area is recessed in relation to the greatest contour. The crest of the marginal gingiva lies in contact with the tooth in this recessed area. Food that is forced over the vestibular and lingual contours of the teeth bypass the marginal gingiva. Similarly, the interproximal marginal gingiva is protected by contours in the embrasure areas.

The alveolar mucosa is demarcated from the attached gingiva by a scalloped line, the mucogingival junction. This line of demarcation occurs on the vestibular surfaces of both jaws and on the lingual surface of the mandible. There is no such line on the palate since the gingiva here is continuous with, and similar in structure to, the mucosa of the palate. In contrast to the thick immovable gingiva, the alveolar mucosa is thin, attached loosely to the underlying periosteum of alveolar bone, and movable. The alveolar mucosa is red, smooth, and shiny. It is continuous with the mucosa that lines the vestibular trough or fold, which in turn is reflected as the lining mucosa of the lips and cheeks. On the lingual surface of the mandible the alveolar mucosa is continuous with the mucosa lining the floor of the mouth. In the vestibular fold the thin reddish mucosa is loosely attached to the underlying structures. The position and movements of the alveolar mucosa and vestibular fold mucosa may depend on muscle attachments such as the buccinator, mental, incisive, and nasal. Folds of mucosa in the midline or laterally that connect alveolar mucosa or attached gingiva with the mucosa lining the lips or cheeks constitute median vestibular or lateral vestibular frena,

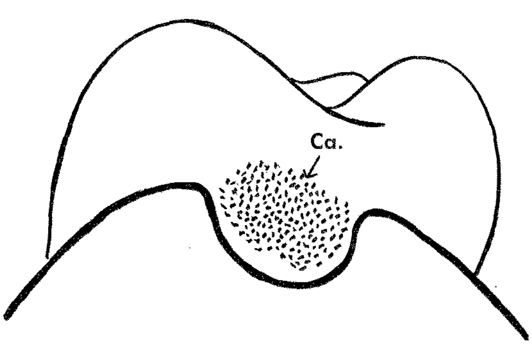


Fig. 4-3. Col. Shape of interdental gingiva between contacting teeth. *Ca.*, Contact area.

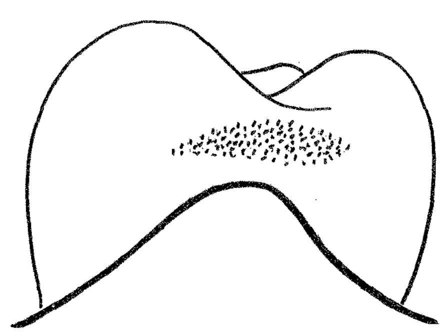


Fig. 4-4. Shape of interdental gingiva where there is space between teeth.

respectively. A midline inferior lingual frenum may be present also.

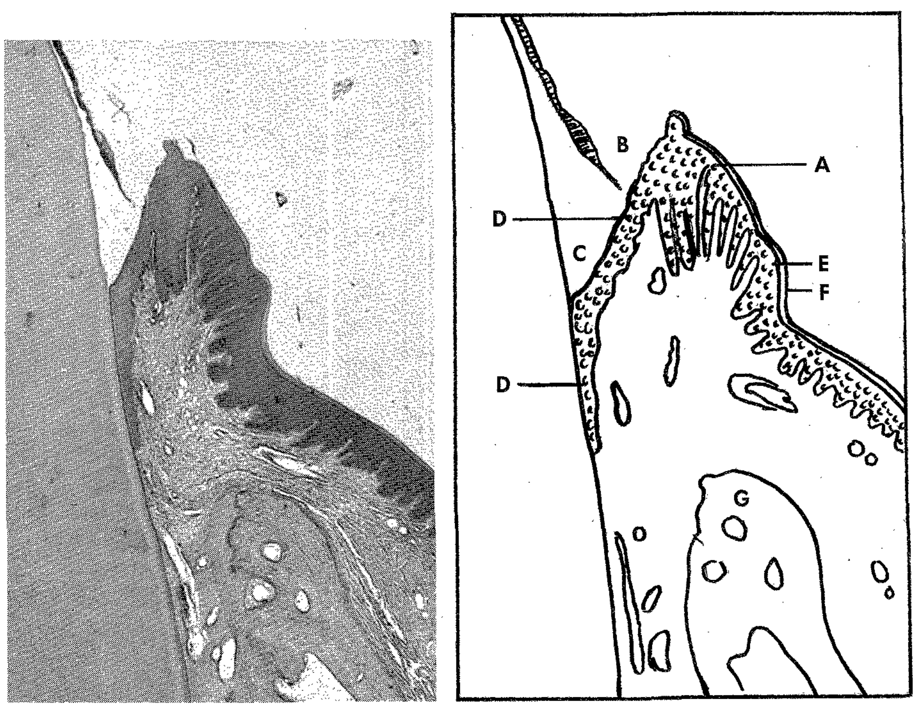
HISTOLOGIC CHARACTERISTICS OF GINGIVOMUCOSAL COMPLEX

The outer covering of the gingiva is composed of a stratified, squamous epithelium that usually has a thick keratinized layer. This layer serves as a protection against chemical and bacterial injuries. However, it may be a combination of keratinization or parakeratinization. The epithelium here is characterized by numerous rete pegs. The epithelium on the inner surface of the gingiva is nonkeratinized and lacks rete pegs, and it serves as the lining of the gingival sulcus. From the base of the gingival sulcus the epithelium attaches to the tooth and continues as a collarlike band composed of ten to twenty rows of epithelial cells as the attached epithelial cuff (Fig. 4-5) or the epithelial attachment. The attached epithelial cuff measures 0.25 to 1.35 mm. in length, with an average length of 1 mm. The function of the attached epithelial cuff is a biologic one, and it seals off the junction of the gingiva and the tooth.

Supporting the epithelial layer is a dense, inelastic but resilient connective tissue, the lamina propria. The papillae of the lamina propria are characteristically long and narrow. Into the lamina propria then insert strong connective tissue fiber bundles that attach the gingiva to the tooth and the surrounding alveolar bone (Fig. 4-6). These fiber groups are classified as follows:

1. Dentinogingival fibers. These fibers arise from the cementum immediately beneath the attached epithelial cuff on the vestibular, lingual, and interproximal surfaces. The fibers adjacent to the attached epithelial cuff project in a fanlike fashion and insert into the lamina propria near the marginal gingiva. The next group of fibers travel directly outward and attach to the lamina propria of the attached gingiva. Subjacent to the aforementioned group of fibers and seen only on the vestibular and lingual surfaces is a third group of fibers, which pass directly over the alveolar bone and incline apically between the outer periosteum of the alveolar process and join with fibers of the outer periosteum and lamina propria of the attached gingiva.

A



B

Fig. 4-5. A, Histologic section of tooth and gingiva. **B,** Diagram of histologic section. *A,* Marginal gingiva; *B,* gingival sulcus; *C,* enamel space; *D,* attached epithelial cuff; *E,* attached gingiva; *F,* keratinized layer; *G,* alveolar bone.

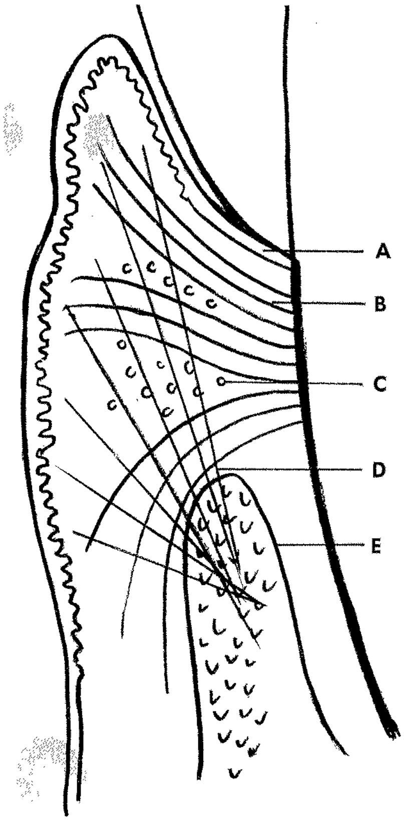


Fig. 4-6. Fiber groups attaching gingiva to tooth and alveolar bone. *A*, Attached epithelial cuff; *B*, dentinogingival fibers; *C*, circular fibers; *D*, alveogingival fibers; *E*, alveolar bone.

2. Circular fibers. These fibers course through the connective tissue of the gingiva, encircling the tooth and interlacing with other fiber groups.

3. Alveogingival fibers. These fibers arise from the alveolar crest and extend to the lamina propria of the gingiva.

4. Transseptal fibers (Fig. 4-7). In the interproximal space and apical to the dentinogingival and circular fibers are prominent connective tissue fibers that arise from the cementum of the tooth, pass directly over the interproximal septum of bone, and attach into the cementum of the adjacent teeth. These fibers form a network to support the interdental gingiva and secure adjacent teeth.

The function of the gingival fibers is to support the gingiva, keeping it closely adapted to the tooth surface and alveolar bone, thus sustaining the gingiva against the forces of mastication. The fibers subjacent to the attached epithelial cuff prevent apical migration of the epithelial attachment. These fiber groups occupy the area from the apical end of the attached epithelial cuff to the crest of the alveolar bone. This area measures approximately 1 mm. in depth.

At the junction of the gingiva and alveolar mucosa is a change in histologic characteristics (Fig. 4-8). The epithelium of the alveolar mucosa is thinner and nonkeratinized, and the epi-

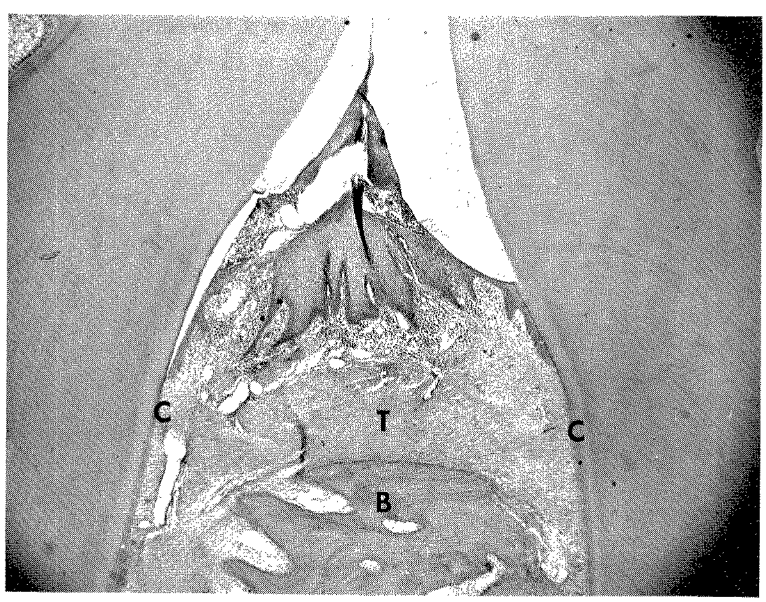


Fig. 4-7. Histologic section of transseptal fibers. *T*, Transseptal fibers; *B*, alveolar bone; *C*, cementum.

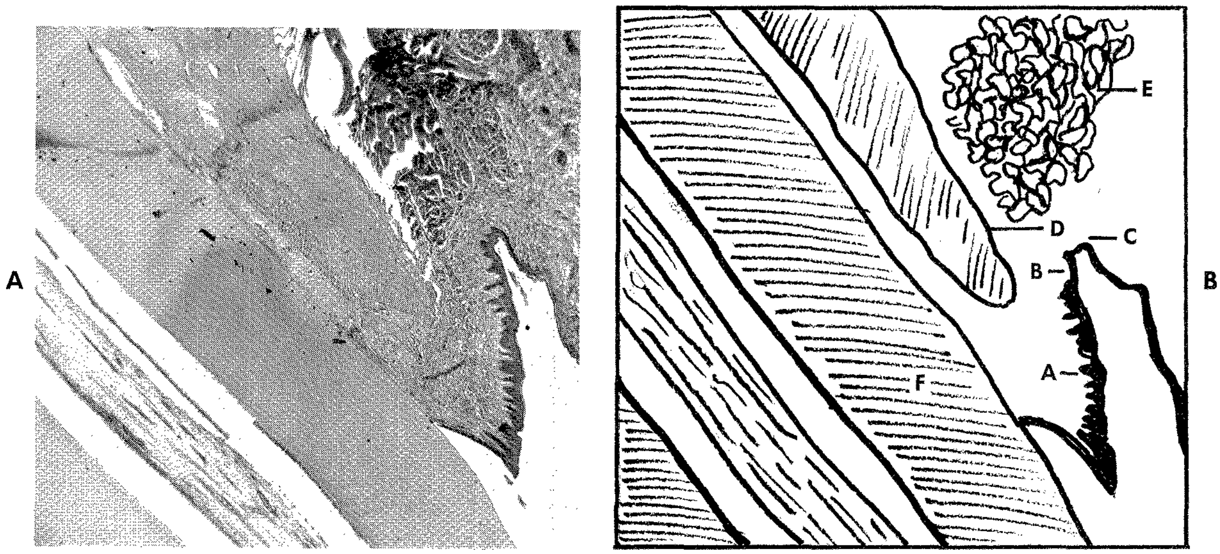


Fig. 4-8. A, Histologic section through tooth, gingiva, alveolar mucosa, and vestibular fold. **B,** Diagram of histologic section. *A,* Attached gingiva; *B,* alveolar mucosa; *C,* vestibular fold; *D,* alveolar bone; *E,* muscle; *F,* dentin.

thelial ridges and connective tissue papilla are insignificant or absent. Since the alveolar mucosa is adapted for mobility, the submucosa is a loosely textured connective tissue containing elastic fibers and glands. The mucosa of the vestibular fold and frena are similar histologically to the alveolar mucosa and are freely movable. Below these submucosal layers will be found striated muscle fibers (buccinator, mental, incisive, nasal) that have attachments to the alveolar bone of maxilla and mandible.

ATTACHMENT APPARATUS

The attachment apparatus consists of the cementum, alveolar bone, and periodontal ligament.

Cementum

Cementum is the hard dental tissue covering the anatomic roots of the teeth. It is light yellow and consists of 45 to 50% of inorganic or calcified substances.

Cementum is deposited in a circumferential pattern about the underlying dentin (Fig. 4-9). Incremental lines separate the layers of cementum and indicate periodontic formation. The surface of cementum is covered by the most recent layer, which is uncalcified cementum or cementoid. The cementoid layer is characterized by a single layer of living cells, cementoblasts, which are responsible for cementoid deposition (Fig. 4-10). Cementum formation is considered to be a continuous process. Under normal conditions resorption of cementum is not significant. Cementum is thinnest at the cementoenamel junction (25 to 50μ) and thickest at the apex and interradicular areas (150 to 200μ). Occasionally there is no cementoenamel junction, and a zone of root dentin is devoid of cementum and is exposed.

Alveolar process

The alveolar process is that part of the maxilla or mandible that forms and supports the sockets of the teeth. The anatomic contour of the alveolar bone generally is dependent on the prominence of the tooth roots (Fig. 4-11). The alveolar bone tapers in thickness as it approaches the cervical area on the vestibular and lingual surfaces. Between the roots the alveolar bone conforms to intervening vertical depressions, which unite from the vestibular and lingual surfaces to form the interdental septum of bone. The crest of the alveolar bone is normally 1 mm. in distance from the apical end of the attached epithelial cuff or 2 mm. from the cementoenamel junction. The outer wall of the alveolar process is composed of dense cortical plates on the vestibular and lingual surfaces. (See Fig. 4-12.) The inner wall of bone, forming the alveolar socket,

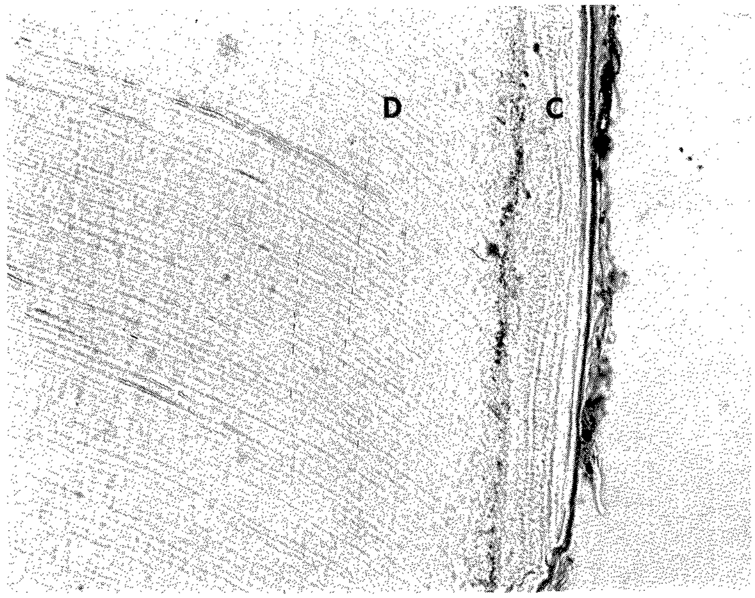


Fig. 4-9. Ground section of tooth. *C,* Cementum; *D,* dentin-incremental pattern of cementum readily visible.

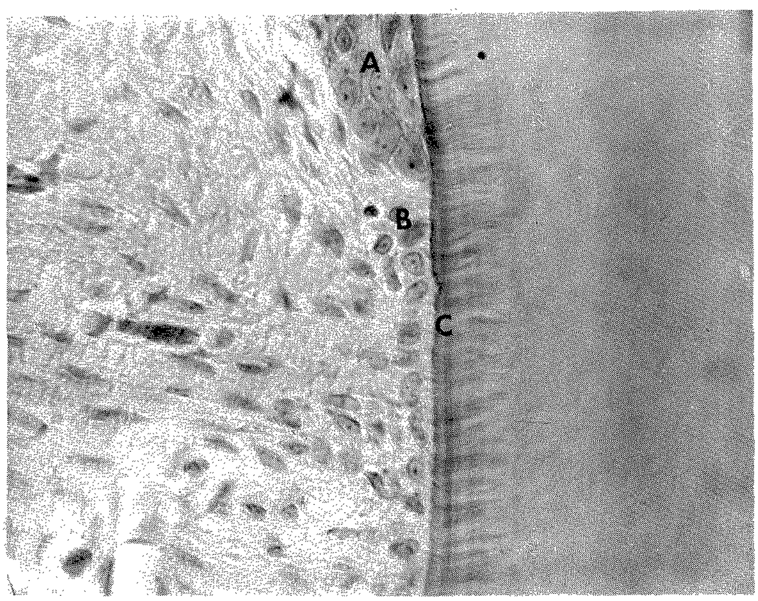


Fig. 4-10. Histologic section. *A,* Apical end attached epithelial cuff; *B,* cementoblasts; *C,* cementum.

is thin and relatively dense. It is termed the *alveolar bone proper,* or *cribriform plate,* since it is perforated by many openings for blood vessels, lymphs, and nerves. Radiographically, the alveolar bone proper appears as a thin, continuous, radiopaque line more commonly known as the *lamina dura* (Fig. 4-13). Between the outer cortical plates and the inner alveolar bone proper are supporting trabeculae of cancellous bone. Alveolar bone is composed of a calcified matrix. Embedded in the matrix are osteocytes lying in lacunae. Extending from each lacuna are minute

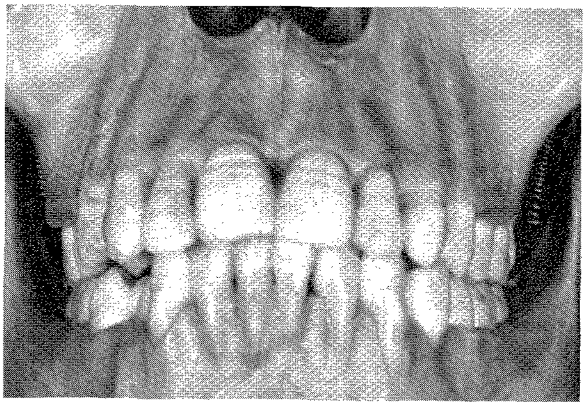


Fig. 4-11. Gross specimen of skull illustrating normal topography of maxillary alveolar bone.

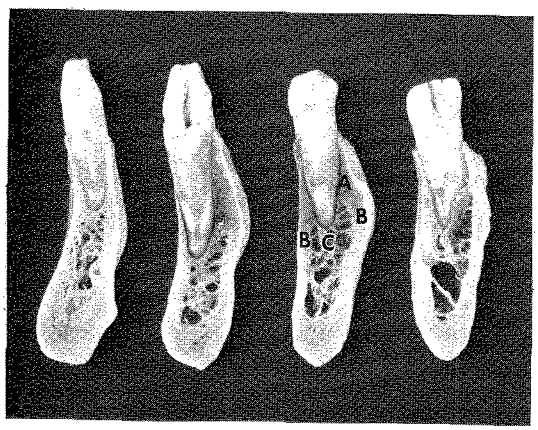


Fig. 4-12. Cross sections through mandible. *A,* Alveolar bone proper; *B,* cortical bone; *C,* cancellous bone.

canals called *canaliculi,* which communicate with canaliculi of adjacent lacunae. The canaliculi form an anastomosing network throughout the intercellular matrix of bone, which brings nutrient material to the osteocyte and removes waste products of metabolism. Since alveolar bone is the least stable component of the attachment apparatus and since it depends upon a functional stimulation for preservation of its structure, it is characterized by areas of bone deposition and bone resorption. Whenever bone apposition is occurring, a layer of noncalcified matrix, or osteoid, is present. A lining layer of osteoblasts is responsible for its deposition. Wherever bone is undergoing resorption, large multinucleated cells, osteoclasts, will be seen.

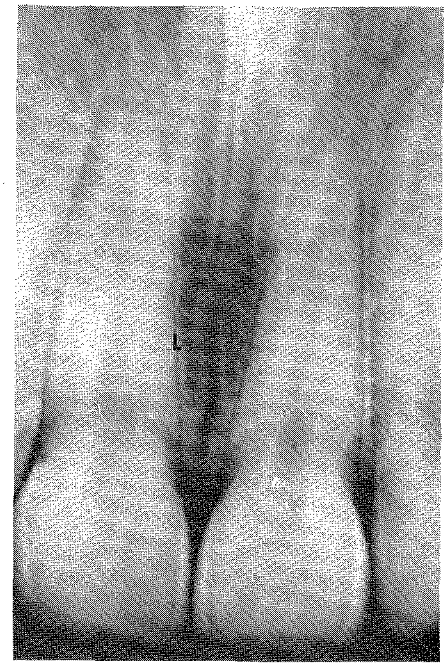


Fig. 4-13. Radiograph of upper central incisor area. *L,* Lamina dura.

Periodontal ligament

The periodontal, or alveodental, ligament is the connective tissue that attaches the tooth to the bony alveolus. The principal fibers of the periodontal ligament arise in the cementum as Sharpey's fibers, pass between the layer of cementoblasts as they emerge from the cementum, and continue on to insert into the alveolar bone again as Sharpey's fibers. Near the bone the fibers seem to form larger bundles before their insertion into it. Although the fiber bundles run directly from cementum to bone, single fibers do not span the entire distance. The bundles are spliced or braided together in an intermediate group of fibers midway between the cementum and bone. Eruptive and drifting movements of teeth occur by a rearrangement or resplicing of fibers in the intermediate zone (Fig. 4-14). The periodontal ligament consists of the following five groups of fiber bundles, which are functionally arranged.

1. Alveolar crest. These fiber bundles radiate obliquely from the cervical cementum and attach to the crest of the alveolar bone. This is the smallest group of principal fibers. These fibers resist the coronal movements of the teeth, help

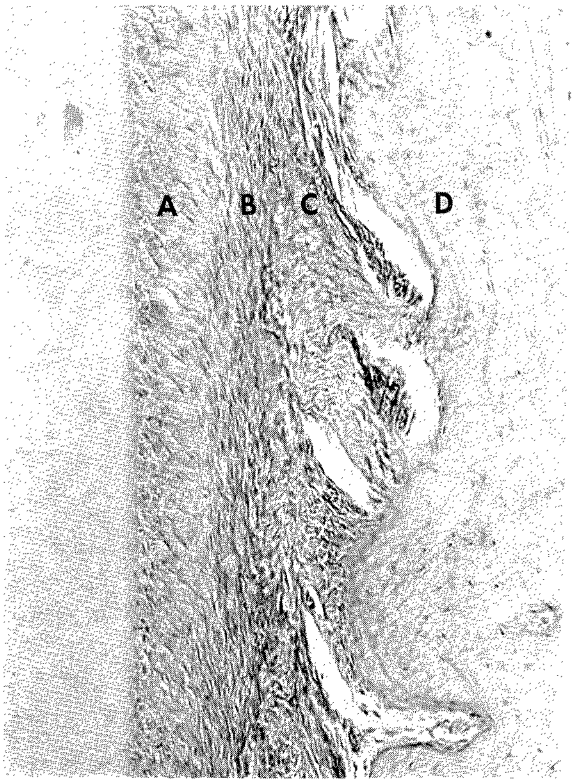


Fig. 4-14. Histologic section through periodontal ligament of rapidly erupting tooth. *A*, Cemental fibers; *B*, intermediate fibers; *C*, alveolar fibers; *D*, alveolar bone.

to retain the tooth within its socket, and resist lateral movements. (See Fig. 4-15.)

2. Horizontal. These bundles have origin from the cervical third of the cementum, run at right angles to the long axis of the tooth, and attach to the cervical third of the alveolar bone. This is the next smallest group of fibers. Their function is to resist tooth displacement by lateral pressure. (See Fig. 4-16.)

3. Oblique. These fibers arise from the apical two-thirds of the cementum. They radiate coronally and have a broader area of attachment as they insert into the alveolar bone. The oblique fibers are most numerous and constitute the main support of the tooth against masticatory stresses. Their function is to transform vertical pressure exerted on a tooth into tension on the alveolar bone. (See Fig. 4-17.)

4. Apical. These bundles are arranged irregularly and radiate from the apical region of cementum to the apical region of the alveolar socket. They counteract lateral and coronal displacement of the apical portion of the root. (See Fig. 4-18.)

5. Interradicular. From the furcation of multirooted teeth fiber bundles extend to the bone of the interradicular septum. The most coronal fibers run vertically to the crest of the interradicular bone, whereas the more laterally located

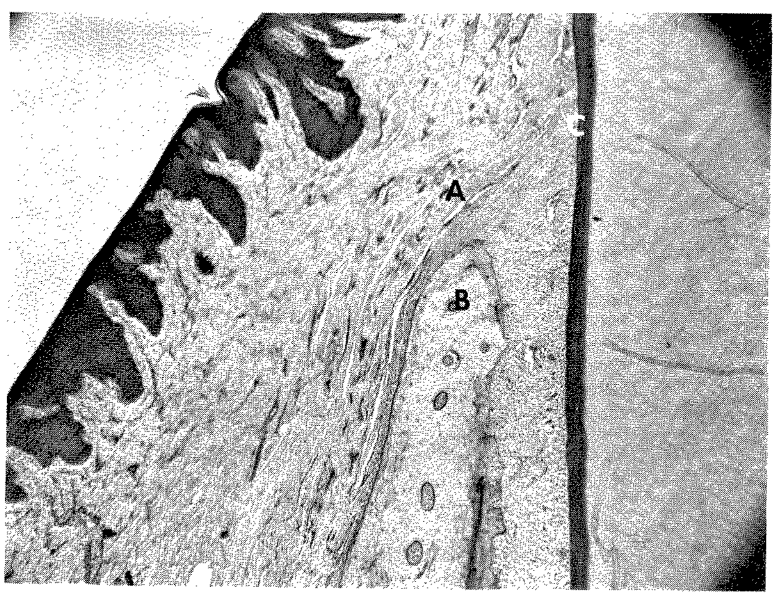


Fig. 4-15. Histologic section through periodontal ligament. *A*, Alveolar crest fibers; *B*, alveolar bone; *C*, cementum.

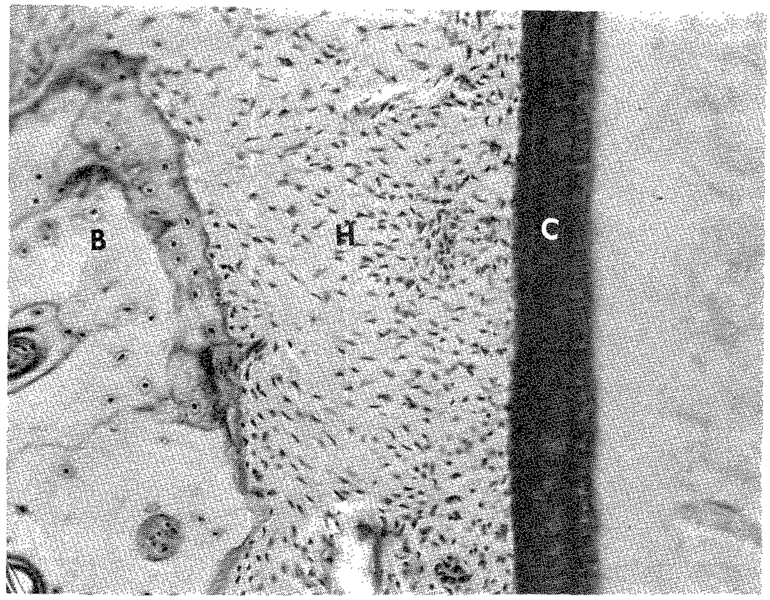


Fig. 4-16. Histologic section through periodontal ligament. *H,* Horizontal fibers; *B,* alveolar bone; *C,* cementum.

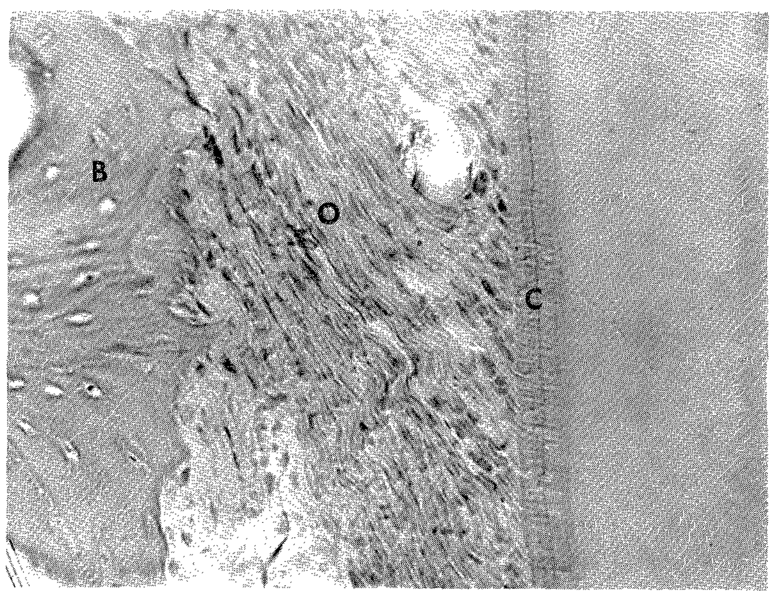


Fig. 4-17. Histologic section through periodontal ligament. *O,* Oblique fibers; *B,* alveolar bone; *C,* cementum.

fibers radiate obliquely from the cementum to the interradicular septum of bone. These fibers resist tipping and torque in multirooted teeth.

Between the groups of principal fibers is a loose interstitial connective tissue. In this tissue are the blood vessels, lymphatic vessels, and nerves for nutrition and enervation of the tooth, periodontal ligament and gingiva. Cells found in the interstitial tissue are fibroblasts, histiocytes, undifferentiated mesenchymal reserve cells, and lymphocytes.

The width of the periodontal ligament varies according to the age of the individual and the functional requirements of the tooth. In a tooth

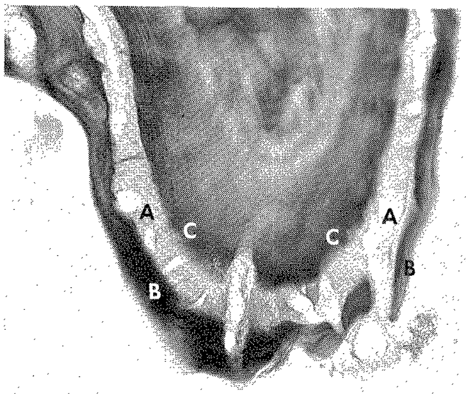


Fig. 4-18. Histologic section through periodontal ligament. *A,* Apical fibers; *B,* alveolar bone; *C,* cementum.

in functional occlusion the width varies from 0.25 to 0.2 mm. The width is narrowest below the midroot area, which is the fulcrum of the tooth.

Pathology of periodontal disease

GENERAL CONSIDERATIONS

In the previous material an attempt has been made to describe the normal gross characteristics of the marginal gingiva, gingival sulcus, attached gingiva, interdental gingiva, alveolar mucosa, and vestibular fornix and their spatial interdependence. The normal histology of these structures as well as that of the underlying and interrelated structures such as the attached epithelial cuff, gingival fibers, cementum, periodontal ligament, and alveolar bone have been presented. Changes in any of the previously mentioned structures or in their relationship to each other may constitute the initiation of periodontal disease.

The tissues are subjected daily to a variety of insults, local and systemic, which may result in either inflammatory or dystrophic conditions or a combination of both. Inflammatory periodontal conditions initially attack the gingiva (i.e., marginal, interdental, or attached gingiva), resulting in some form of gingivitis. Following are clinical manifestations of inflammatory conditions in the gingiva:

1. Changes in gingival color. A change from the normal light pink or coral color to varying shades of red to blue occurs.
2. Change in consistency. The normal gingiva is firm and resilient. Inflammation results in a puffiness, softness, and ulceration.
3. Change in surface texture. Normal gingiva is characterized by stippling. Edema and swelling cause a loss of stippling and replacement with a smooth glossy surface.
4. Change in form and position. As a consequence of inflammation the knife-edged and well-contoured appearance of the marginal gingiva may become rounded, enlarged, and irregular (Fig. 4-19). If necrosis should occur, however, portions of the gingiva could be destroyed. The gingiva either can enlarge in height and in bulk and cover a larger portion of the tooth or can recede and denude a portion of the root surface. Gingival enlargements and recession may go on simultaneously.
5. Bleeding. In the normal gingiva the epithelial lining of the gingival sulcus is intact. In inflammatory conditions the epithelium is ulcerated and thinned, allowing for passage of blood from more permeable dilated capillaries through the epithelium into the space between the tooth and gingiva.
6. Exudation. Products of necrosis and degeneration in inflammation may form an exudate, which escapes through the ulcerated sulcular epithelium and may be expressed on applying pressure to the gingiva against the tooth. The exudate may be purulent or serous.
7. Increase in depth of gingival sulcus. Increase in bulk of gingival tissue results in an increase in depth of the gingival sulcus and may form a gingival pocket. Increase in sulcular depth

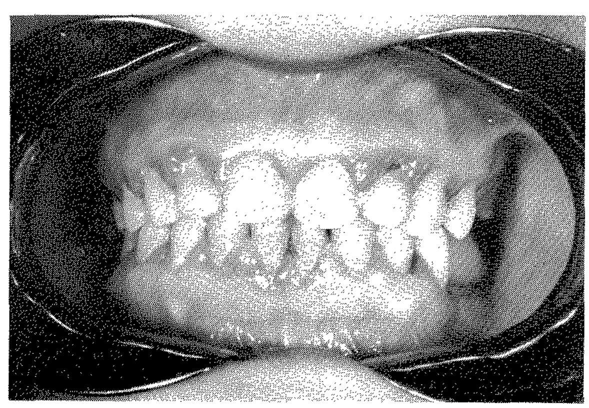


Fig. 4-19. Gingivitis. Changes in surface texture, form, and position of gingiva.

because of coronal enlargement of gingival margin may result from edematous accumulation or inflammatory hyperplasia.

8. Pain. Pain may or may not be an accompanying symptom. It is more often present with acute exacerbations of gingival disease.

HISTOPATHOLOGY OF GINGIVITIS

Inflammatory agents of local etiology or their toxic products invade the nonkeratinized epithelium of the gingival sulcus and penetrate the lamina propria. The initial inflammation is localized in the lamina propria beneath the sulcular epithelium (Fig. 4-20). Here the capillaries will be dilated and engorged. Extravasations of red blood cells into the connective tissue follow. Accumulations of inflammatory cells are present in the lamina propria. The inflammatory cells are mainly plasma cells and lymphocytes. Polymorphonuclear cells may be present, particularly beneath the sulcular epithelium, and macrophages are seen occasionally. The epithelium of the sulcus, the outer gingiva, and the attachment cuff proliferate into the lamina propria. Concomitant is an influx of inflammatory fluid and cellular exudate in the lamina propria. Degeneration of epithelium and connective tissue occurs, and ulcerations may appear in the epithelium of the sulcus. Polymorphonuclear leukocytes may be seen migrating through these ulcerations. As the inflammatory process progresses, destruction of the connective tissue of the lamina propria and of the dentinogingival fibers takes place. Along with the breakdown, areas of repair may be apparent. Fiber bundles may be replaced by a young proliferating connective tissue, consisting of new capillaries, mesenchymal cells, and inflammatory cells. Because of the increased bulk of the gingiva, the epithelium of the outer gingiva may become thinned. As a result of the inflammatory process and the destruction of gingival fibers, the epithelial attachment may shift apically on the cementum, increasing the depth of the gingival sulcus or pocket. The nature and character of the inflammatory process in the gingiva determines in large measure the extent of the clinical manifestations.

Fig. 4-20. Histologic section of gingiva in gingivitis. Note proliferation of epithelium and accumulation of inflammatory cells.

GINGIVAL ENLARGEMENTS

Although enlargements of the gingiva are predominantly of an inflammatory nature, some are true hyperplasias (noninflammatory) of the connective tissue and epithelium (Fig. 4-21). Dilantin hyperplasia illustrates such an enlargement and is of systemic etiology (Fig. 4-22). Other enlargements may be caused by a combination of inflammatory and noninflammatory (hyperplastic) agents, while still other enlargements of the gingiva, such as gingivitis seen in pregnancy, are conditional enlargements; that is, they require local irritating factors to initiate a response under a certain set of systemic conditions.

GINGIVAL ATROPHY

While inflammatory changes initially exhibit swelling and enlargements, necrosis and degeneration are accompanying features. Recession or atrophy may take place, and a loss of quantity of gingiva may result. Pronounced loss of gingiva is seen in necrotizing ulcerative gingivitis (Vincent's gingivitis) as the interproximal marginal and attached gingivae are destroyed (Fig. 4-23). Interproximal craters may be formed. On the other hand atrophy may spare the interproximal tissue in patients who use too vigorous toothbrushing techniques, and severe recession may be seen on the vestibular or lingual

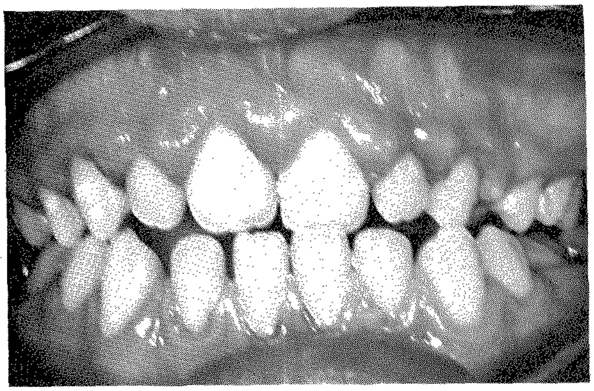


Fig. 4-21. Gingival enlargement caused by inflammation.

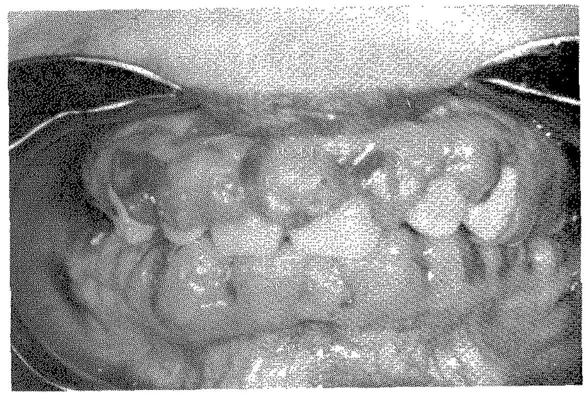


Fig. 4-22. Gingival hyperplasia caused by intake of Dilantin.

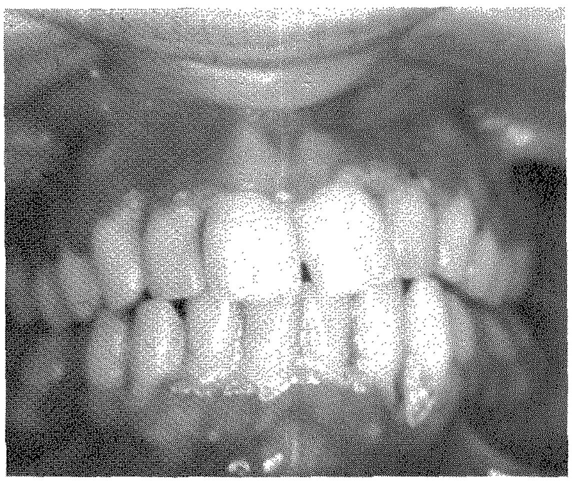


Fig. 4-23. Destruction of interproximal gingiva about lower anterior teeth in necrotizing ulcerative gingivitis.

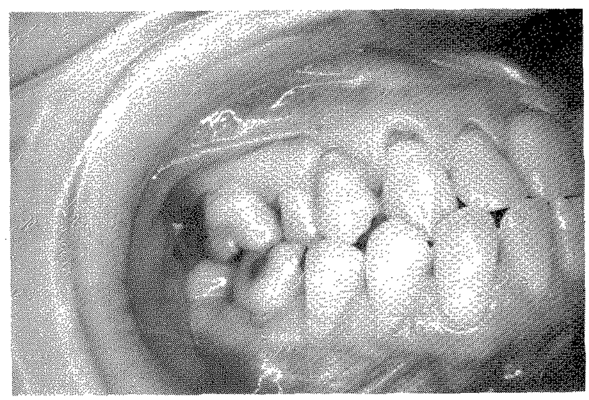


Fig. 4-24. Atrophy of gingiva.

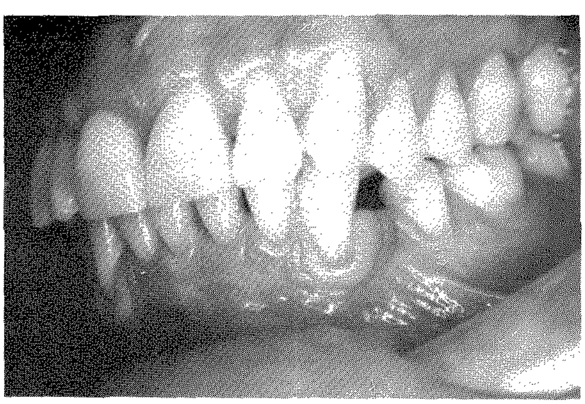


Fig. 4-25. Atrophy of gingiva with rolled margin about lower left cuspid tooth.

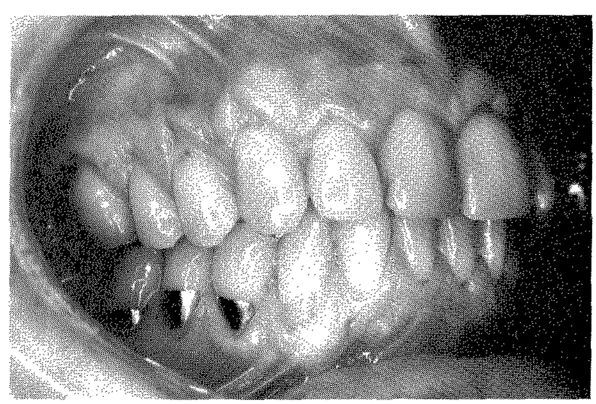


Fig. 4-26. Atrophy of gingiva with cleft formation about upper right cuspid and bicuspid teeth.

surfaces with an even destruction of the marginal and portions of the attached gingiva (Fig. 4-24). In this type of recession the gingival sulcus is usually very shallow and without exudate. The remaining gingiva may have a very thin margin or may have a rolled or festooned border (Fig. 4-25). In other instances an uneven atrophy may take place, and formation of clefts may result (Fig. 4-26). In recession the attached epithelial cuff will shift to a more apical position on the cemental surface of the root.

PERIODONTITIS

As the inflammatory process in a gingivitis progresses into the deeper supporting periodontal tissues, a transition from a gingivitis into a periodontitis occurs. The clinical signs and symptoms of a periodontitis are similar to those of gingivitis but with the following variations and additions:

1. Color. Circulatory stagnation will cause a bluish red color of the gingiva to predominate. The color change may extend through the attached gingiva and even into the alveolar mucosa. Occasionally the color will be pink and appear to be clinically normal.
2. Change in consistency and surface texture. The gingiva may present, on pressure, a smooth, shiny surface and pitting (Fig. 4-27). However, a long-standing periodontitis may be undergoing fibrotic changes in the gingival wall and may present a firm, healthy-looking appearance.
3. Change in form and position. As the inflammatory process extends apically, marginal enlargements tend to diminish. The marginal gingiva may present a rolled margin or may revert back to a regular uniform appearance. The interproximal tissue may retain some enlargement and exhibit a convex surface. Separation of the vestibular and oral components of the interproximal papilla may occur. Some marginal recession may take place and cementum may be exposed.
4. Bleeding. Bleeding is usually a constant finding. Again, as fibrosis takes place bleeding may diminish and become less noticeable.
5. Periodontal pocket. Destruction of supporting periodontal tissues transforms a gingival pocket into a periodontal pocket. As more destruction of the dentinogingival fibers are destroyed by progressive inflammation, the epithelial attachment will proliferate apically. As a result, the periodontal probe will enter deeper into the periodontal pocket (Fig. 4-28). The deepest part, or base of the periodontal pocket, will be located at the coronal portion of the epithelial attachment cuff. Periodontal pockets may be either suprabony or infrabony. Suprabony pockets comprise the great majority of pockets. The wall of this type of pocket is formed wholly of soft tissue. The soft tissue wall can be gingiva, gingiva and alveolar mucosa, gingiva and palatal mucosa, alveolar mucosa, or palatal mucosa. The wall of the infrabony pocket is composed of the aforementioned soft tissues and a scaffolding of alveolar bone that has survived the resorptive process.
6. Exudation. A purulent exudate is usually a prominent symptom in periodontitis. There is, however, no correlation with the amount of suppuration and the severity of the periodontal condition. (See Fig. 4-29.)
7. Pain. Pain is not a constant finding in periodontal disease, although an awareness of discomfort may be present. Severe pain may be an accompanying symptom in acute conditions such as a periodontal abscess.
8. Bone resorption. The progression of the inflammatory process apically and the destruction of the dentinogingival fibers eventually result in resorption of the alveolar crest of bone (Fig. 4-30). It must be remembered that bone resorption is taking place before it is seen in the radiograph since a sufficient amount of resorption must occur before it can be recorded. Initially, bone resorption would be seen as a cupping out of the interdental septum. Resorption

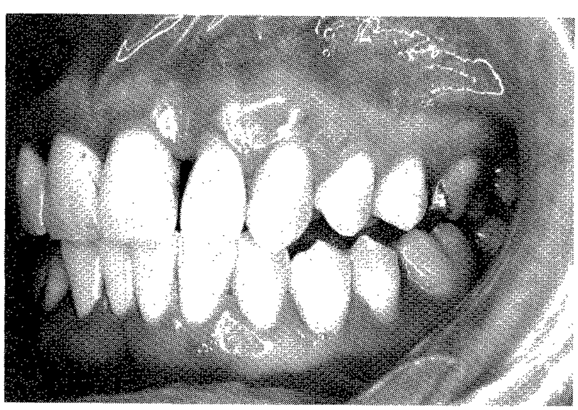


Fig. 4-27. Periodontitis. Gingiva about upper left cuspid and lateral incisor exhibiting smooth, shiny, pitted appearance.

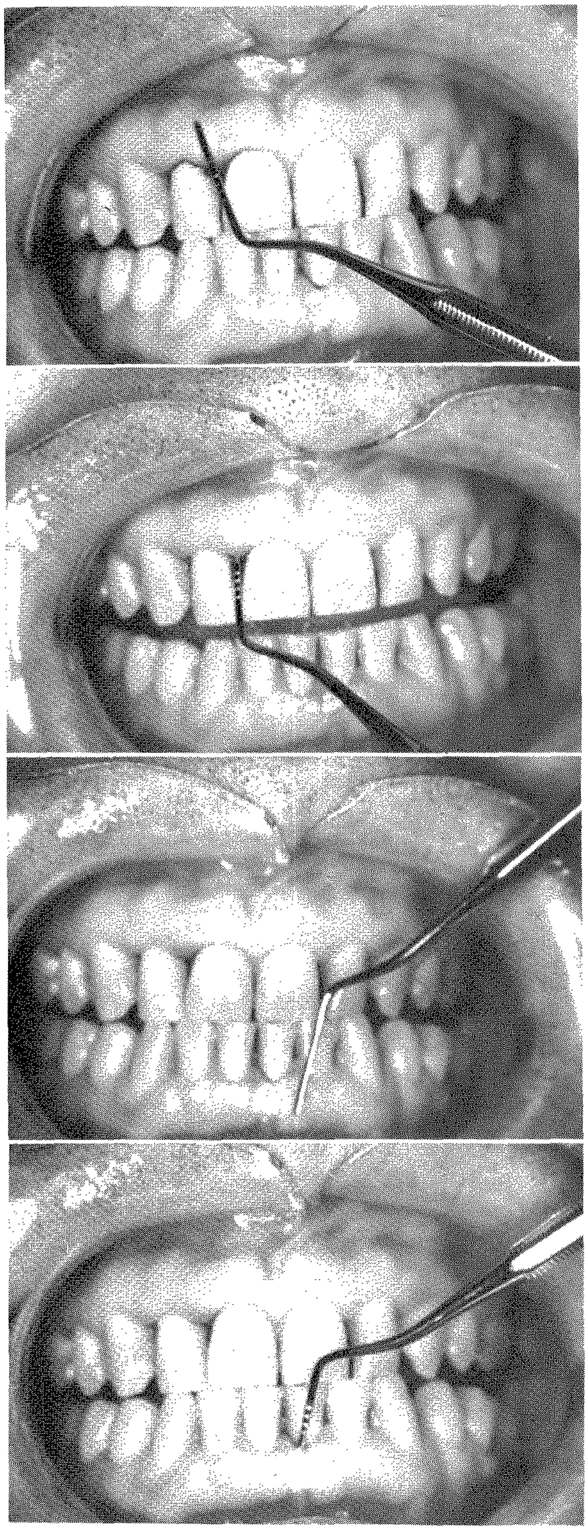


Fig. 4-28. Probe in periodontal pockets of long standing. Periodontitis with gingiva presenting an almost normal appearance in shape and size.

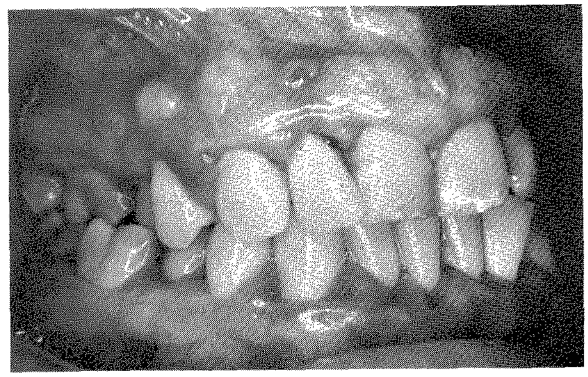


Fig. 4-29. Periodontal abscesses above upper right first biscuspid, cuspid, and lateral incisor teeth in well-advanced periodontitis.

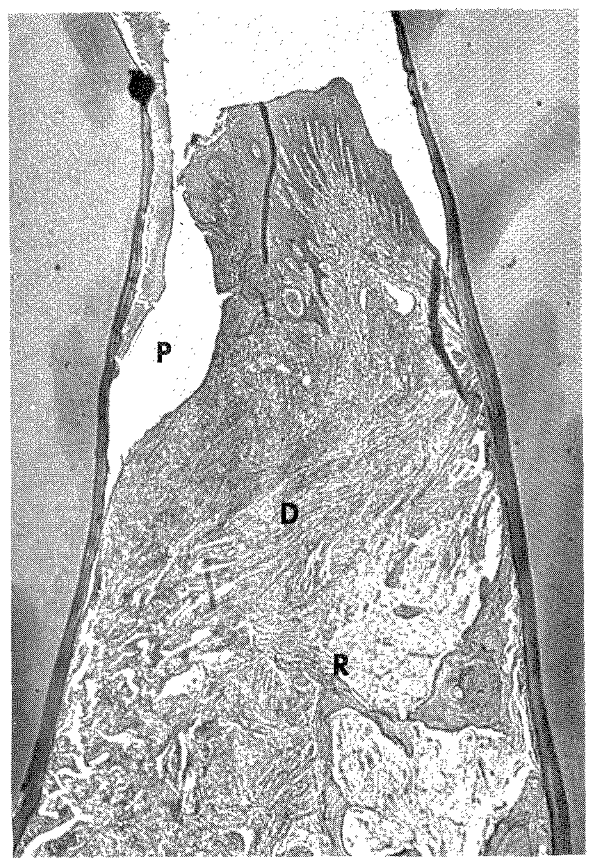


Fig. 4-30. *P,* Histologic section of periodontitis illustrating pocket formation; *D,* destruction of dentinogingival fibers; *R,* resorption of alveolar bone.

proceeds apically from the alveolar crest and progresses slowly in a horizontal manner along the periosteal aspect of the alveolar bone (Fig. 4-31). Early resorption on vestibular and oral surfaces of alveolar bone will not be seen readily since the tooth overlays these areas in the radiograph. Extension of the inflammatory process along the blood vessels into the bone marrow spaces will produce further bone resorption and destruction of fibers of the periodontal ligament.

The most common pattern of bone loss that is caused by inflammation is usually a horizontal type of bone resorption (Fig. 4-32). When traumas from occlusion and bruxism, or systemic factors are combined with inflammation, a vertical type of bone resorption may take place. Such resorption may result in infrabony defects, craters, ledges, inconsistent margins, hemisepta, or exostoses (Figs. 4-33 to 4-35).

9. Mobility. Resorption of alveolar bone and destruction of fibers of the periodontal ligament eventually will result in varying degrees of looseness of the teeth. On the other hand, teeth subjected to occlusal trauma may exhibit mobility with no apparent loss of supporting structures.

10. Migration. With loss of supporting tissues a tooth may no longer be able to resist normal forces and may elongate, tilt, rotate, or drift into another position (Fig. 4-36). While migration occurs most frequently in the anterior area, posterior teeth may be similarly affected.

Fig. 4-31. Histologic section showing resorption of bone at alveolar crest, *A*.

Fig. 4-32. Horizontal bone resorption in periodontitis.

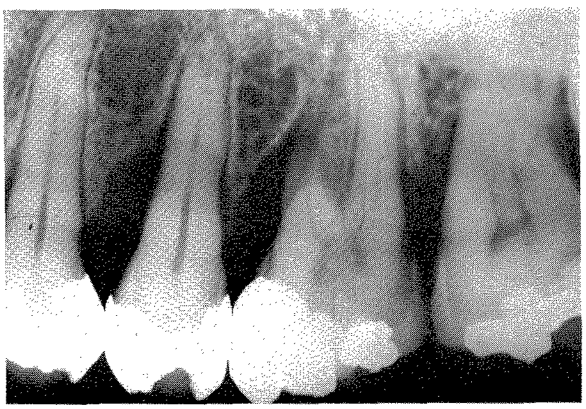


Fig. 4-33. Vertical bone resorption resulting in formation of hemisepta.

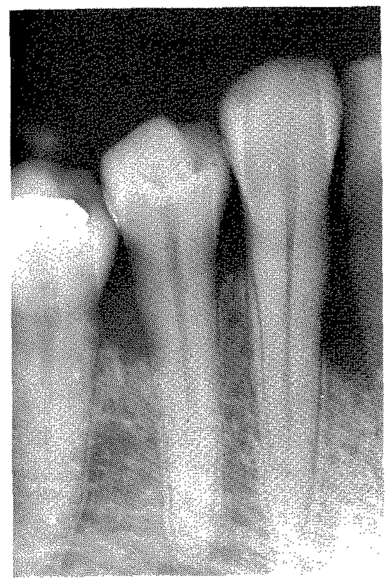


Fig. 4-34. Bone resorption with inconsistent bony margins.

Fig. 4-35. Circular infrabony defect about distal root of lower right first molar tooth.

Fig. 4-36. Migration of upper anterior teeth in periodontitis.

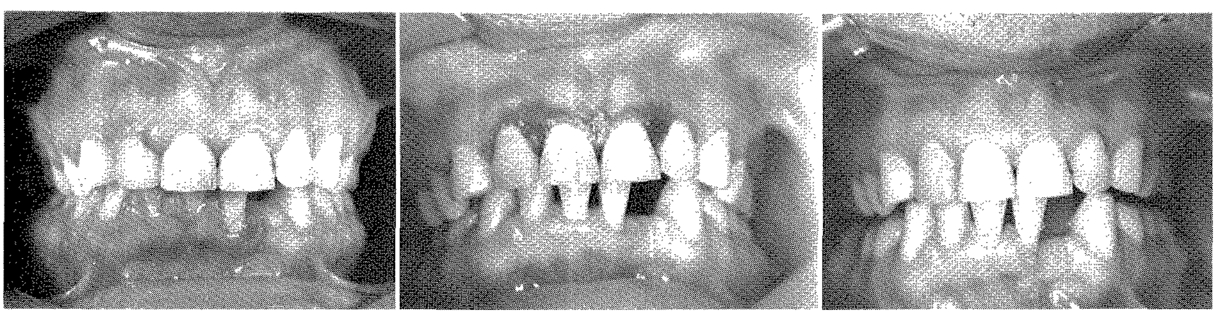
Objectives of periodontal therapy

Although it is not within the scope of the chapter to discuss therapy, it is the responsibility of the individual performing advanced restorative procedures not only to recognize periodontal disease in its various forms, but also to be well versed in the objectives, attainments, and techniques of periodontal therapy. As in all scientific endeavors these may change as research and newer knowledge make possible a greater insight into the understanding and management of periodontal disease.

Some of the current-day objectives are as follows:

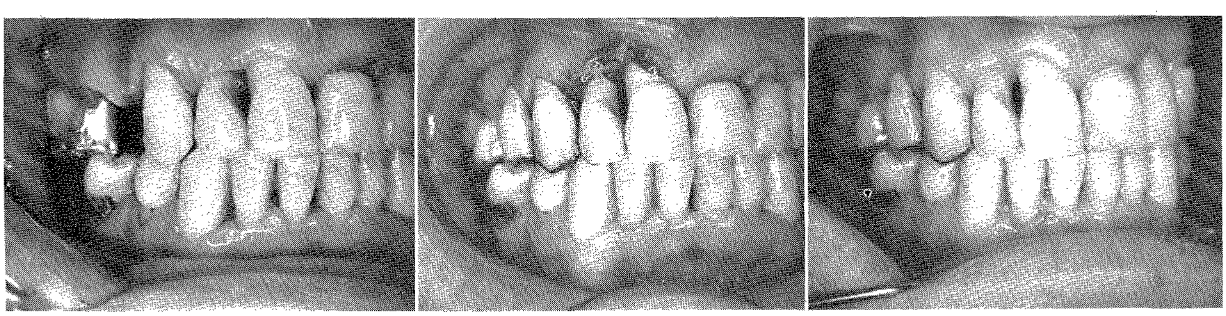
1. Pink, firm, well-attached gingiva
2. Knife-edged marginal gingiva
3. Minimal depth of gingival sulcus
4. Adequate amount of attached gingiva
5. Elimination of pull of frena and muscle attachments
6. Intact foundation of alveolar bone (elimination of infrabony defects, exostoses)
7. Stability of remaining dentition

The cases that are presented now will attempt to illustrate many of the previously mentioned objectives (Figs. 4-37 to 4-64).



A B C

Fig. 4-37. A, Gingival enlargement of upper central incisor teeth. **B,** Gingivoplasty. **C,** Postoperative view after gingivoplasty.



A B C

Fig. 4-38. A, Interproximal crater between upper right lateral and central incisor teeth. **B,** Gingivoplasty. **C,** Postoperative view after gingivoplasty.

A B

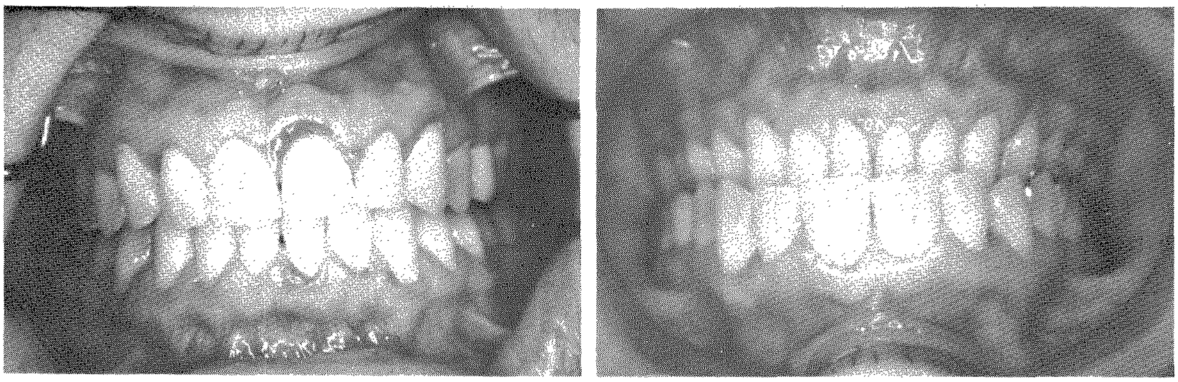


Fig. 4-39. A, Edematous gingival enlargement of upper left central incisor tooth. **B,** Postoperative view after gingival curettage.

A B

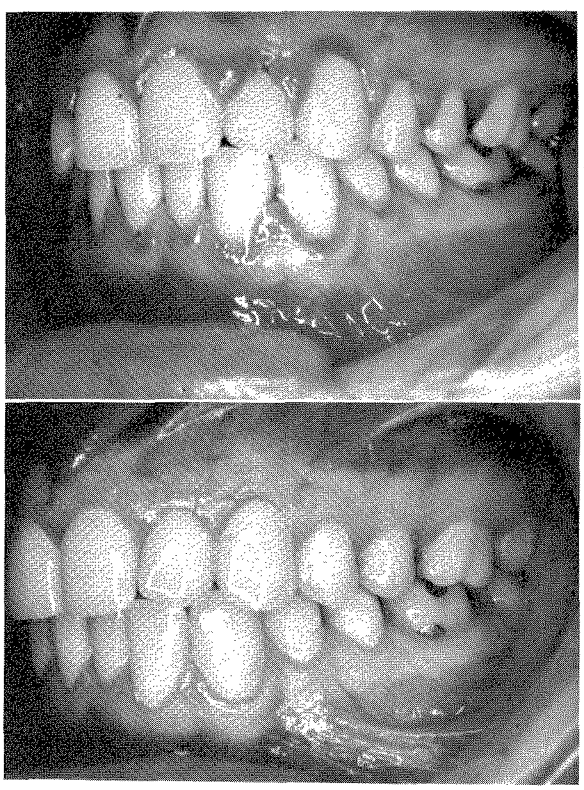


Fig. 4-40. A, Numerous areas of edematous gingival enlargement. **B,** Postoperative view after gingival curettage.

A B

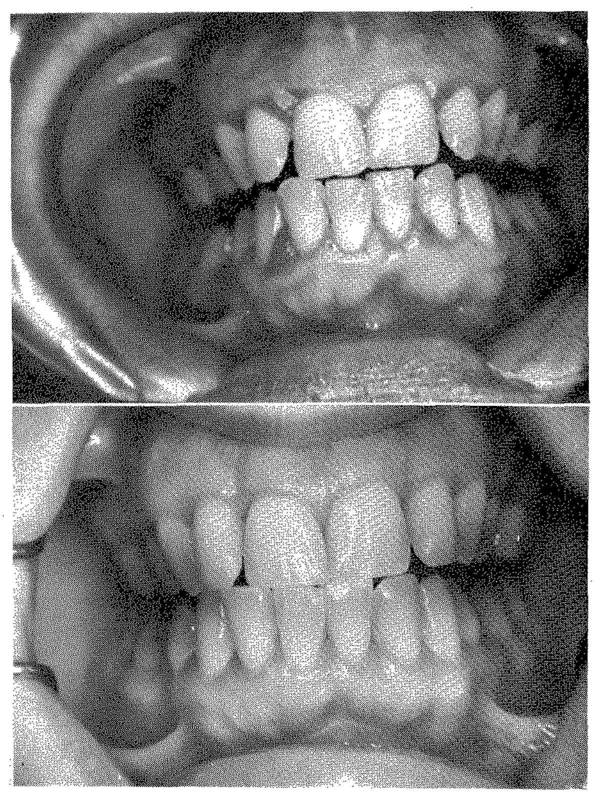


Fig. 4-41. A, Inflammatory hyperplasia of gingiva. **B,** Postoperative view after gingivectomy.

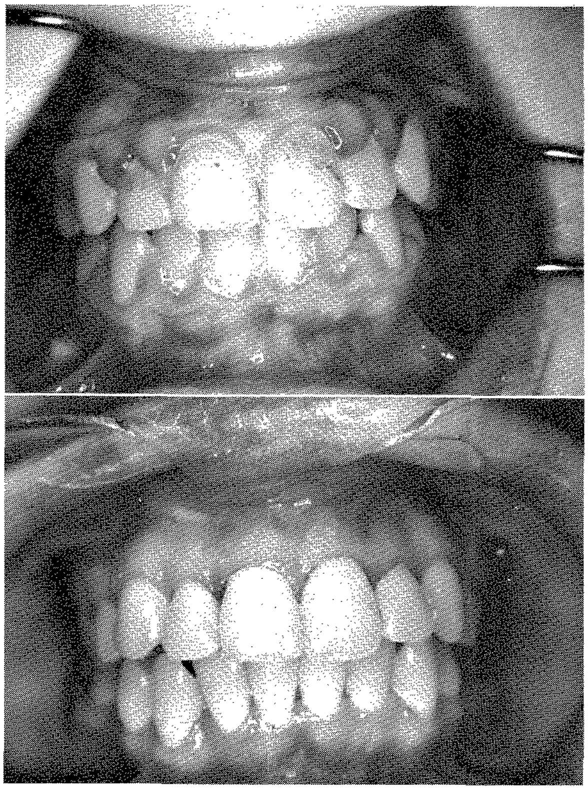


Fig. 4-42. A, Inflammatory hyperplasia of gingiva after orthodontic treatment. B, Postoperative view after gingivectomy.

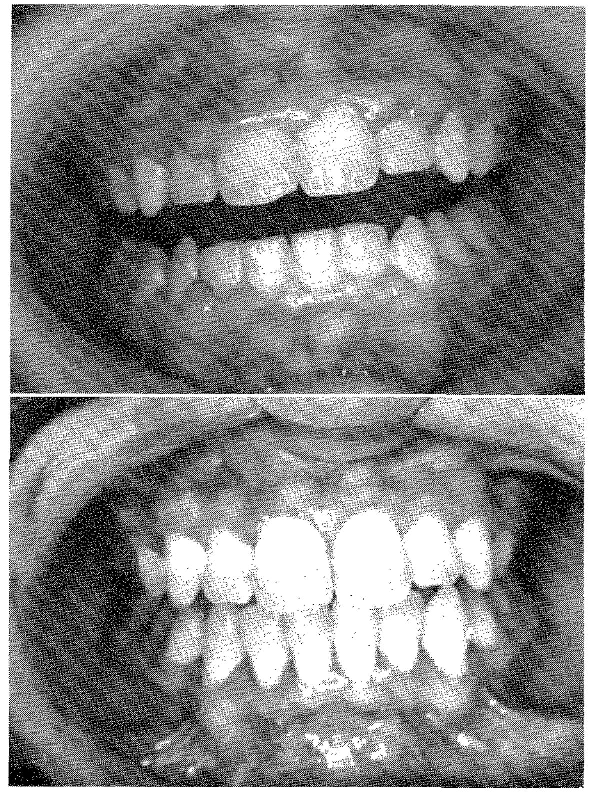


Fig. 4-43. A, Gingival enlargement in delayed passive eruption. B, Postoperative view after gingivectomy.

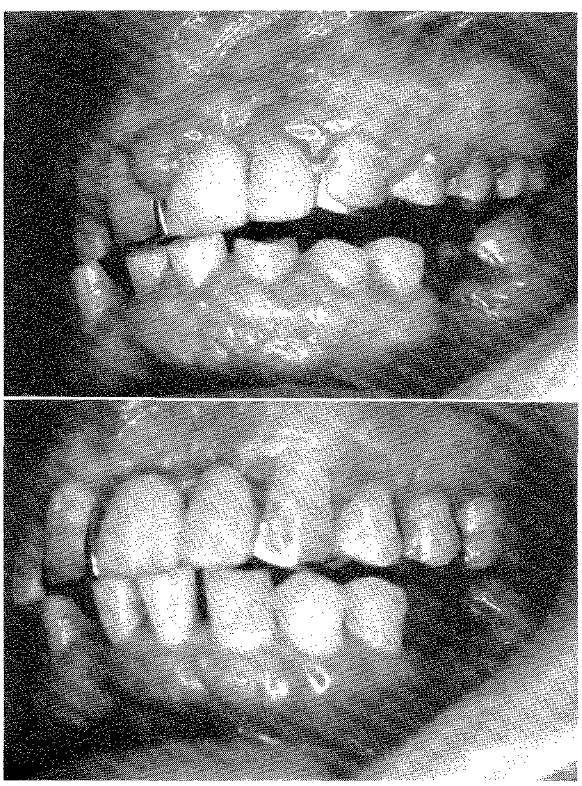


Fig. 4-44. A, Hyperplasia of gingiva caused by intake of Dilantin. B, Postoperative view after gingivectomy.

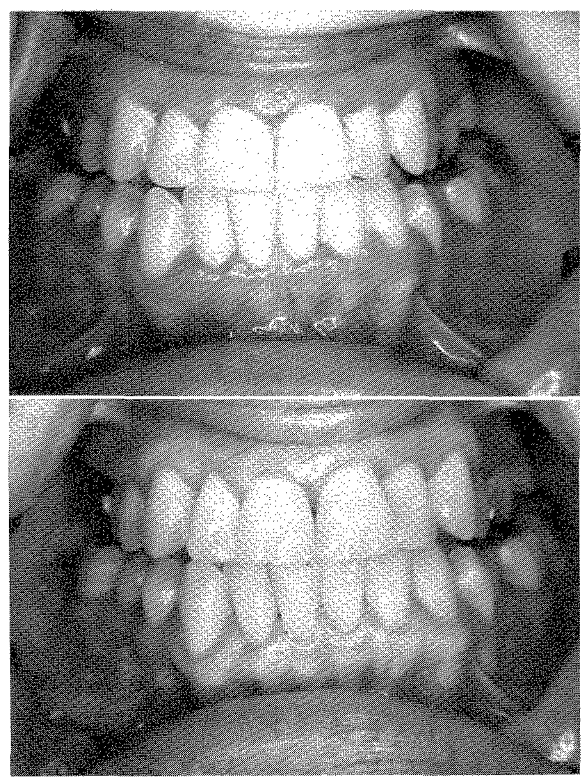


Fig. 4-45. A, Interproximal crater formation in recurrent necrotizing ulcerative gingivitis. B, Postoperative view after gingivectomy.

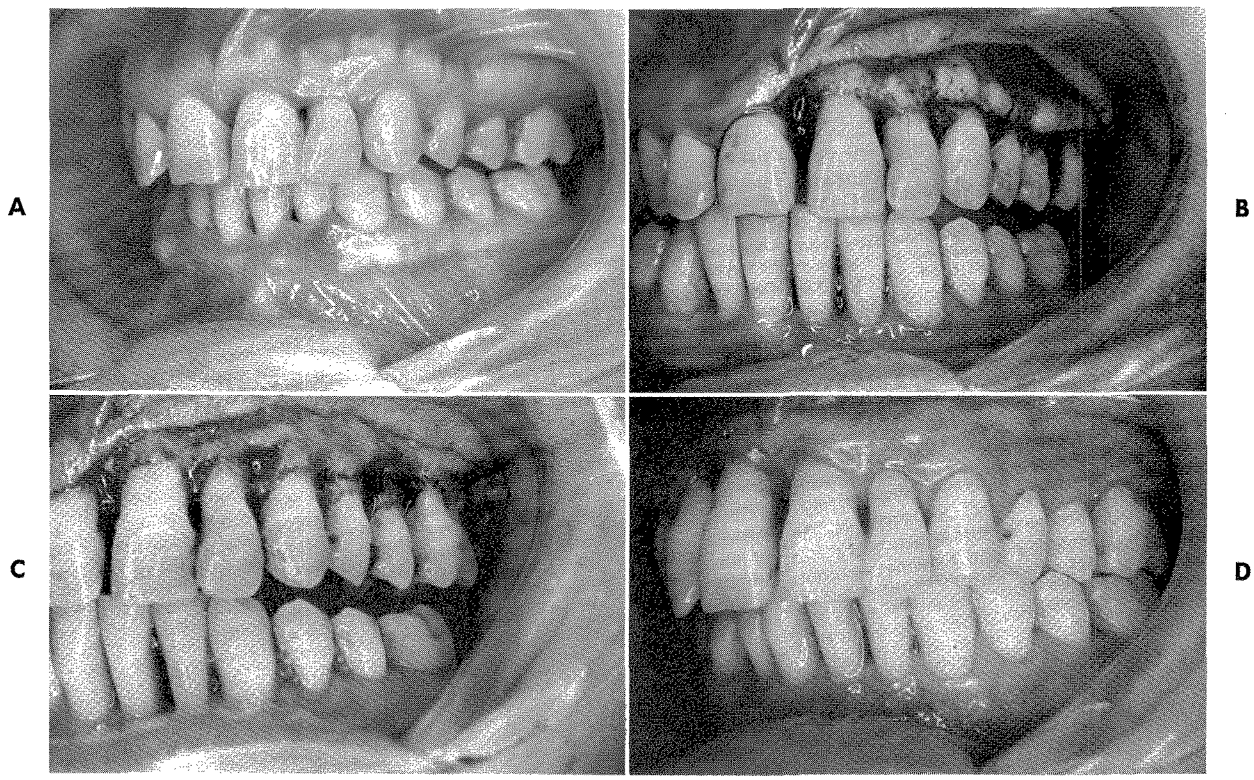


Fig. 4-46. A, Periodontitis. Pocket formation in upper left area extending to numerous exostoses of alveolar bone. **B,** Alveolar bone exposed. **C,** Osteoplasty. **D,** Postoperative view after osteoplasty.

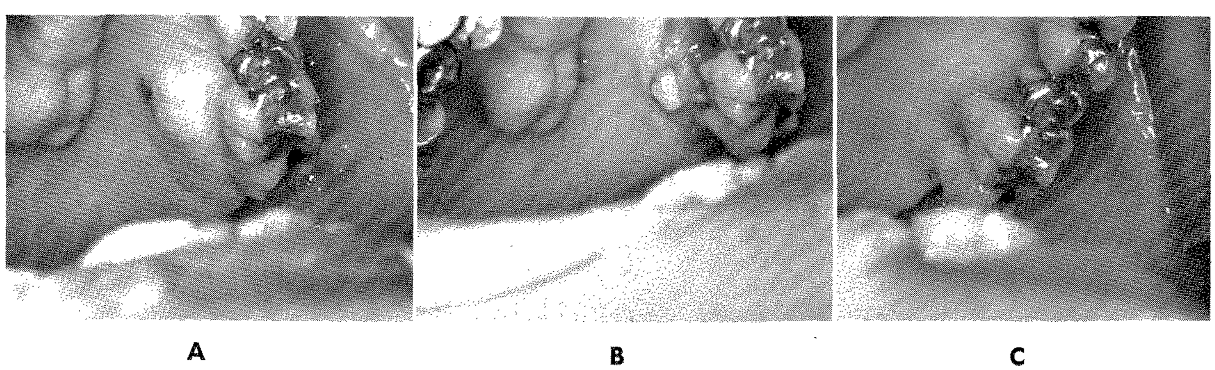


Fig. 4-47. A, Periodontitis. Pocket formation and large exostosis lingual of upper left first molar tooth. **B,** Exostosis exposed. **C,** Postoperative view after osteoplasty.

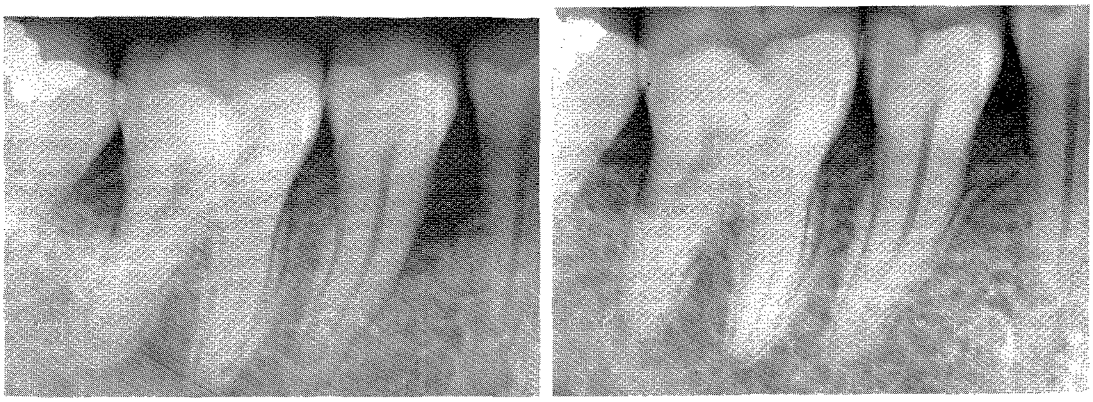
A  B

Fig. 4-48. A, Intrabony pocket mesial of lower left second bicuspid tooth. **B,** Postoperative view after operation for new attachment. (From Schreiber, H. R.: Oral Surg. **17**:161, 1964.)

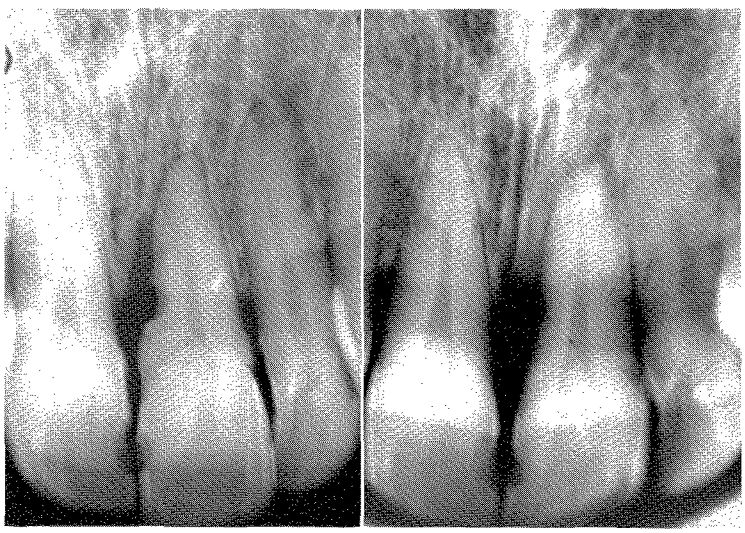
A  B

Fig. 4-49. A, Infrabony pocket mesial of upper right central incisor tooth. **B,** Postoperative view after operation for new attachment.

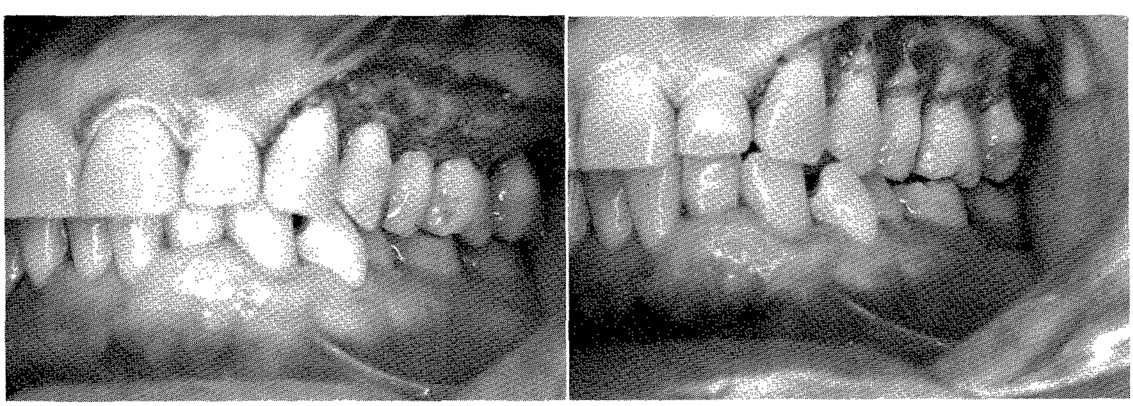
A  B

Fig. 4-50. A, Infrabony pocket present on buccal surface of upper left second molar tooth. **B,** Postoperative view after ostectomy to eliminate infrabony pocket of upper left second molar (osteoplasty performed about bicuspids and first molar teeth).

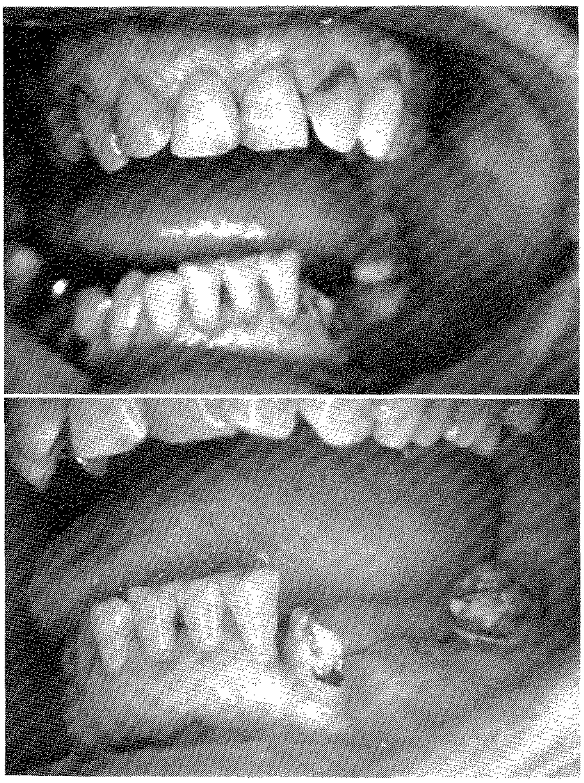
A
B


Fig. 4-51. A, Broken down crowns of lower left first bicuspid and second molar teeth. **B,** Postoperative view after ostectomy to expose root surface for full-coverage restorations.

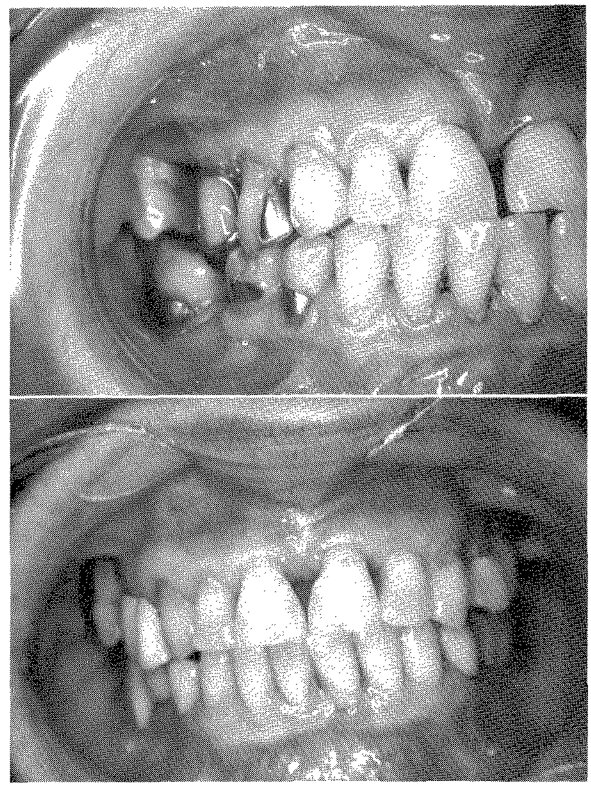
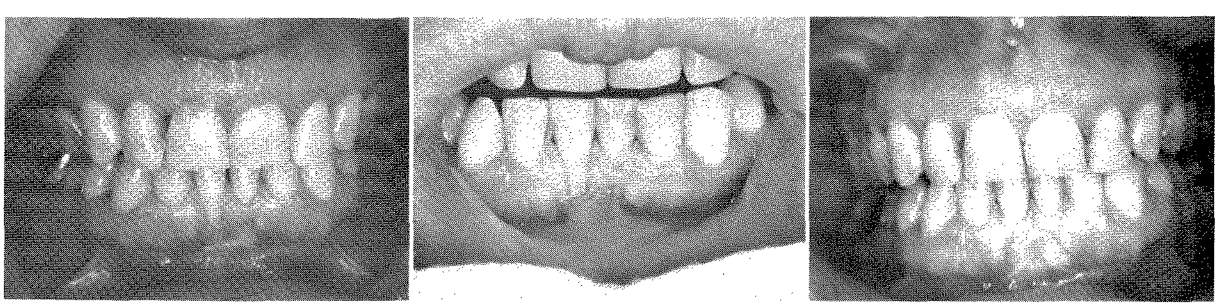
A
B


Fig. 4-52. A, Pocket formation about upper central incisors involving large frenum and separation of incisor teeth. **B,** Postoperative view after frenectomy and ligation of incisor teeth.



A B C

Fig. 4-53. A, Gingival recession about lower right central incisor tooth caused by improper toothbrushing and broad lower frenum attachment. **B,** Enlargement of frenum in **A. C,** Postoperative view after frenectomy and lowering of attachment of incisive and mental muscles.

A

B

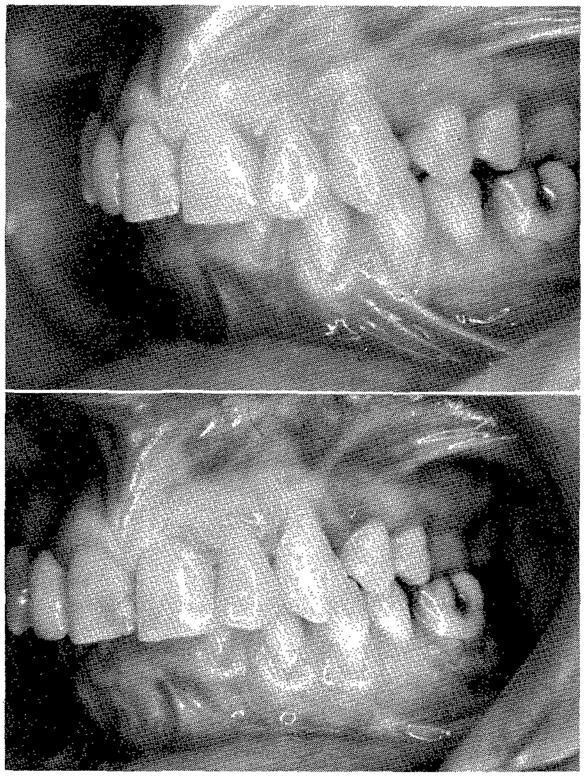


Fig. 4-54. A, Gingival recession about lower left first bicuspid tooth with lateral frenum pull. **B,** Postoperative view after frenectomy.

A

B

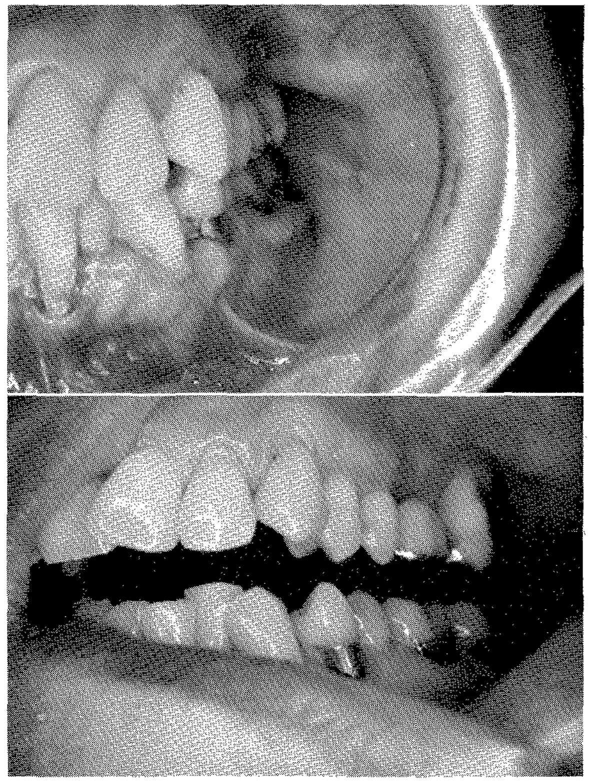
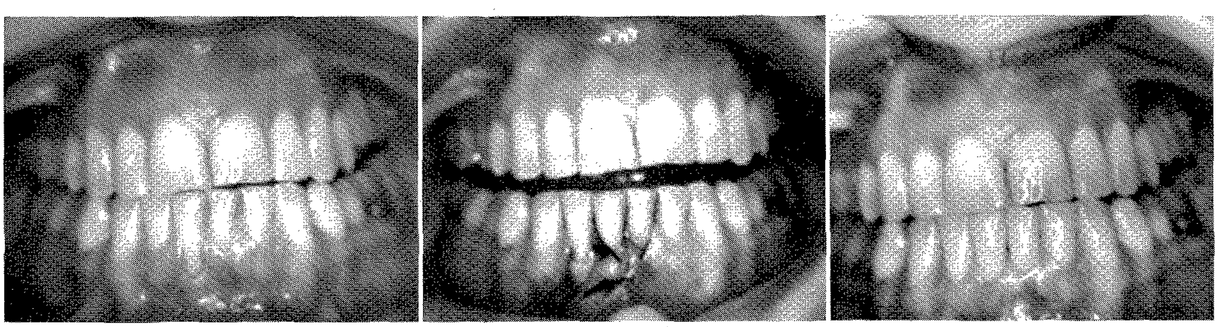
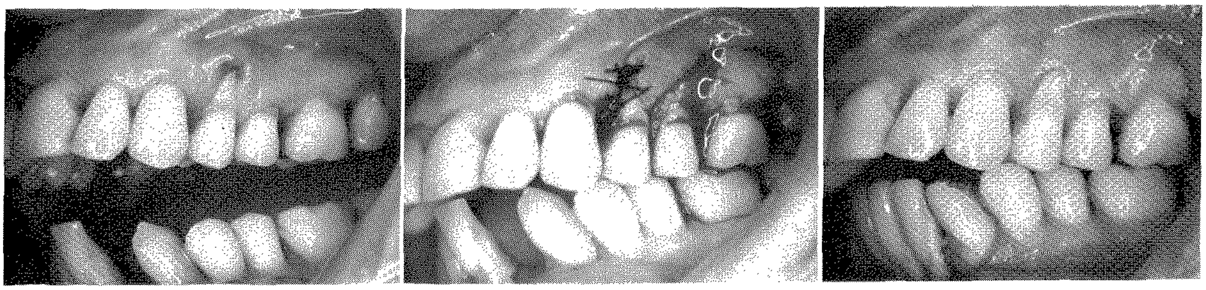


Fig. 4-55. A, Buccal mucosa and buccinator muscle attaching near gingiva about upper left second molar tooth. **B,** Postoperative view after separation of buccinator muscle attachment and deepening of vestibular fold.



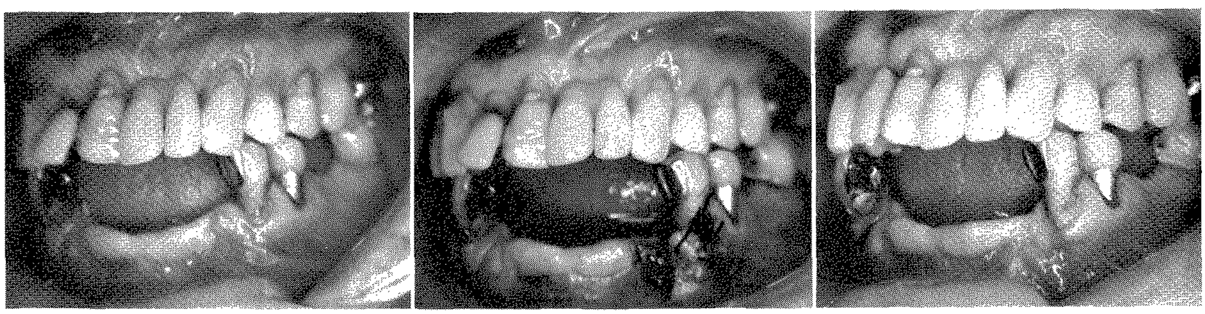
A B C

Fig. 4-56. A, Recession of gingiva about lower right central incisor tooth. **B,** Lateral repositioned flap from lower right lateral incisor area. **C,** Postoperative view after lateral repositioned flap. Attached gingiva now present about lower right central incisor tooth.



A B C

Fig. 4-57. **A,** Severe recession about upper left first bicuspid tooth with pocket formation in alveolar mucosa to vestibular fold. **B,** Lateral repositioned flap from upper left second bicuspid area. **C,** Postoperative view after lateral repositioned flap. Attached gingiva has replaced alveolar mucosa about upper left first bicuspid tooth.



A B C

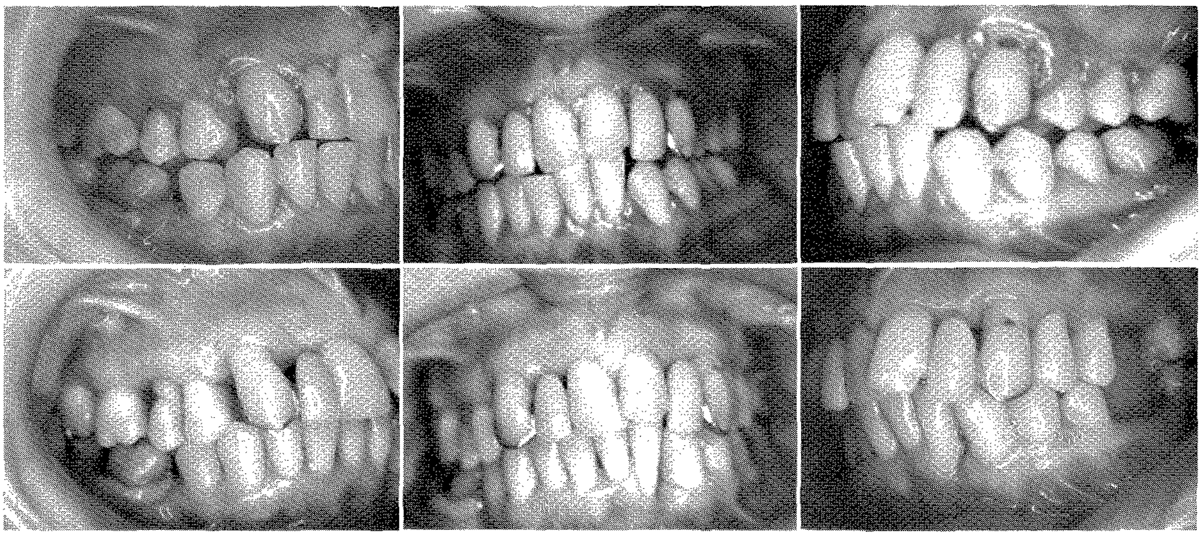
Fig. 4-58. **A,** Pocket in alveolar mucosa about lower left first bicuspid tooth. **B,** Lateral repositioned flap from edentulous ridge area. **C,** Postoperative view after lateral repositioned flap. Attached gingiva has replaced alveolar mucosa about lower left first bicuspid tooth.

A B C

D E F

Fig. 4-59. **A** to **C,** Periodontitis, moderately advanced. **D** to **F,** Postoperative views after mucoperiosteal flaps with internal beveled incisions. Elimination of pockets with retention of attached gingiva. Orthodontic appliance with bite plane was used to correct overbite.

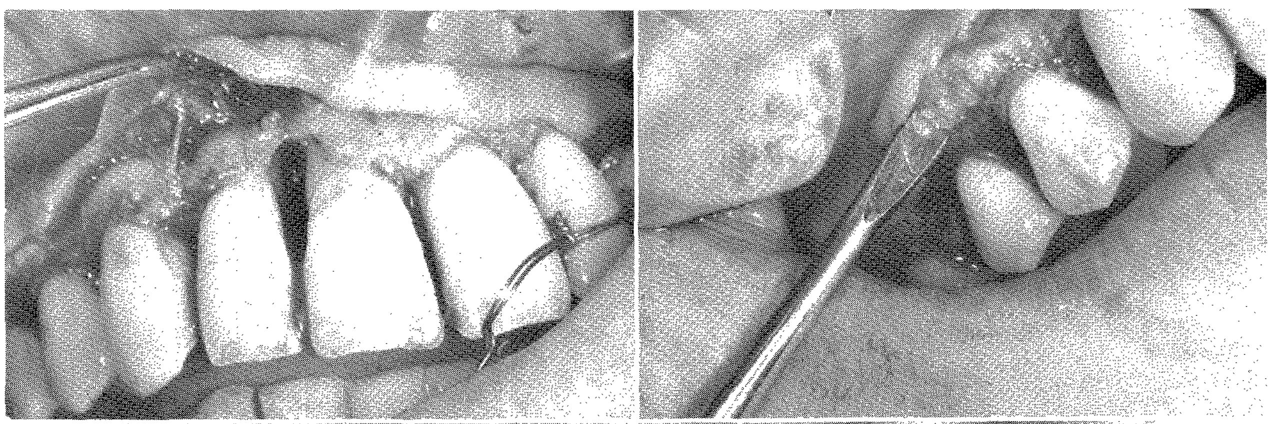
A B C



D E F

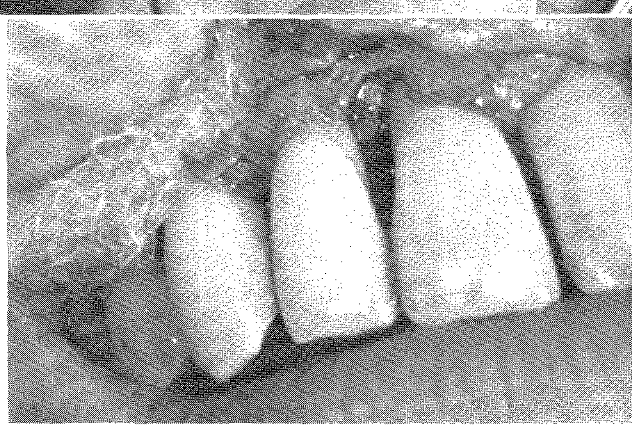
Fig. 4-60. **A** to **C**, Periodontitis, well advanced. **D** to **F**, Postoperative views after apically repositioned flaps. Elimination of pockets with apical repositioning of attached gingiva and alveolar mucosa.

A



B

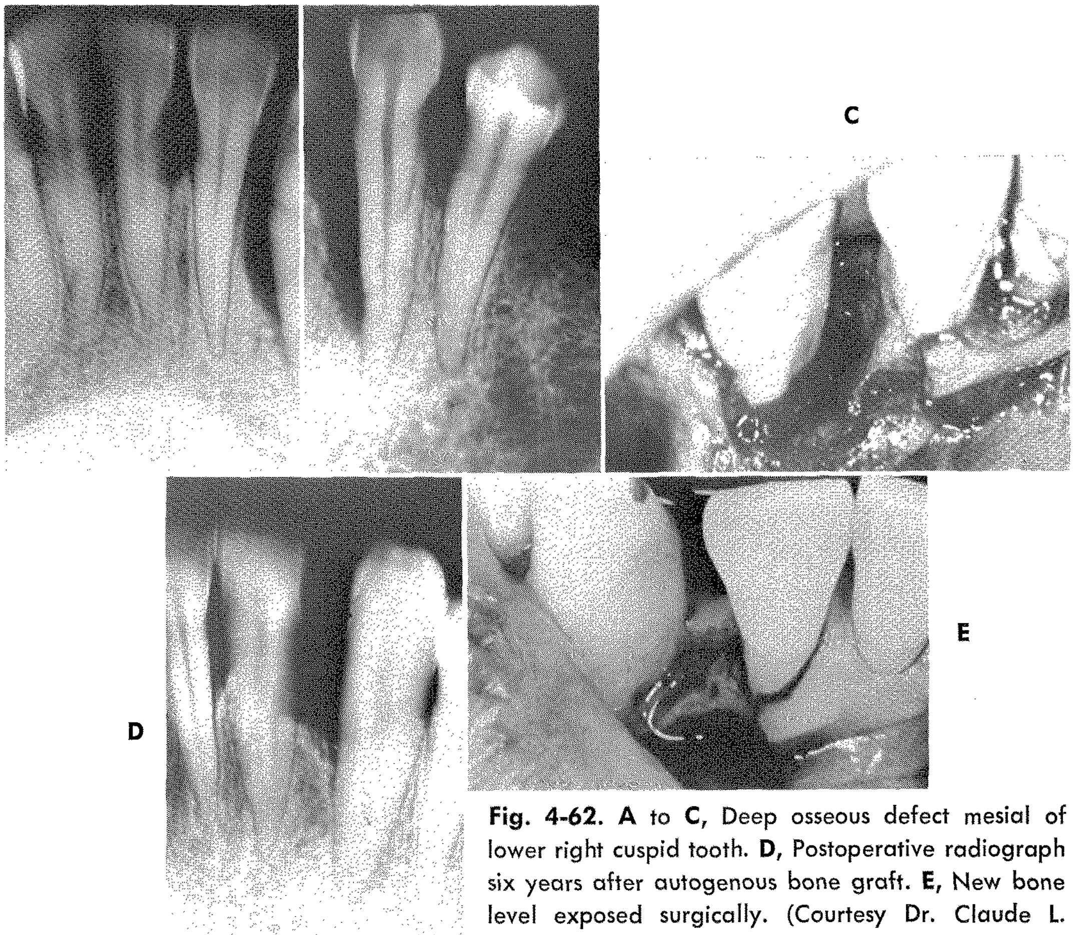
C



D

Fig. 4-61. **A**, Osseous defect distal of upper right central incisor tooth. **B**, Autogenous bone being removed from donor site. **C**, Autogenous bone placed in defect. **D**, Postoperative radiograph after eleven months. (Courtesy Dr. Edward F. Sugarman, Atlanta, Ga.)

A B C



D E

Fig. 4-62. **A** to **C**, Deep osseous defect mesial of lower right cuspid tooth. **D**, Postoperative radiograph six years after autogenous bone graft. **E**, New bone level exposed surgically. (Courtesy Dr. Claude L. Nabers, San Antonio, Texas.)

A

B

Fig. 4-63. A, Osseous defect about lower right cuspid tooth. **B**, Postoperative view three years after autogenous bone graft. (Courtesy Dr. D. Walter Cohen, Philadelphia, Pa.)

A B C D

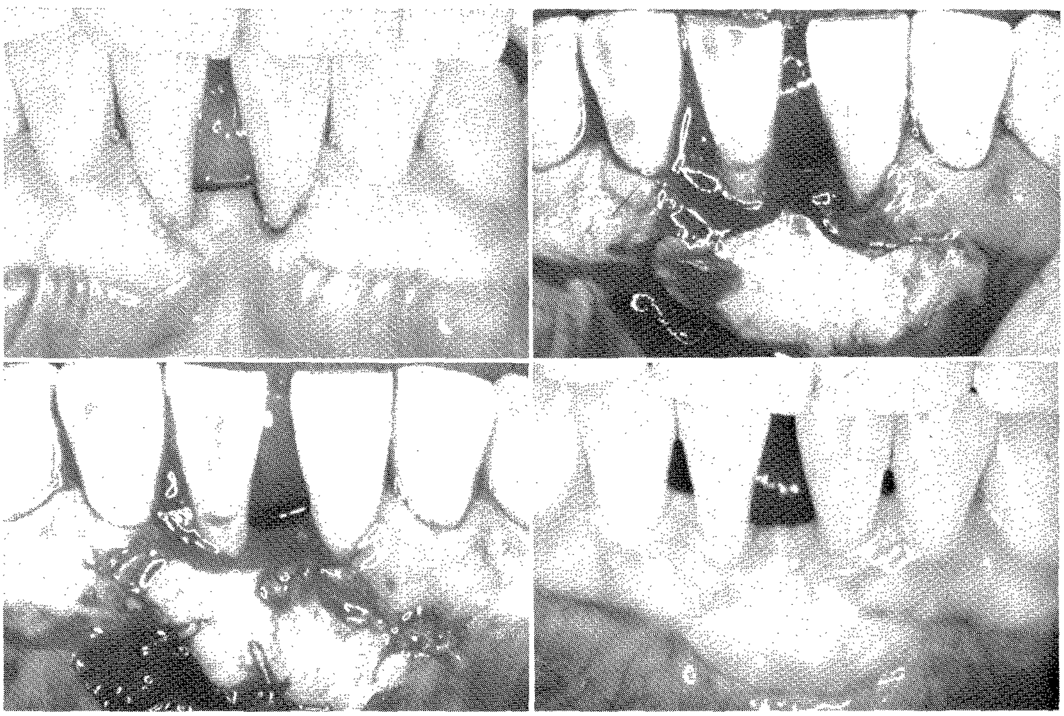


Fig. 4-64. A, Absence of attached gingiva about lower central incisor teeth with involvement of labial frenum. **B,** Excision of alveolar mucosa and frenum and placement of a free gingival graft. **C,** Free gingival graft sutured in position. **D,** Postoperative view five months after free gingival graft. Attached gingiva now present about lower central incisor teeth and elimination of frenum pull. (Courtesy Dr. John M. Nabers, Wichita Falls, Texas.)

REFERENCES

1. Bowers, G. M.: A study of the width of the attached gingiva, J. Periodont. 34:201, 1963.
2. Fish, S. W.: Etiology and prevention of periodontal breakdown, Dent. Progr. 1(4):234, 1961.
3. Glickman, I.: Clinical periodontology, Philadelphia, 1964, W. B. Saunders Co.
4. Goldman, H. M., Schluger, S., Fox, L., and Cohen, D. W.: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co.
5. Grant, D., Stern, I. B., and Everett, F. G.: Orban's periodontics, ed. 2, St. Louis, 1963, The C. V. Mosby Co.
6. Provenza, D. V.: Oral histology, Philadelphia, 1964, J. P. Lippincott Co.
7. Sicher, H.: Orban's oral histology and embryology, ed. 6, St. Louis, 1966, The C. V. Mosby Co.

Chapter 5

Prosthetic-periodontal interrelationships

General considerations

The most important task in dentistry is the preservation and maintenance of the natural dentition in health. Restorative dentistry and periodontics are interdependent and interrelated in this particular objective.

The periodontal tissues are the ultimate testing ground for the validity of all concepts of occlusal function. In the final analysis the response of the periodontal tissues is the yardstick by which longevity of prosthetics is measured.[1]

Modern periodontic concepts have made possible the retention of many teeth that previously were condemned for extraction, in spite of the fact that the treated dental apparatus is somewhat different than the normal. Reference is made here to new sulcular depths, variations in crown-root ratios, embrasure spaces, bifurcation and trifurcation areas, etc. The proper periodontal environment is created before restorative procedures are undertaken.

The close interrelation of periodontal health and correct prosthetic function is of the utmost importance. The functional stimulation provided by the properly designed and executed dental restorations is supportive to the periodontium and is essential for its preservation. Similarly, periodontal health is very necessary for the proper function of the dental restorations. In other words, the periodontal tissues must be restored to health, and the operative and fixed prosthesis must be constructed in a manner that fulfills the necessary biologic concepts for the maintenance of this healthy state.

We not only establish an environment that is conducive to the health of the peridontium but also to the physiologic function of the muscles, temporomandibular joints, and associated structures. We must not transgress the periodontium, the joints, or the muscles. The aim of good dentistry is to create optimal functional conditions in order to give the supporting dental tissues and associated structures the optimal chance of maintenance or recovery under pathologic conditions.

The theme of this chapter is the stability of teeth in the periodontium and the maintenance of the health of the attachment apparatus. Among other things, it will deal with the biologic implications of occlusal forces in the maintenance of periodontal health. *It will deal with form and function—form as it relates to function.*

Despite the fact that I am thoroughly in accord with the modern concept of periodontics, I might add that complete pocket elimination, as important as it is, comes to naught if stability in function is not attained. Therapeutic procedures directed solely at eliminating pocket depth, with failure to give adequate consideration to the causative influences, will only result in the perpetuation of the disease. It is necessary to eliminate all other factors capable of impairing the reparative capacity of the tissues. In many cases periodontics alone is not enough.

BASIC OBJECTIVES OF PERIODONTAL PROSTHESIS

Following are the basic objectives of periodontal prosthesis.

1. To reduce lateral stresses
2. To distribute stresses equitably
3. To eliminate areas of food impaction
4. To eliminate premature and/or deflective contacts; elimination of occlusal traumatism—primary or secondary
5. To direct occlusal stresses of functional forces in the long axes of the teeth with the removal of any conflict between joint and teeth during normal function
6. To correct tooth contours
7. To correct temporomandibular joint conditions

To accomplish these objectives, a number of factors must be taken into consideration.

1. In planning treatment for a debilitated dentition, a major objective is the sequential intergration of all technical procedures—periodontal, surgical, orthodontic, endodontic, and prosthodontic.
2. Therefore, one must be trained not only in prosthodontics, but must develop an overall concept, particularly in periodontics, endodontics, and orthodontics.
3. A careful mounting of the patient's dental casts should be made on an instrument that copies his mandibular movements so that a diagnosis of the functional relations may be made by studying them in conjunction with roentgenograms and all other available data (muscles, joints, systemic factors, and parafunctions).
4. It is of the utmost importance to give certain form to teeth and certain relation of teeth to each other in order to ensure the health of the periodontium. All this, of course, implies an understanding of the normal function of the stomatognathic system.

The oral cavity must be considered as a whole, a tooth being an integral part of a highly organized mechanism that, in the ideal, functions harmoniously and physiologically.

The fundamental requirement of a successful biomechanical result is a harmonious relationship between form and function. Therefore, the object of periodontal prosthesis is, by alteration of the functional relations, to create forms that will reduce stress and distribute forces throughout the entire supporting structures of the mouth. But to achieve this, these tooth forms also must be in harmony with the muscles and temporomandibular joints. We must use every tool at our command and not place our reliance on treatment of local factors alone. We must take intelligent advantage of the tools and knowledge that are available so as not to hamper nature in her struggle to maintain a healthy mouth.

To reduce the forces and stresses by a harmonious relationship between form and function, nature provided us with cusps. Unlike the mandible of the herbivorous animal the human mandible in all its paths of motion, horizontal or vertical or any combination of the two, describes arcs that demand natural cusp forms to maintain a state of functional equilibrium as a means of avoiding stresses resulting from unequal forces.

Compromises in cusp forms that, by oversimplification, attempt to circumvent the physiologic requirements of healthy supporting structures become pathologic cusp forms, which end by defeating themselves. Nature's response in an effort to achieve functional equilibrium with pathologic cusp forms results in the drifting of teeth, inflamed and thickened gingival tissues, loose partial dentures, etc.

Splinting will prevent teeth from drifting, but will not prevent stresses on supporting structures. Splinting is necessary when the functional relations are such that it is impossible to achieve functional stability of individual teeth. However, splinting is not a crutch to be used as a substitute for adequate occlusal forms.

Now to the question of the part adaptation plays in condoning our sins of omission. The burden of struggling to adapt to pathologic functional relations creates stresses that, when they exceed physiologic limits, become an intolerable insult, to which nature's response is inflammatory anger.

It is the lack of adaptation that produces the sick mouth. It would appear then that the objective of restorative treatment is to create a prosthesis that is adapted to the individual requirements of form and function, to obviate the forces and stresses resulting from lack of adaptation.

A knowledge of the science of occlusion is necessary for the proper correction of the local tooth contact mechanism so that it is capable of functioning in physiologic equilibrium with the periodontal supporting tissues. The better the functional relation between the maxillary and mandibular teeth in every possible position, the more favorable is the strain on the supporting tissues.

"Occlusion in its fullest interpretation includes a knowledge of the anatomy and physiology of the muscles of mastication, the temporomandibular articulation, of jaw-to-jaw relationships, tooth form and position, mandibular movements, vertical dimension, functional and afunctional uses and abuses of teeth, of the periodontal supporting tissues, that is, the periodontal ligament, and, above all else, the alveolar bone and its reaction to the transmission of stresses to it by tooth contacts through muscle power.

"In all studies and treatment of occlusions a differential diagnosis must be made between discrepancies of jaw-to-jaw relationships and tooth-to-tooth positions.

"The determination of correct jaw-to-jaw relationships and tooth-to-tooth positions is based on an understanding of centric relation and centric occlusion.

"A physiologic occlusion implies a balance between occlusal stress and tissue resistance. It may be natural to the individual or it may be acquired through reconstruction.

"*Occlusal* stress is based on: (1) *function*, which may be masticatory or non-masticatory, (2) *force*, which is initiated by the muscle and transmitted by the teeth, and (3) *tissue* resistance, which is represented by the bone and the periodontal ligament.

"It then becomes clear that in order to produce an acquired physiologic occlusion which will balance occlusal stress and tissue resistance, our efforts in equalization must be concerned with the muscles, tooth form, tooth position, jaw relationship and function."*

In other words, the biomechanics in these cases requires a balance between the forces of occlusion and the resistance of the periodontal supporting tissues.[3] An occlusal concept must be correlated intimately with the influencing factors of the temporomandibular articulation and the incisal guidance.

*From Fox, Lewis: The occlusal factor in periodontal disease, Alpha Omegan 43:124-133, 1949.

Obtaining basic objectives

Now the question arises—how do we attain these goals?

First, a complete examination must be made so that we can arrive at a properly evaluated diagnosis and thereby be able to evolve a total treatment plan. In this way we know what type of case faces us—(1) is it just a case of bad dental work complicated with some gingival inflammation and a primary occlusal traumatism requiring some curettage, some selective grinding, well-made restorations constructed on an adjustable articulator, and proper home care instructions, or (2) is it a bad, periodontally involved mouth with mobile teeth, migrations, osseous lesions, collapsed posterior bite, etc? The latter is my idea of an example of the indication for procedures referred to as periodontal prosthesis. In these type of cases, after hopeless teeth have been removed, curettage, repositioning of teeth, gross selective grinding (if necessary after tooth movement), osseous and mucogingival surgery, and provisional splinting to help redirect eccentric stresses into direct forces within the long axes of the teeth must be done, and usually in that procedural order. It is in the provisional stage that the case can be evaluated properly as to the possibility of achieving our treatment objectives. If this is possible in the provisional stage, the treatment objectives will carry over to the permanent stage. By creating a different environment the dental mechanism can survive.

Much debate goes on as to partial versus full coverage in tooth preparations used in periodontal prosthesis. In what has been mentioned previously as a case of bad dental work, without serious complication, it really does not matter most of the time which type of preparation is used because there are no problems of crown-root ratios, coronal contours, embrasure forms, and unilateral or bilateral splinting.

However, in the second example, a case in need of involved periodontal surgery that will alter the architectural form, the embrasures, and gingival position, only full coverage can be considered. The biomechanics of the case requires full coverage.

It must be kept in mind that the full crown is the most difficult restoration to make properly in our whole repertoire of restorations—because it is almost humanly impossible to reproduce the anatomic contours of a tooth in its entirety, especially in its proper relation to the gingival tissues for maintenance of periodontal health. Intelligent, well-trained, and sincere dentists, being quite aware of what has just been written, would not use full coverage if partial coverage would suffice, but, for the survival of an involved periodontal prosthesis case, full coverage is a "must," utilized with finesse, understanding, and precision technique. Full coverage must provide an architectural environment capable of maintaining and preserving the integrity of the supporting structure.

Another important step that we are trying to achieve is an accurate method of transferring records of oral movements to an instrument so that all the work can be done on that instrument.

The accurate recording and transferring of mandibular relations is now attainable, provided certain principles are understood and executed carefully.[4,5]

We must concern ourselves with a *center* that can be easily located and can be useful for our procedures—in other words, a center that will enable us to reproduce the patient's movements on a suitable articulator.[6]

In the evolution of our knowledge of functional harmony the face-bow has come to play a very prominent part. Pioneers in this field—Snow, Gritman, Gysi, and others—recognized the need for a means of orienting the cusps to each other in a rotational relationship that would produce a vertical thrust within the axis of the supporting structures.

The hinge-bow is a precise refinement of the philosophies known and tested for over sixty years. The importance of the hinge axis mounting does not lie alone in the convenience of opening or closing the bite on an articulator. If that was its only objective, we could achieve it by simple repeated remountings with successively thinner bites. The real importance of the hinge axis is the fact that it is the inescapable anatomic center of all rotary movements of the mandible as the teeth make contact with each other, whether it be mastication, swallowing, or bruxing.

A conventional face-bow mounting in which the position of the stylus pins is altered to conform to the fixed intercondylar distance of the articulator can cause the axis to be displaced by as much as ½ inch (Fig. 5-1).

Weinberg[7] pointed out that biologic variables must be considered a source of error in all techniques. Steel instruments are precise and rigid, whereas muscles, ligaments, and bone have a degree of physiologic tolerance. The effect of external stimuli—pain, temperature of waxes, muscle distention, weight of instruments, muscle tone at time of measurement, head position, force exerted by the dentist, the psychic stimuli by the patient or dentist—is another variable factor.

I believe that our ability to treat and save mouths is directly related to our ability to capture and transfer jaw function to the restoration. If we do just that, according to Stuart and Stallard,[8] (1) the cusps will be well geared to the axes of the condyles. Achieving this, the teeth are

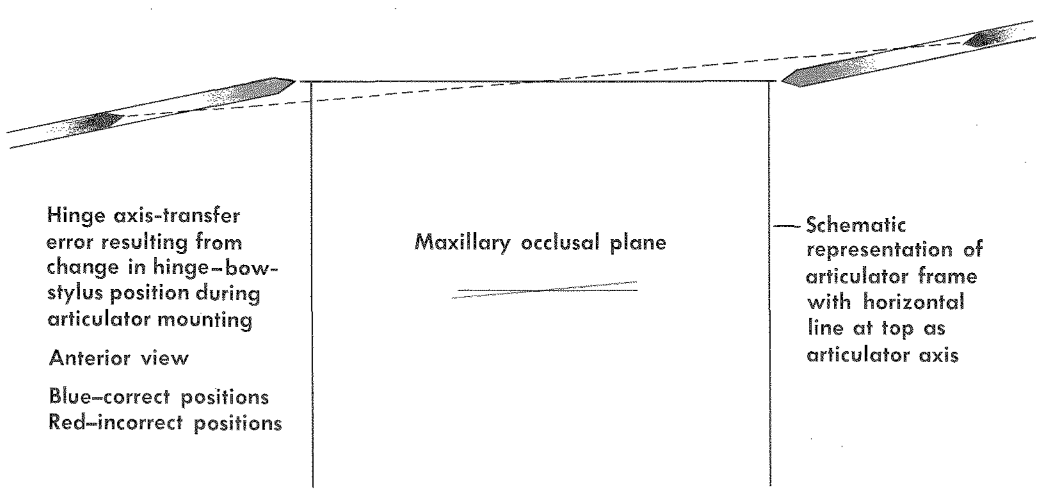


Fig. 5-1. Alteration of position of stylus pins to conform to fixed intercondylar distance of articulator (which usually occurs in a conventional face-bow mounting) can cause axis to be displaced by as much as ½ inch.

strengthened and stabilized, and premature wear is kept to a minimum; (2) the directions of the grooves will conform to jaw motions, and the cusps will have grooves to work in and grooves to idle in without colliding (the grooves between cusps are channels in which cusps may travel without collisions); and (3) the timing of the Bennett movement which is expressed in the concavity of the lingual surface of the upper cuspid is dependent upon the lateral condylar movements.

By gearing the cusps to the axes of the condyles, the new restorations are then shaped so that the cusps of the teeth glide by each other without interference, never touching, but shearing the food by reason of the close tolerances created in the carvings of the restorations.

PROTECTION OF INVESTING TISSUES

In many instances patients will come to us with some form of periodontal disease, and they will be told that their present pathologic condition can be arrested or cured. After extensive gingival or subgingival curettage or periodontal surgery, the crown and bridge restorations, as planned, are completed and cemented.

After a while, despite proper toothbrushing, stimulation, etc., these extensive and expensive restorations are surrounded by enlarged, edematous, and inflammatory gingivae. In some instances recession takes place. Why did this happen after so much time and effort had been expended by the dentist and/or periodontist? Why, after our primary objective to cure pathology had been accomplished, has pathology been recreated? Probably we have failed to take into consideration what constitutes correct tooth preparation and impression taking in these cases, the importance of physiologic tooth form as applied to both the temporary coverage and permanent restoration, and the importance of tooth position and function. Tissues that are allowed to become inflamed and distorted architecturally certainly will jeopardize the final result and often will be the cause for failure. It is directly proportional to the correctness of the crown-tissue relationship. The crown must create the maximum opportunity for the maintenance of the health of the free marginal gingiva and the gingival sulcus, and it should not create a gingival problem or further periodontal disease. Existence of systemic disturbances capable of altering the periodontal tissues also will impair the maintenance of a healthy periodontium.

It has been said many times that subgingival extensions of full-coverage margins produce an environment unfavorable to the health of the marginal gingiva, resulting in tissues that are more rolled, more thickened, and more inflammatory in character. Is this the fault of the restoration or the dentist? Can a better understanding of tooth form and function, cavity design, and skillful and careful use of the necessary tools and materials prevent this catastrophe? I think so.

Criteria for success in periodontal therapy

At this point let us establish the criteria for success in periodontal therapy:

1. One factor is the conversion of a pathologic gingival attachment to health. The gingivae should be firm, pink, and with physiologic architectural form. The sulci should be of a depth within the range of "norm."
2. The tooth should be capable of physiologic function. It should be firm in the socket and should function without tenderness or movement.
3. Roentgenographically, the crestal bone should be cortical in character, and the lamina dura should be intact.
4. The periodontal climate should be conducive to health for maintenance.
5. The oral hygiene program should be satisfactory.
6. The dentition should function as a healthy apparatus.[9]

In periodontal prosthesis we must deal with the restoration of alterations in form as it relates to function. It is essential to master typical preparations and procedures, but it is also advisable to learn the fundamental principles that enable us to introduce change when function dictates deviation.

A healthy periodontium, in which the free gingival margin is in a stable relationship to the tooth, is essential to the success of the restoration. This healthy periodontium must exist prior to the making of the preparation and must be maintained after the restoration has been placed.

In health, the exposed part of the tooth in the mouth is surrounded by a peripheral seal (epithelial attachment) regardless of the gingival level or contour. Our operative and restorative procedures must try to preserve this protective feature.

Clinical analysis of periodontal problems

TRAUMA FROM OCCLUSION

The resistance of the periodontium to occlusal load takes place in the attachment apparatus—cementum, periodontal ligament, and alveolar bone.

Because of the design of this system, vertical forces generally are tolerated better than horizontal forces. The principal and periapical fibers of the periodontal ligament are arranged to withstand the forces best in a vertical direction, parallel to the long axis of the tooth.

It generally is recognized that trauma from occlusion and gingival inflammation represent different types of tissue changes that initially occur in different areas of the periodontium. Gingival inflammation starts in the gingival margin and is caused by local irritation, whereas trauma from occlusion involves the supporting periodontal tissues rather than the gingiva.

If trauma occurs and inflammation is present at the same time, the inflammatory reaction might extend into the tissues damaged by trauma. In other words (1) trauma is not a primary etiologic factor in producing periodontal disease—it is a severe aggravating factor—and (2) trauma may accentuate pocket depth if it occurs in association with other local irritants. In such instances trauma induces destructive changes in the

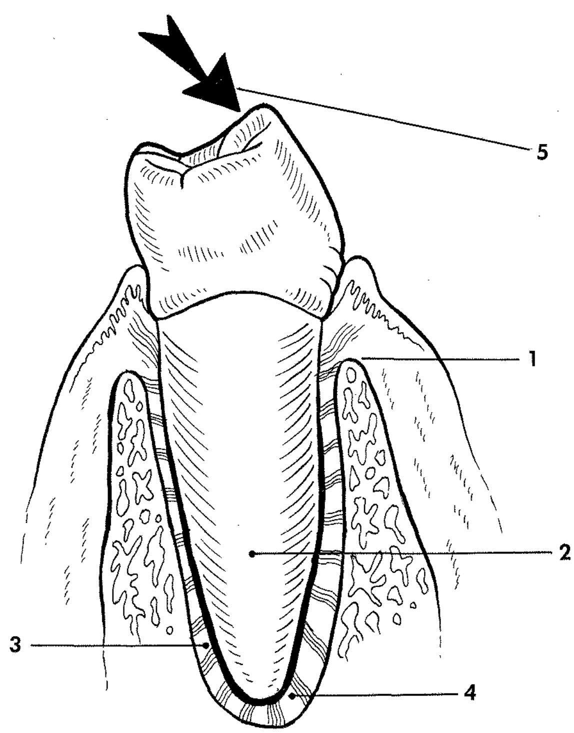


Fig. 5-2. Primary occlusal traumatism. *1,* Height of alveolar bone (normal); *2,* fulcrum point; *3,* area of pressure; *4,* area of tension; *5,* horizontally applied pathologic force. (Redrawn from Amsterdam, M., and Abrams, L.: Periodontal prosthesis. In Goldman, H. M., Schluger, S., Fox, L., and Cohen, D. W.: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co.)

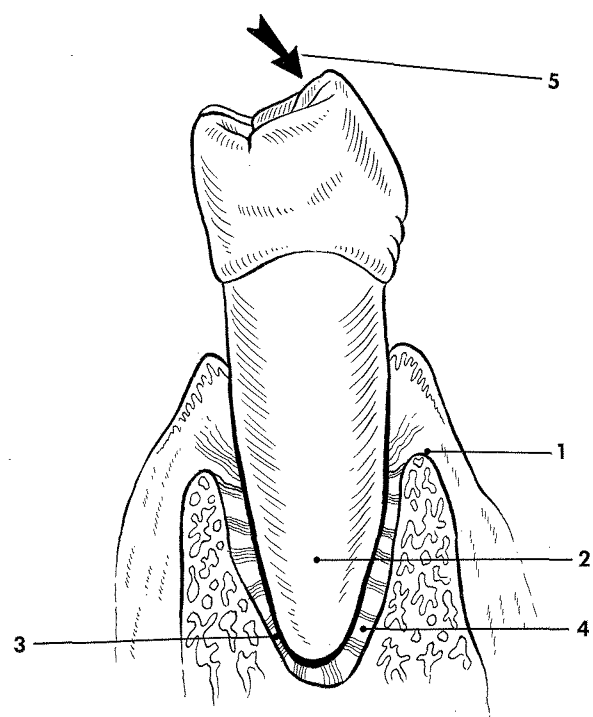


Fig. 5-3. Secondary occlusal traumatism. *1,* Height of alveolar bone (lost due to previous disease); *2,* fulcrum point; *3,* area of pressure; *4,* area of tension; *5,* horizontally applied force during normal function. (Redrawn from Amsterdam, M., and Abrams, L.: Periodontal prosthesis. In Goldman, H. M., Schluger, S., Fox, L., and Cohen, D. W.: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co.)

periodontal ligament, and inflammation in the marginal gingiva, within the confines of the gingival and transseptal fibers, is aggravated and spreads faster and farther into the tissues damaged by trauma. Trauma deflects the pathway of inflammation, and we have on our hands a biomechanical problem.

Primary occlusal traumatism is the result of excessive force in the presence of a normal amount of supporting tissue that will alter the attachment apparatus, but will not produce any significant gingival changes or form periodontal pockets (Fig. 5-2).[10]

Secondary occlusal traumatism is trauma coupled with gingival inflammation that creates a summative effect leading to the loss of supporting structure because of the inflammatory penetration into the periodontal structures, resulting in an apical migration of the epithelial attachment. This creates an alteration in form and function—a disparity of embrasure forms, crown-tissue relations, and marginal gingiva.[10] (See Fig. 5-3.) This type of condition produces a specific type of periodontal pathology, which is referred to as angular bone destruction.

Angular bone loss on opposing posterior teeth combined with a mobility pattern and a migration of anterior teeth caused by bone destruction creates a syndrome that points up the existence of direct and indirect trauma from occlusion.

A force is traumatic because the destructive changes it induces exceed the reparative capacity of the tissues. The extent of involvement of the supporting structures in a traumatic situation is dependent upon the interplay of direction, duration, intensity, and frequency of the applied force. The afunctional contacts of teeth produced by clenching and grinding habits also are important factors that require serious consideration.

Excessive forces upon the teeth result in pathologic changes, which are manifested clinically by mobility and/or migration of teeth because of a loss of the attachment apparatus necessary for tooth stability, temporomandibular disturbances, and roentgenographically by a widening of the periodontal ligament space, loss of lamina dura definition, root resorption, and resorption-induced radiolucencies of supporting bone. Cemental tears are in evidence, and it is somewhat of a common occurrence to observe pathologic attritional wear of teeth, cuspal and root fractures, and pulpal changes from a hyperemic pulp to one that has undergone degeneration.

It is therefore obvious that occlusal forces not only have influence on tooth structures, but also upon the structures of the periodontium; variations in the functional requirements are met by structural changes within the range of adaptability. Disturbances in this equilibrium can occur if the functional demands are beyond the tissue tolerance and adaptability. The physiologic limits of irritation must always be measured by the resistance values of the individual and his tissues. These resistance values must be computed on the basis of the presence or absence of certain signs and symptoms that are known to be associated with trauma from occlusion. In the absence of the signs and symptoms of periodontal breakdown, we may be justified in accepting health as evidence of repair and adaptation.

The aforementioned facts point up the importance of the creation of optimal functional conditions in order to give to the supporting tissues the optimal chance of maintenance or recovery under pathologic conditions. Avoidance of mesial and distal drifting, distorted lateral stresses, food impaction, and pocket formation cannot be overstressed.

CROWN-TO-ROOT RATIO

The relation of the clinical crowns to the clinical roots of the teeth is of the utmost importance. The crown-to-root ratio is the proportion between the clinical crown and clinical root, and it is important in the resistance against leverages of oral forces. This factor must be kept in mind when considering the problem of loss of supporting tissues, which creates an adverse leverage on the remaining alveolar housing of the teeth, and, if complicated by parafunctional movements, the problem becomes even more exaggerated. The ideal situation would be clinical crown and root ratios that are practically equal in proportion. If this is not possible, multiple abutments and splinting of teeth must be instituted to equalize as much as possible the ideal ratio balance.

In the evaluation of crown-to-root ratios the vertical aspect of the teeth is not the only factor to be considered, but also the size, shape, and form of the crown as it relates to the size, shape, form, number, and position of the roots. Axial inclination of the tooth and its relation to its

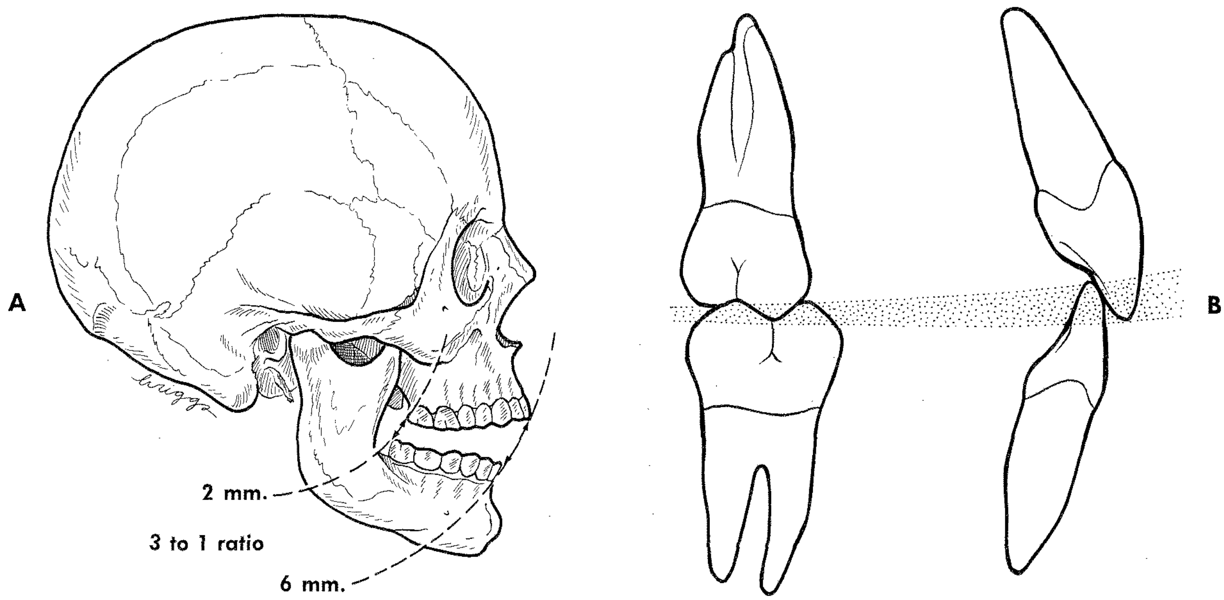


Fig. 5-4. Reduction in clinical crown length. **A,** Relative difference between opening in anterior part of mouth as compared to posterior area. Ratio is approximately 3:1. **B,** Difference between amount of overbite in anterior and posterior areas of mouth is shown as a shaded band. Any decrease in clinical crown length of posterior teeth will have a threefold effect on anterior teeth. (Redrawn from Amsterdam, M., and Abrams, L.: Periodontal prosthesis. In Goldman, H. M., Schluger, S., Fox, L., and Cohen, D. W.: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co.)

housing, as well as the type and amount of remaining bone and the number and distribution of remaining teeth, also must be considered seriously.

Reduction of the clinical crown length of the crown-to-root ratio that shows adverse leverages is a limited procedure, particularly in the posterior teeth, with the exception of extruded teeth and raised cusps on tilted teeth. Bohannan and Abrams[11] have shown that a 1 mm. reduction in posterior height results in a 3 mm. increase in the anterior overbite. Reduction of the height of anterior teeth is feasible, as a rule, allowing for better function and esthetics, but before performing this operation the problems of anterior incisal guidance, esthetics and phonetics, lip line, and the possibility of pulpal involvement should be studied carefully. Intentional or elective vital pulp extirpation is good clinical judgment and practice in many instances.

"Very little reduction can be accomplished on posterior teeth. The main reason for this is found in the mechanics of jaw closure and the relationship of the anterior and posterior parts of the dental arch to the center of mandibular rotation. The nearer the tooth is to the condyle, the shorter will be its arc of closure, and, consequently, the less distance it will travel in the closing movement. Because of this, a 1 mm. closure in the molar region may result in as much as a 3 mm. closure anteriorly (Fig. 5-4). Therefore, any effort to reduce the crown length of posterior teeth generally creates a problem anteriorly. This can lead to an unacceptable situation both esthetically and functionally, the "open bite" occlusion being an exception. Anterior teeth, on the other hand, can be shortened within esthetic limits to effect a more favorable crown-to-root ratio."*

As previously stated, intentional vital pulp extirpation is good clinical judgment and, in a number of cases, allows for the retention of teeth that would otherwise have to be sacrificed. This fact should be considered seriously when arriving at a total treatment plan. Should abutment

*From Bohannan, Harry M., and Abrams, Leonard: Intentional vital pulp extirpation in periodontal prosthesis, J. Prosth. Dent. 11:781-789, 1961.

teeth be moved into position orthodontically, should they be telescoped, or should intentional pulp extirpation be used? Not only is elective endodontics indicated sometimes in the reduction of crown length to effect a better crown-to-root ratio, but also in the establishment of parallelism of clinical crowns and in the reorientation of the plane of occlusion.

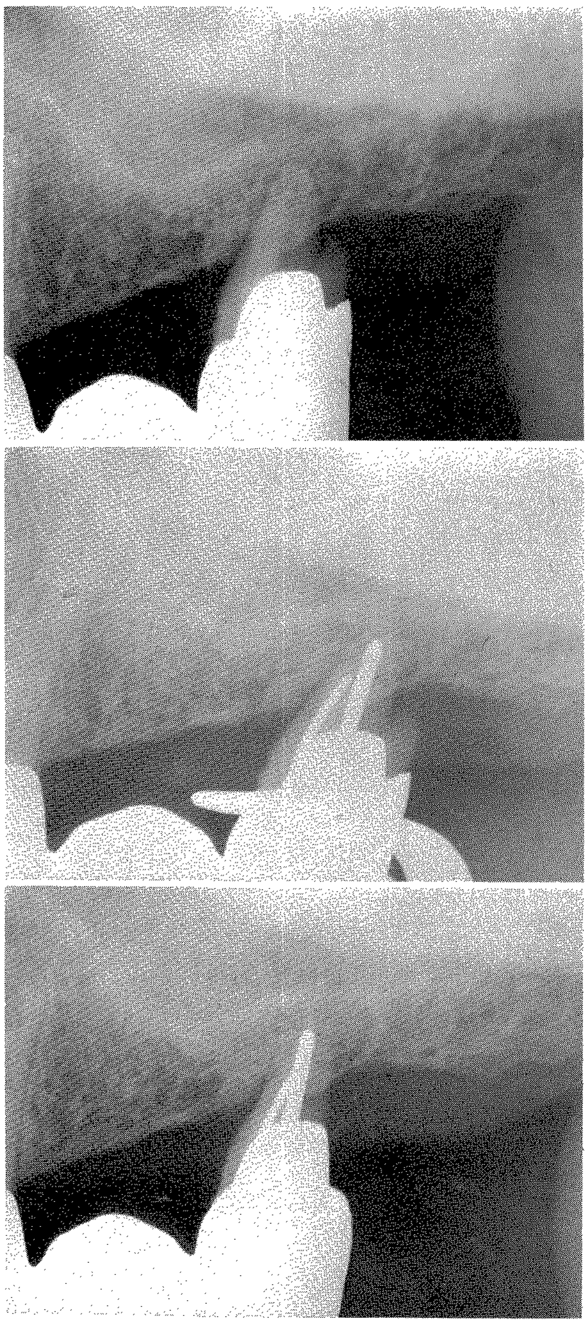


Fig. 5-5. Hopelessly periodontally involved root. Roots to be retained were treated endodontically, and involved root was split and removed.

ROOT RESECTION

In some cases of multirooted teeth involved periodontally the hopelessly diseased part of the tooth can be removed surgically, and the part that can be treated successfully, both periodontally and endodontically, may be retained to serve as an abutment tooth for a fixed prosthesis.

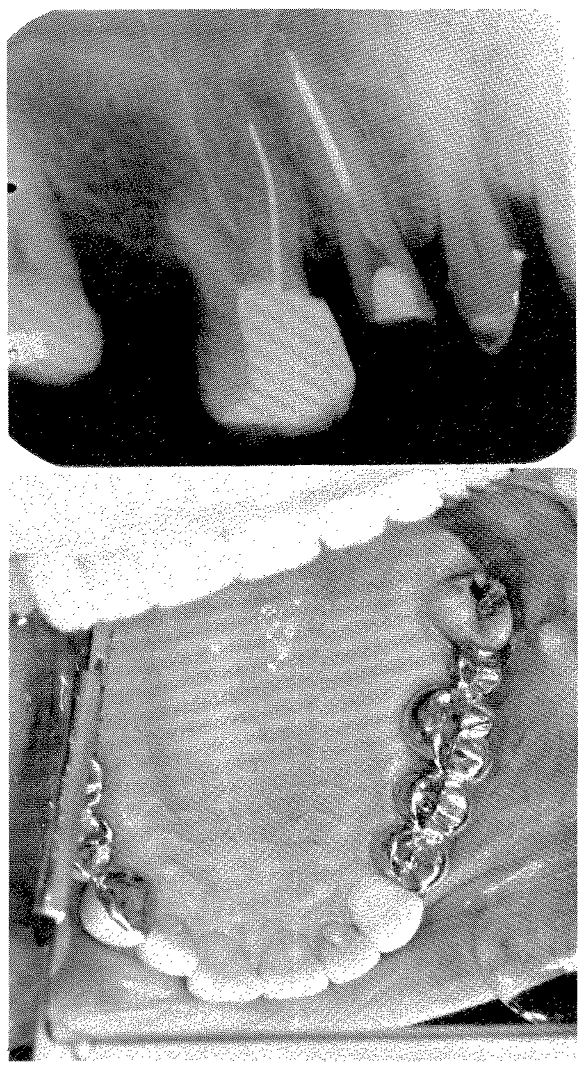


Fig. 5-6. A canal in a multirooted tooth (upper first molar) that could not be treated successfully by endodontic means. Flap was turned back and root resected, leaving entire crown intact. A fixed splint was constructed utilizing two bicuspids and this tooth as abutments to increase stabilization.

The feasibility of this plan hinges on whether the tooth structure that remains is sound with a substantial bony support, is located properly relative to its alveolar housing, and demonstrates an attachment apparatus with a well-defined lamina dura and thin periodontal ligament space as seen roentgenographically.

The periodontic and endodontic procedures must be executed successfully, correct occlusal relations and coronal contours must be established, stabilization must be attained by means of a fixed splint, and oral physiotherapy must be possible of attainment.[15,16]

The operative procedure is to treat the root to be retained endodontically and then to split the tooth and remove the hopelessly periodontally involved root (or roots) (Fig. 5-5). Stabilization by means of a provisional splint then should be instituted until there is sufficient evidence of periodontal healing, after which a permanent restoration can be constructed and positioned.

This therapy of root resection also can be used in cases in which all the canals of a multirooted tooth cannot be treated successfully by endodontic means. After the flap has been loosened and turned back, the root to be resected is severed at the cementoenamel junction with a fissure bur and is removed. The entire crown of the tooth is left in place. Usually double abutments are used in these cases to increase stabilization (Fig. 5-6).

CORONAL CONTOURS

Crown form and tooth position are important considerations in the etiology of periodontal disease. The restoration of the correct form of a tooth will help regain its function. Crown form plays an important role in the protection of the gingival tissues from the traumatizing effects of many foodstuffs, thereby making it essential for the gingival contours and the occlusal and incisal forms of the restored teeth to be shaped so as to shunt food and protect the marginal gingivae. The importance of the correct contour in the cervical third region of all teeth cannot be overemphasized, because while correct convexities assist in maintaining and protecting the health of the gingivae, an excessive contour in this area causes the investing tissues to lose their tone and also results in the formation of food pockets, causing a chronic inflammation of the gum tissues (Figs. 5-7 and 5-8).

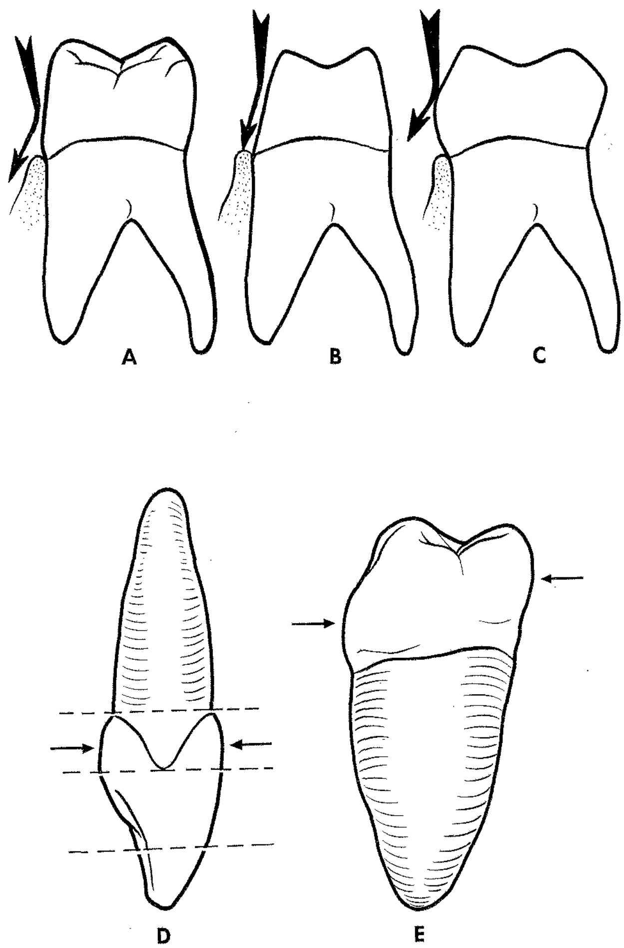


Fig. 5-7. Facial and lingual contours (protective). Schematic drawings of curvatures labially, buccally, and lingually. **A,** Normal curvatures as found on mandibular molar. Arrow shows path of food material as it is avalanched over these curvatures during mastication. **B,** Molar with little or no curvature. The gingiva is likely to be stripped or pushed apically through lack of protection and consequent overstimulation. **C,** Molar with curvature in excess of normal. Gingiva will be protected too much and will suffer from lack of proper stimulation. Food material and bacterial cultures may lodge under these curvatures, promoting pathologic disturbance. **D,** Normal cervical curvatures as found on maxillary incisors. The crests of curvature are opposite each other labiolingually. **E,** Curvatures as found on mandibular posterior teeth. Protective curvature is located at cervical third to buccal and at middle third to lingual surface. (Redrawn from Wheeler, R. C.: J. S. Calif. Den. Ass. **31**:382, 1963.)

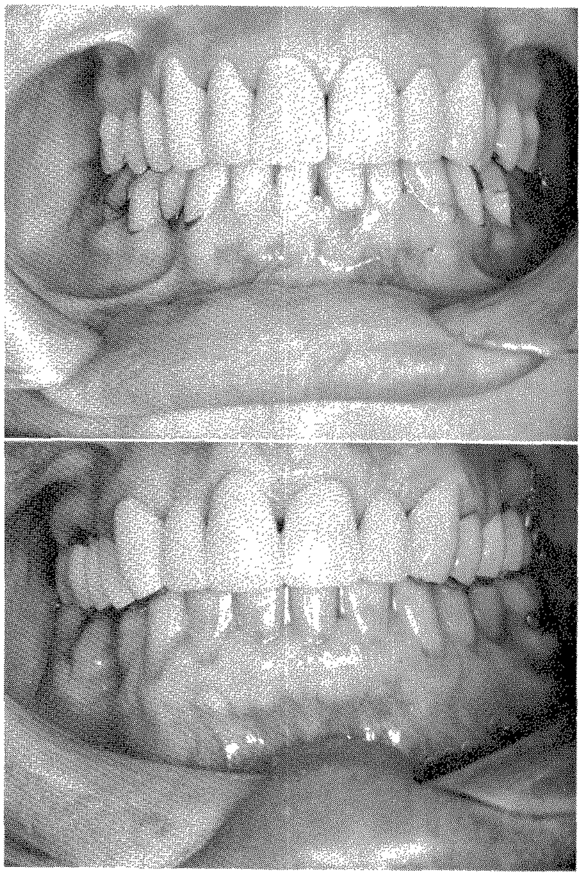


Fig. 5-8. Results of correct coronal form, especially in cervical third area, maintaining and protecting health of gingivae (8 years postoperatively).

Amsterdam[10] has told us that the basic functional implement of the masticatory organ is the dental unit (Fig. 5-9).

The *dental unit* consists of the *tooth,* the *attachment apparatus,* and the *gingival unit.* The tooth consists of the anatomic crown and the anatomic root; the attachment apparatus is composed of the cementum, the alveolar housing, and the periodontal ligament (its primary function is to enable the tooth to perform its function by resisting forces that would tend to dislodge the tooth); and the gingival unit provides a tough collagenous and epithelial covering to the neck of the tooth and the underlying attachment apparatus, which in turn protects these underlying structures from the bacterial flora of the mouth.

Careful examination of the gingival unit shows that its weakest link lies in the sulcular area, the epithelium lining of which is protected from the injurious effects of food retention, impaction, and plaque by the contours and positions of the anatomic or clinical crowns.

The gingival attachment to the tooth is at the cementoenamel junction. The enamel swells out from the cementoenamel junction, forming the cervical ridge, the deflective convexity under which the free marginal gingiva rests. Ideally, the cervical ridge and the tip of the free marginal

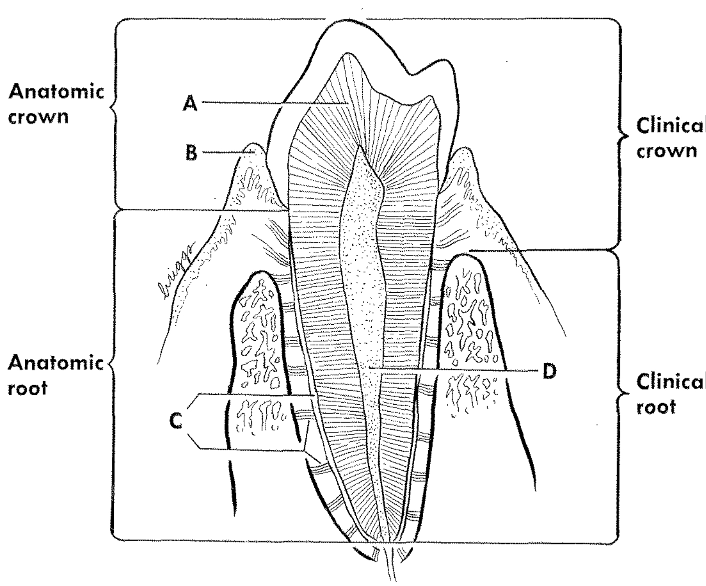


Fig. 5-9. Basic dental unit consists of the tooth *(A),* gingival unit *(B),* attachment apparatus (C), and pulp *(D).* (Redrawn from Amsterdam, M., and Abrams, L.: Periodontal prosthesis. In Goldman, H. M., Schluger, S., Fox, L., and Cohen, D. W.; Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co.)

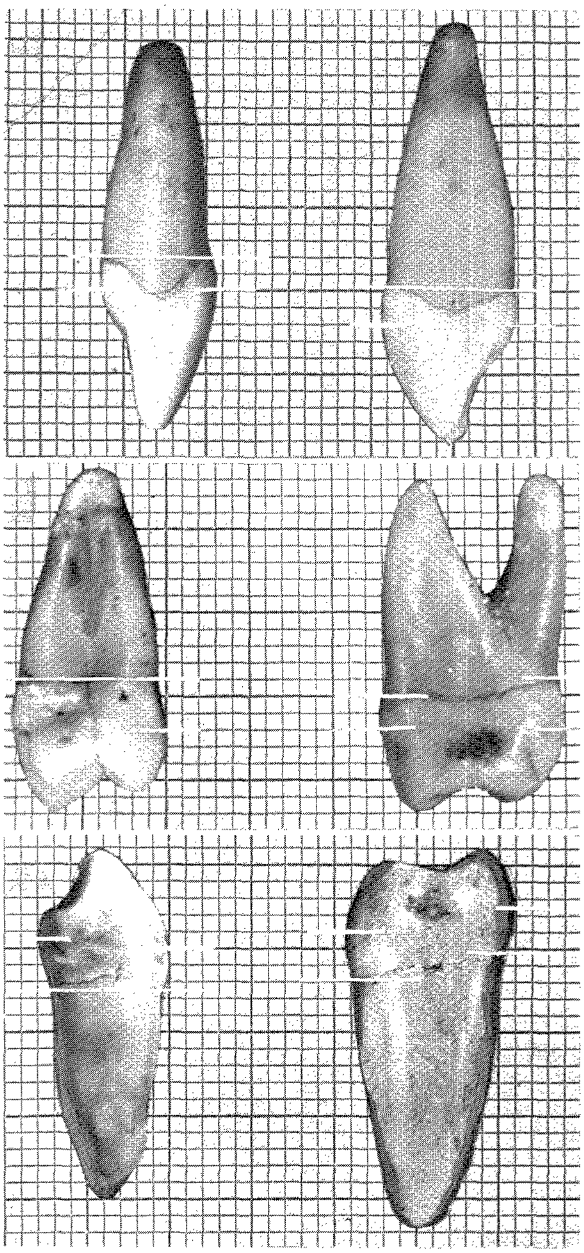


Fig. 5-10. A, Maxillary central incisor and maxillary canine. **B,** Maxillary first premolar and maxillary first molar. **C,** Mandibular first premolar and mandibular first molar. White lines represent levels of cemento-enamel junctions and crests of contour of crowns when viewing teeth from mesial or distal aspect. Epithelial attachment is somewhere between these lines when it is on enamel surfaces. These curvatures are protective, difficult to reproduce, and should be left intact whenever practicable. (Courtesy Dr. R. C. Wheeler, St. Louis, Mo.)

gingiva are of the same width so that the gingival portion of the anatomic crown buccally and lingually forms a continuous line with the buccal or lingual surface of the tissue, turning the corner mesially and distally to the interproximal papillae. This enamel ridge is the deflecting contour of the tooth that acts to protect the free gingival margin. The surface of the tooth should not extend buccally, lingually, or labially beyond the surface of this tissue; otherwise, the functional stimulation of the tissue by the musculature will be lost.[12]

Tooth crowns have a fairly uniform facial and lingual curvature at the "cervical third." The facial and lingual surfaces of the crowns exhibit convex contours of approximately 0.5 mm. at the gingival third, and in mandibular molars it may be as great as 1 mm. on the lingual surface.[13] This convexity is precisely related to the position of the gingival sulcus and directs the passage of food away from the sulcus and onto the more keratinized surface of the attached gingiva. (See Fig. 5-10.) The curvature also should allow sufficient functional stimulation for necessary tissue massage because the gingival tissues are directly dependent upon the functional stimulation of mastication to retain their normal healthy character.

Morris[14] says: "The contour may vary in different mouths, in different parts of the same mouth, or on the same tooth. If such contours do not protect against food impaction but rather permit free muscular flow, the final shapes of those surfaces will range from flat to the most subtle of convexities. These forms are more truly comparable to natural curves and will most likely preserve gingival health. (See Fig. 5-11.)

"The rationale of muscular molding and cleansing, rather than that of food impaction, more adequately explains clinical phenomena and is a more accurate guide for the construction of gingivally tolerated full crowns."*

To reiterate: The importance of establishing a correct anatomic form in the restoration cannot be overemphasized. A basic relation exists between the form of the tooth and its function. Particular attention may well be given to the enamel curvatures on the facial and lingual surfaces of the cervical third of the crown. These

*From Morris, Melvin L.: Artificial crown contours and gingival health, J. Prosth. Dent. **12**:1146-1155, 1962.

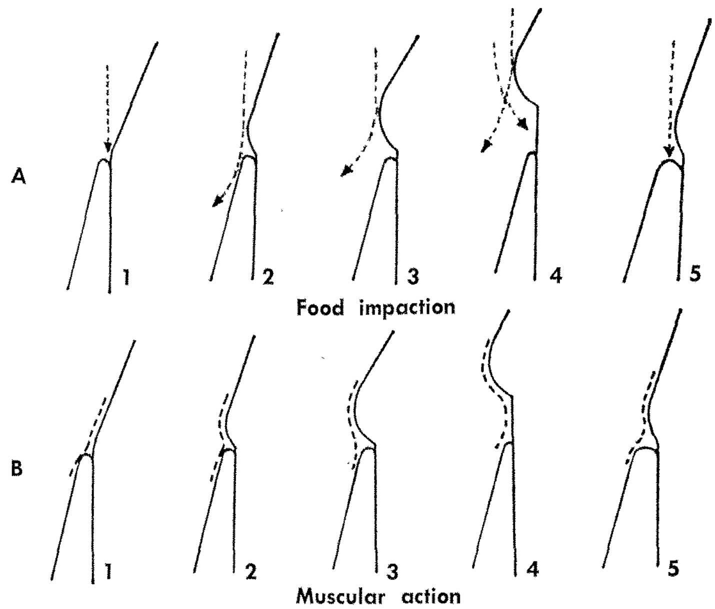


Fig. 5-11. Comparison of identical contour conditions that are interpreted in two different ways. **A,** Food impaction theory regards bulges as protection against impaction of food into buccal and/or lingual crevice. **B,** Muscle action theory pictures a constant cleansing and molding action by muscles and food, which can be impaired when the necessary intimate contact is prevented by a bulge of crown or bone. **1,** No coronal contour: **A,** unhealthy—direct food impaction with no protection; **B,** healthy—most efficient muscular action. **2,** Slight "physiologic" convexity: **A,** healthy—food is deflected to outer surface of gingivae; **B,** healthy—good muscular action. **3,** Thick crown contour: **A,** unhealthy—food is deflected away from gingivae; no stimulation; **B,** unhealthy—muscle contact is prevented by bulge of crown. **4,** Thick crown contour with gingival recession: **A,** unhealthy—bulge is too distant to protect gingivae; **B,** healthy—a distant bulge cannot prevent muscular contact with gingivae. **5,** Thick bone with "physiologic" crown contour: **A,** unhealthy—food can be impacted on wide gingival surface and then toward gingival crevice; **B,** unhealthy—muscular contact is prevented by bulge of bone. (From Morris, M. L.: J. Prosth. Dent. **12:**1146-1155, 1962.)

natural curvatures have a definite function in that they maintain the desired tension between the tooth and the free gingival margin and permit the necessary frictional stimulation of these tissues in masticating. If the curvature established by restorative measures is less or more than the natural curvature, the restoration will cause irritation and lead to gingival disturbances. Exaggeration of the degree of curvature of the cervical third is a common error in restorative work.

In cases of surgically lengthened clinical crowns, as in that of the normal anatomic crown, the height of coronal contour is to be placed at the cervical third of the crown. The clinical crown varies markedly with the anatomic crown because of the alveolar and supporting bone loss with resultant apical migration of the epithelial attachment, and the deflecting contours of these teeth are no longer physiologic as a result of the changed tooth–soft tissue relationship. The gingival third of this type of restored teeth, with the apical reposition of the gingival attachment to the tooth and their exposed root surfaces, which may be susceptible to dimineralization and decay, must be contoured to imitate true anatomic crown form, making use of double deflecting contours with the most subtle of convexities, if it is to be compatible with the gingiva (Figs. 5-12 to 5-15).

Where furcations have been exposed, the crown and exposed root surfaces should be

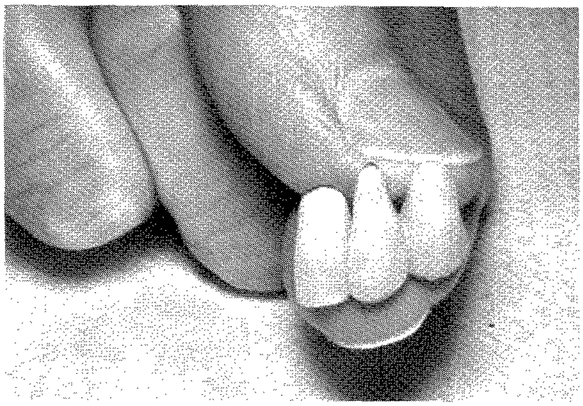


Fig. 5-12

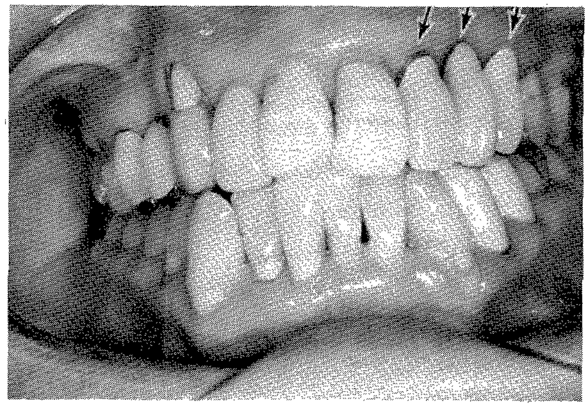


Fig. 5-13

Figs. 5-12 and 5-13. In cases of surgically lengthened clinical crowns, place height of coronal contour at cervical third of crown. If it is to be compatible with the gingiva, contour to imitate true anatomic crown form, making use of double deflecting contours with most subtle of convexities.

Fig. 5-14

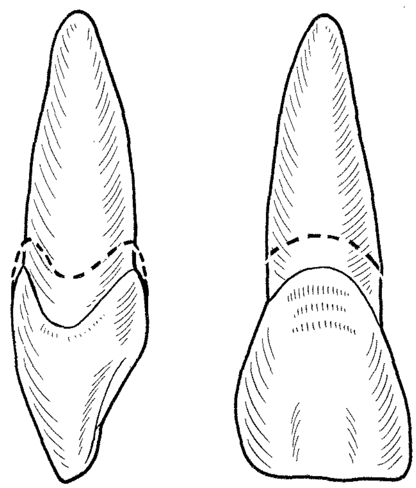
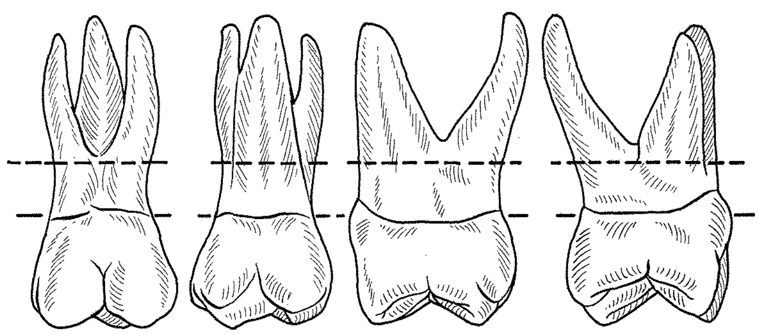
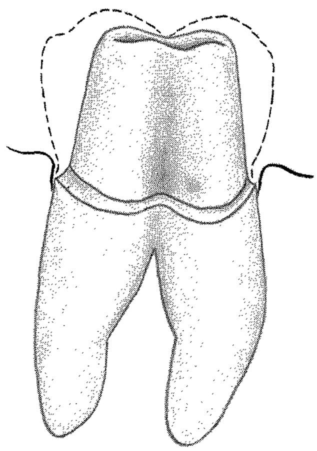


Fig. 5-15



Figs. 5-14 and 5-15. Because of great difficulty of restoring cervical third, some investigators feel that crown form may be extended on root trunk of single-rooted teeth, but no attempt should be made to cover root trunk of multirooted teeth because of complicated form of root trunk. An exception—if caries or erosion demands it. In that case original root form must be reproduced to maintain proper dental hygiene. (Redrawn from Wheeler, R. C.: J. S. Calif. Den. Ass. **31**:389, 1963.)



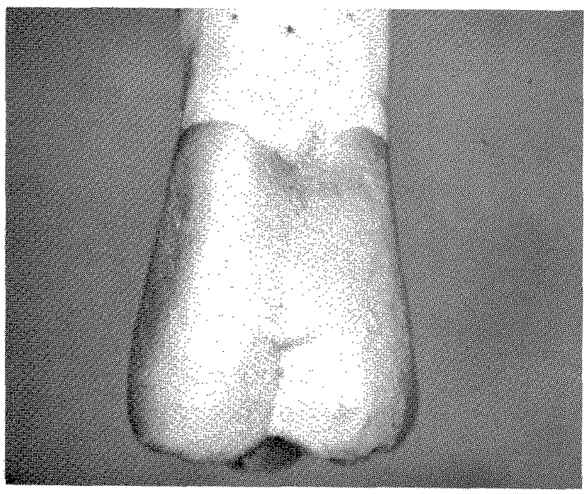


Fig. 5-16

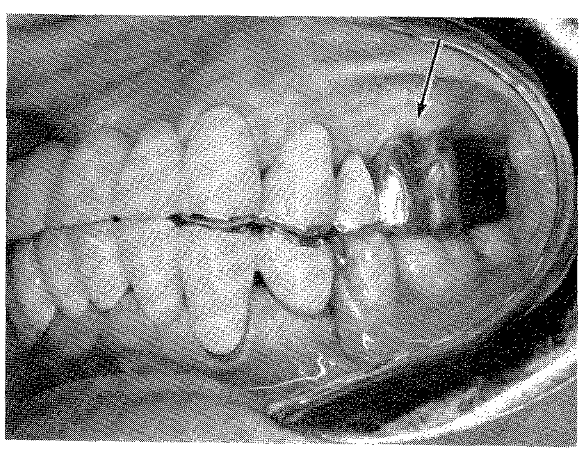


Fig. 5-17

Figs. 5-16 and 5-17. Where furcations have been exposed, crown and exposed root surfaces should be covered, care being taken not to cover furcation opening with crown margins. Adequate oral physiotherapy must be carried out.

covered, but care must be taken not to cover the furcation opening with the crown margins (Figs. 5-16 and 5-17). The area should be treated as if it were an interdental papillary region so that adequate oral physiotherapy may be carried out.

When a removable appliance is indicated, it is most essential to design the denture base and connectors so that proper skirting of the gingival and proximal tissues is provided. This prohibition also applies to solder joints.

Restorative dentistry, if not executed properly, can be an etiologic factor in periodontal disease or recreation of this condition after periodontal therapy. Gross to subtle errors in restorations will cause or recreate pathology. A great deal is dependent on the way in which the tooth is prepared and the restoration is contoured.

Keep in mind that reproduction of the cervical third is almost humanly impossible; so think carefully before destroying all of it in tooth preparations. Also, teeth possess a protective capacity by virtue of their individual coronal contours and collective alignment.[10]

The forms of the facial, lingual or palatal, and interproximal surfaces of the teeth should be modified in periodontal prosthesis to improve their influence on the character of function.

EMBRASURES

When teeth are in proximal contact, the spaces that widen out from the contact area are known as embrasures. Embrasures protect the gingiva from food impaction and deflect food so as to massage the gingival surface.

Embrasure form is related directly to the coronal form of the proximal areas of adjacent teeth and must be designed in all aspects to protect the interdental papillae and the underlying interproximal bone. These tissues will be influenced greatly by their environment.

Joe H. Smith helped me immeasurably to understand better the role of the interdental topography in periodontal disease which is most essential.

Healthy gingivae may possess either col-shaped or triangular-shaped papillae. The ideal gingival picture is one in which triangular-shaped papillae are found.

Smith[18] has told us that the reason for the col existing as it does is the relationship of the gingival papillae to the contact areas of the adjacent teeth. The most common place for the col-shaped gingiva is between posterior teeth because of the wider tooth contact area. It is common also between anterior teeth, where the contact area extends apically enough to prevent the triangular-shaped papilla from forming. Another area is around crowded teeth, when the roots are close together.

While all col-shaped papillae are not clinically diseased, most diseased papillae are col shaped or cratered to some degree. Stahl[17] demonstrated in histologic sections that the middle part of the col is thin and devoid of the protective substance that covers stratified squamous epithelium and is subject to friction, that is, keratin. The buccal and lingual peaks were covered with keratinized epithelium that became unkeratinized as it approached the middle of the col.

Since bacteria and their enzymes are present in the col and the middle portion of the col is not subject to friction and thereby devoid of keratin, the inflammatory process will start in this vulnerable area. It is necessary to alter the cratered shape of the interdental alveolar crestal bone to obtain an acceptable architectural form that will maintain itself in function and health.

This enables the overlying gingiva to assume the new shape of the contoured bone, at a distance from the contact area that will permit the necessary cleansing and dental massage. Thus regrowth of the papilla to its original height is prevented, and with conscientious home care the keratinization of the epithelium of the papilla will increase.[18]

Healthy interdental papillae exhibit many and varied shapes depending upon (1) the anatomic form of the underlying interdental bone, (2) the proximity of the roots of teeth allowing for or limiting interdental space, (3) the shape and outline of the interdental space as formed by the proximal surfaces of the teeth, and (4) the alignment or malalignment of the teeth in a jaw to each other.[19]

Anatomic variations of teeth may pose special problems in the shaping of full crowns and pontics. Among these variations are tilted and rotated teeth that distort, widen, narrow, or even obliterate the embrasures. A crowded or obliterated embrasure may present an insoluble problem, necessitating the use of much home care including brushing, interdental stimulation, and lavage. (See Figs. 5-18 to 5-20.)

The interproximal contour and contact point

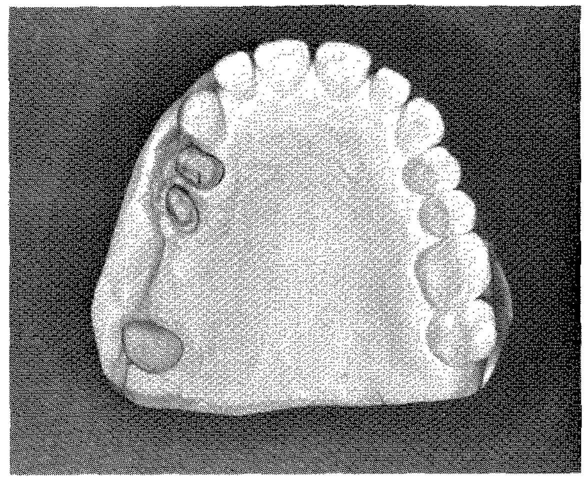


Fig. 5-18

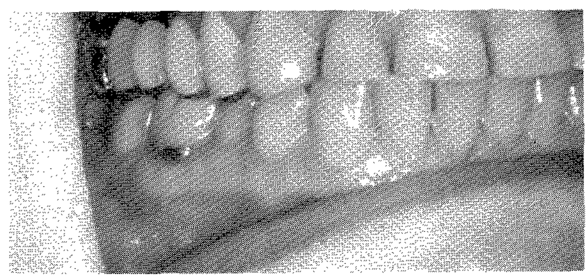


Fig. 5-19

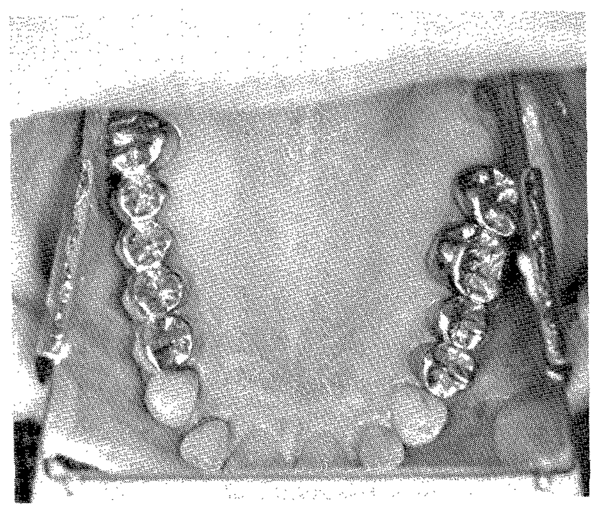


Fig. 5-20

Figs. 5-18 to 5-20. Rotated and tilted teeth may widen, narrow, or even obliterate the embrasures. Crowded or obliterated embrasure may present an insoluble problem necessitating great care in crown form and solder joints to allow for interdental stimulation and lavage.

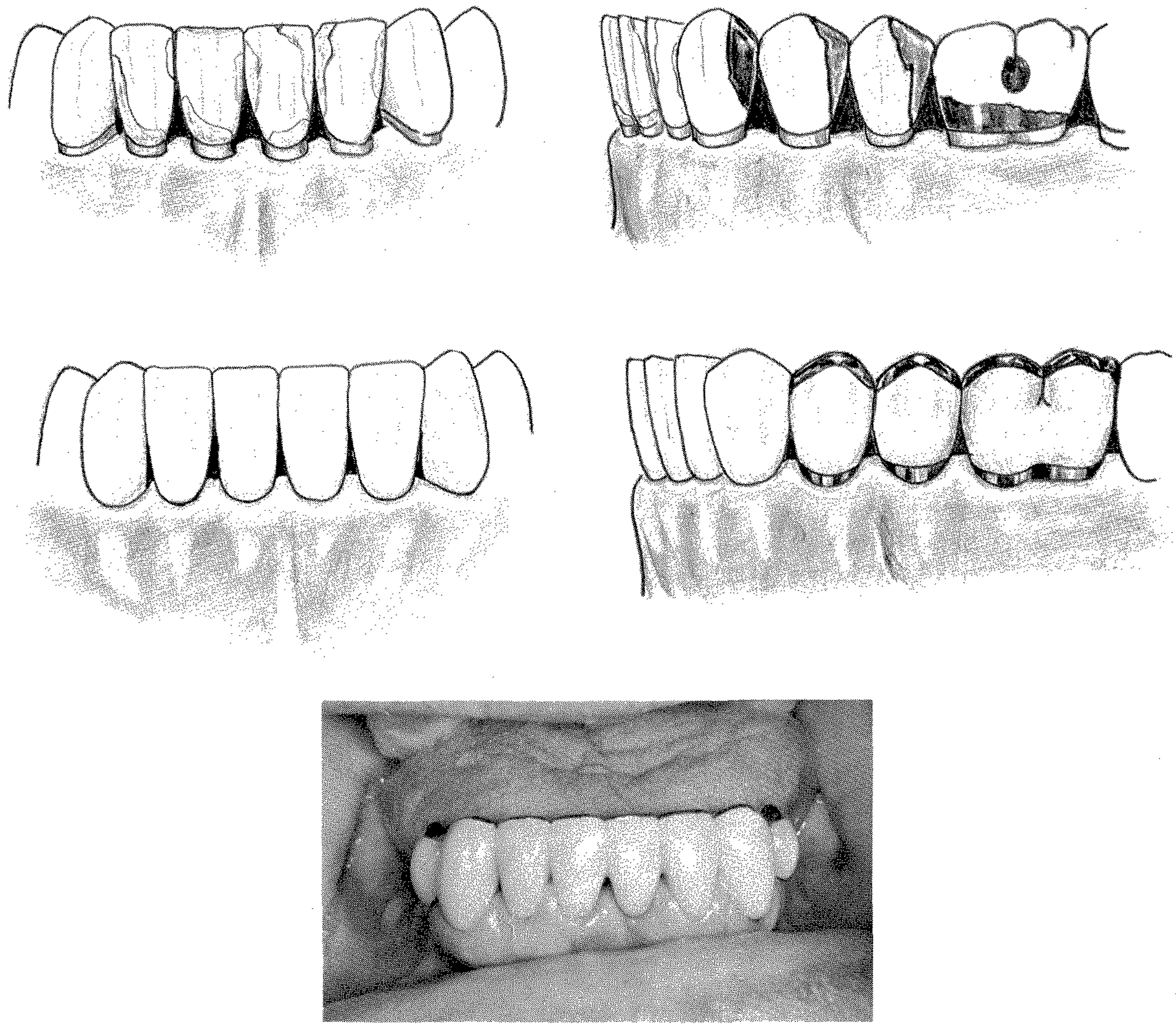


Fig. 5-21. Contact areas must be placed correctly. In cases of large interdental embrasures move gingivally. Keep in mind, however, that interproximal space should be large enough to accommodate papilla without restriction.

of the restoration will depend upon the size, shape, and height of the papilla. The contact area must be placed correctly and, in many cases of large interdental embrasures, moved gingivally. Keep in mind that the interproximal space should be large enough to accommodate the papilla without restriction, which also permits proper oral hygiene and tissue stimulation of these interdental tissues. (See Fig. 5-21.)

The proximal surfaces are either flat or, in some instances, concave. "The proximal surfaces of the restorations create the interproximal embrasures that form the canopy that houses the interdental papilla. The roof is created by the very tight and correct positioning of the contact areas of the teeth. The walls are formed by the proximal surfaces of the adjacent teeth. The base is formed by the cementoenamel junctions of the proximal surfaces."*

Ideally, the cementoenamel junctions of proximating teeth will be at the same level; crestal bone height will be parallel with the relative heights of the proximal cementoenamel junctions, and the distance between the base of the contact areas and the cementoenamel junction will be

*From Amsterdam, Morton, and Abrams, Leonard: Periodontal prosthesis. In Goldman, Henry M., Schluger, Saul, Fox, Lewis, and Cohen, D. Walter: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co., p. 766.

the same in adjacent teeth. Sufficient room will be created by these symmetrical walls for the establishment of an adequate interdental gingival papilla with a minimum of col formation.

Ritchey and Orban[20] reported the following in a research project:

1. If approximating tooth surfaces are relatively flat, the septa must of necessity be narrow and the crests more or less pointed. If mesial and distal tooth surfaces are strongly convex, the interdental septa will be wide and the crests flat.
2. In the absence of periodontal disease the configurations of the crests of the interdental alveolar septa are determined by the relative positions of the cementoenamel junctions.
3. In the presence of periodontal disease, alterations in the configuration of the interdental alveolar septa are governed principally by the specific pathologic process.

All this information points up most vividly the disastrous results of posterior bite collapse with the drifting and extrusion of molars and bicuspids, giving rise to the development of unlevel marginal ridges and marginal gingiva and altered embrasure forms. For every unlevel marginal ridge there is an unlevel cementoenamel junction, which gives rise to angular crestal bone formation that may lead to alveolar osseous defects such as infrabony pockets since inflammation and occlusal traumatism are part and parcel of this situation.

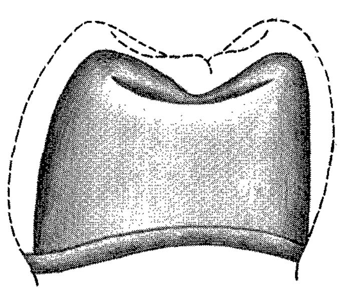


Fig. 5-22. Facial shoulder should be carried into interproximal embrasure in use of veneer crowns. This provides space for casting and veneering material without encroaching on triangular space.

After periodontal therapy we are confronted many times with unusually long clinical crowns. The embrasure spaces are now long and opened, and buccolingual concavities are found on the mesial and distal surfaces of the maxillary and mandibular canines and maxillary bicuspids. Also the furcations of all molars are exposed. All this necessitates the negotiation of the cemental surface of the root or roots, requiring an excellent knowledge of tooth form to avoid gross to subtle errors in the restoration that would recreate pathology.

The fact that in many instances the enlarged, edematous, inflammatory gingivae are caused by improper cavity design, especially in the interproximal area, must not be overlooked. The facial shoulder should be carried into the interproximal embrasure in the use of veneer crowns. When no shoulder is provided on the proximal surface, the gold framework must be extended into the interproximal space to make room for acrylic resin or porcelain. This added bulk outside the normal contour of the tooth encroaches on the triangular space and leads to a pathologic periodontal condition and also an unesthetic, abnormally shaped crown.[21] In other words, sufficient tooth structure must be removed on the proximal surfaces to allow for the restoration of proper embrasure form. (See Figs. 5-22 and 5-23.)

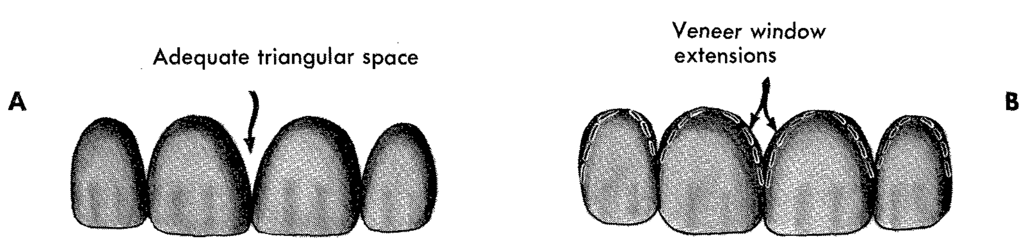


Fig. 5-23. A, A full crown should provide proper interproximal contour for esthetics and adequate space for papillae. **B,** If gold framework is extended into interproximal space, added bulk outside normal contour of tooth encroaches on triangular space. (From Weinberg, L. A.: Atlas of crown and bridge prosthodontics, St. Louis, 1965, The C. V. Mosby Co.)

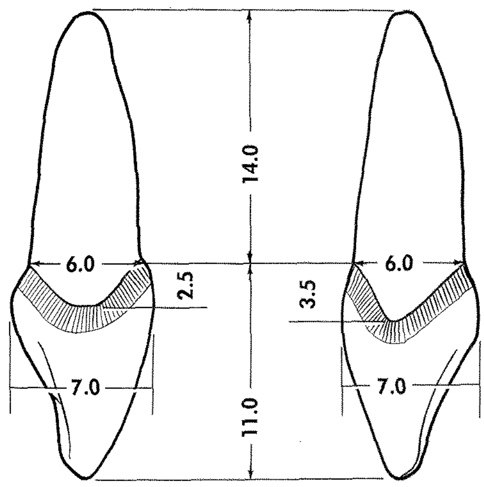


Fig. 5-24. Mesial and distal curvatures of cervical line (cementoenamel junction) on maxillary central incisor demonstrate points of measurement in determining relation between curvature of cervical line mesially and distally. Other points of measurement of crown and root are outlined. The shaded area in form of a band on enamel follows curvature and represents epithelial attachment of gingival tissue to enamel of crown. (Redrawn from Wheeler, R. C.: J. S. Calif. Den. Ass. **31**:385, 1963.)

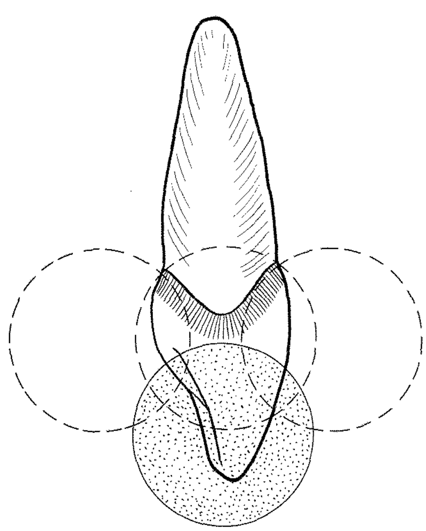


Fig. 5-25. A study of Fig. 5-24 brings to mind the possibility of injury to epithelial attachment if extreme care is not exercised in crown preparation. Ascertain height of attachment. (Suggested by Dr. R. C. Wheeler, St. Louis, Mo.)

By all means avoid injury to the tissues through careless use of cutting tools (especially with high-speed equipment), improper handling of the impression material, poor marginal fit of both temporary and permanent restorations, entrapment of tissue between the crown margin and the prepared tooth, retention of excessive cement subgingivally, etc. In tooth preparation, by the careful selection of instruments it is possible to avoid cutting the outer epithelial layer; only the inner crevicular epithelium is touched subgingivally. (See Figs. 5-24 and 5-25.)

The interproximal space is more difficult to maintain than the buccal and lingual tissue. The interproximal space occupied by the papilla must not be violated (Fig. 5-26). All operative and restorative procedures must be done with a minimum of gingival insult.

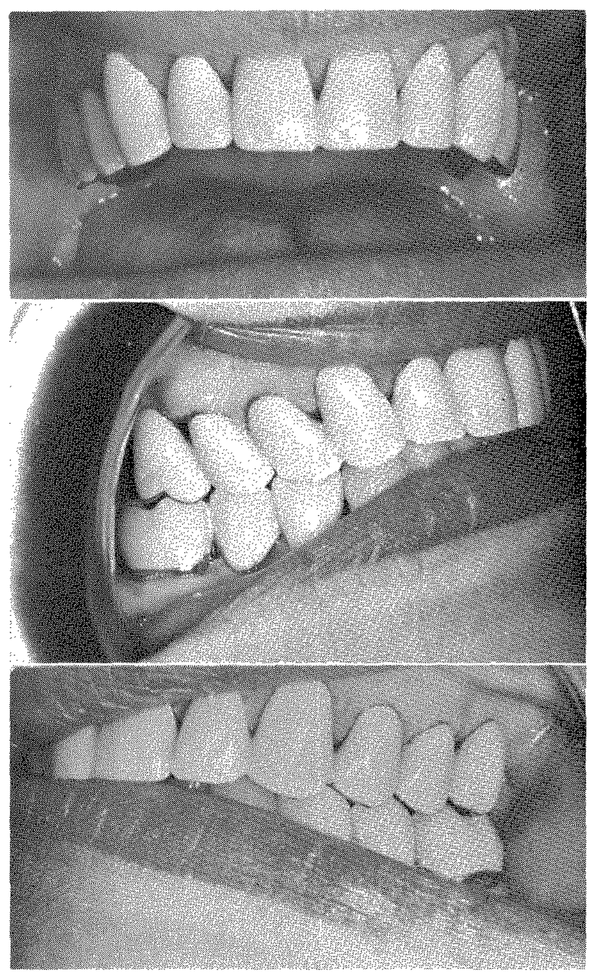


Fig. 5-26. Interproximal spaces occupied by papillae have not been violated. Case at present is of 10 years' standing.

MARGIN PLACEMENT

The question as to where to finish the crown margin—supragingivally or subgingivally—is often asked. Caries, restorations, and cosmetics in many instances indicate subgingivally. If this is the case—how far subgingivally? The acceptable healthy gingival sulcus is from 1.5 to 2 mm. in depth. The margin of the restoration should finish short of the epithelial attachment, which means that it should not be more than 1 to 1.5 mm. subgingival, depending, of course, upon the depth of the sulcus. If supragingival—how far supragingivally? Whenever possible, it is advantageous to lay the peripheral margins on sound enamel with a definite abrupt bevel and a fair distance above the gingival margin since it not only facilitates accurate marginal adaptation of the gold margin, but also prevents tissue irritation.

Caution must be exercised not to go subgingivally into areas where the gingival tissues would not be receptive to this transgression. According to Gordon,[22] these are areas where (1) the band of attached gingiva is very narrow, (2) the gingival margin ends in areolar tissue or the tissue is not keratinized properly, and (3) the anatomic form of the facial alveolar bone and gingival tissue is so thin that the area is not conducive to subgingival extension.

When the outer plate of bone and the gingival tissue are thin, the thickness of the subgingival portion of the crown becomes critical, for if the crown is rendered thick in the facial area, it causes the free marginal gingiva to be distorted, and the response in most instances will be recession or inflammation.[22]

In margins of restorations that are extended subgingivally, the deeper the preparation is extended into the crevice, the greater is the hazard for irritation close to the insertion of the periodontal fibers into the cementum.

After periodontal surgery the sulcular depth is negligible. However, in a short period of time the depth may increase to 1 to 2 mm., which is a usual finding. Knife-edged gingival margins begin to roll slightly. Goldman has described this phenomenon as "creeping reattachment". Therefore there is the need to wait several months before starting tooth preparation and restorative measures.

Rosen and Gitnick[23] begin tooth preparations, if circumstances permit, just after epithelization

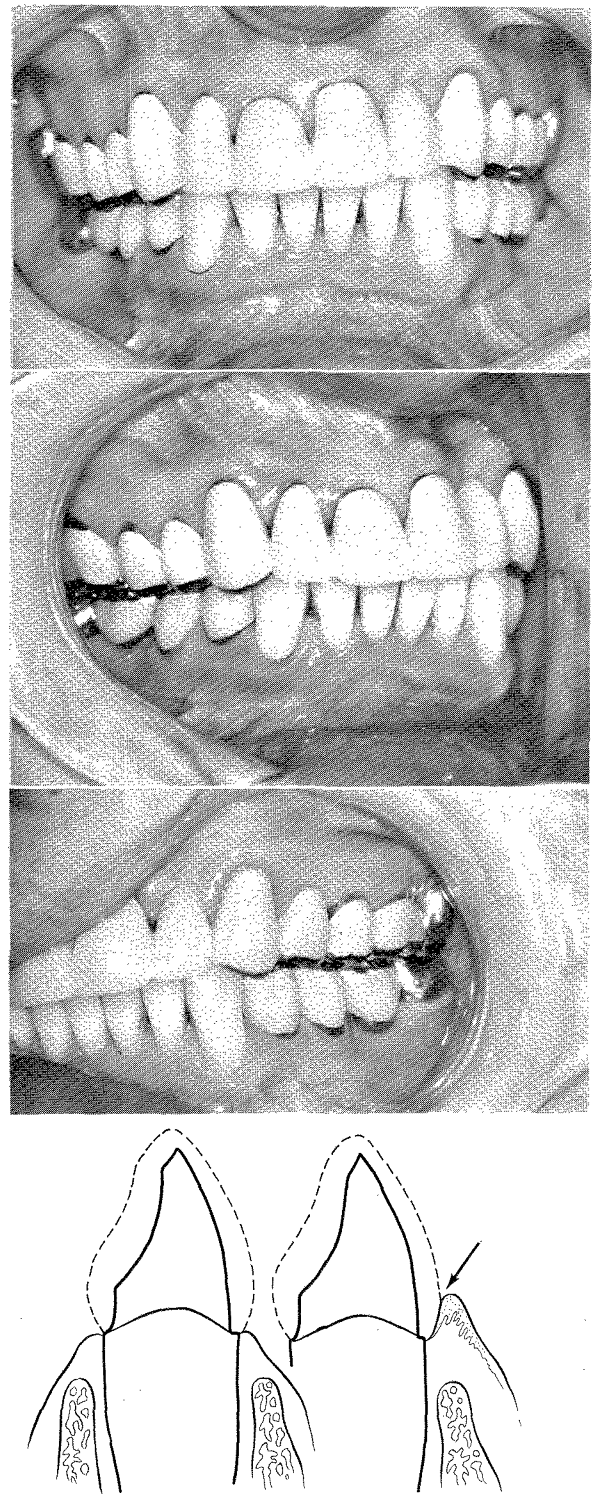


Fig. 5-27. Tooth preparation was started just after epithelization of gingiva had taken place. Supragingival margins were established, which allowed for great accuracy in impression taking and marginal adaptation of cast restoration. As gingival tissues matured, a shallow crevice developed and supragingival margin became subgingival.

of the gingiva has taken place, which is usually six to eight weeks after periodontal surgery. By so doing, a supragingival margin is established, which allows for great accuracy in impression taking (hydrocolloid, rubber base, or silicone) and in marginal adaptation of the cast restoration. Later, as the gingival tissue matures a shallow crevice develops, and the supragingival margin becomes subgingival. Whenever possible, I choose this method, and the end results are most satisfactory. (See Fig. 5-27.)

PARAFUNCTIONS

Types

Parafunctions may be defined as occlusal habits that result in tooth-to-tooth or foreign object-to-tooth contact. They are mandibular movements other than those associated with chewing, swallowing, or speech.

Some pernicious habits such as grinding and clenching may be practiced at night, as evidenced by soreness of teeth or the masticatory muscles in the morning. Patients under emotional stress may even continue these habits during the day when not masticating or swallowing.

Some patients have such habits as biting on fingernails, bobby pins, pipes, thread, or toothpicks, habitually pressing one anterior tooth against another, or tapping on incisal edges of anterior teeth.

Sucking habits or biting on the tongue or lips does not transmit such heavy forces as aforementioned since the intermediate object is softer, but the constant application of these forces still may be enough to cause migration of the teeth.

Observation of the patient's swallowing pattern is important. In normal swallowing the teeth are brought together in centric relation and the tongue is pressed against the palate in the area of the anterior palatine papilla. Incorrect swallowing, in which the tongue places heavy pressure on the anterior teeth or it may even be forced between them, is a major cause of open bite. Myofunctional therapy methods may be used to treat these patients.

In bruxism the teeth and supporting structures are involved, and, because of this grinding, they both abrade and exert pressures leading to attrition of teeth and loss of alveolar bone. A type of bruxism, clenching, may produce severe alveolar bone destruction because of the forceful sustained biting pressure (Fig. 5-28).

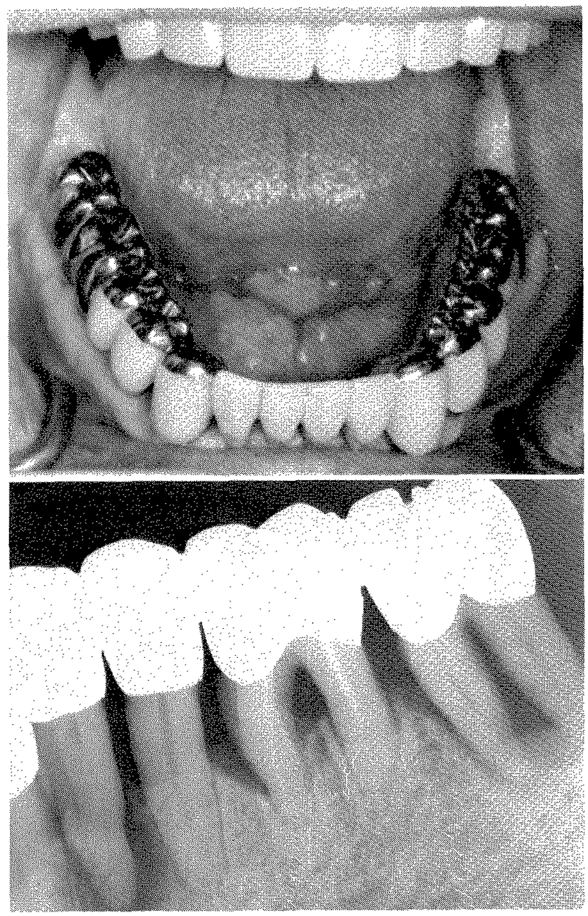


Fig. 5-28. A "bruxer" and "clencher," because of his sustained biting pressure, produced severe alveolar bone destruction in spite of well-established prosthetic-periodontal interrelationships.

Bruxism may be initiated by local factors such as cusp interference, mobile teeth, improperly contoured fillings, and "indeed any continuing stimulus to the afferent nerve endings in the periodontal tissues, which normally are associated with the reflex arcs of the rhythmical movements of mastication."* Discrepancies in occlusal contacts, primarily in centric relation–centric occlusion pathways, causing the patient to slip into an acquired relationship, are of prime importance in triggering off the bruxing habit.[25] Parafunctional tooth contacts are believed to be the initial insult in the origination of the lesion of primary occlusal traumatism.[10]

It is unquestionably true that this action, para-

*From Walsh, J. P.: The psychogenesis of bruxism, J. Periodont. 36:417-420, 1965.

functional tooth contacts, is complex, being of both local and emotional origin. It is correct to say that local tooth interferences play an important role in the initiation of these destructive habits, thereby requiring a correct centric relation–centric occlusion relationship. In my opinion, after many years of close observation, the most important factor in bruxism is undoubtedly psychologic or emotional tension, which is manifested through the muscular system. Occlusal interferences act as a trigger for bruxism if combined with nervous tension, but objective observation and careful questioning of these patients will bring to the fore that they are the kind of people who either experience disproportionate anger or who do not know how to express rage effectively. They have a need to prevent aggressive tendencies from being manifested, and many of these people have a set, determined, or hostile facial expression.

Fenichel[26] considers that the physical effects of being emotionally "damned up" produce changes in the muscular system, either hypertonic or hypotonic or both alternating. He designates this field as "psychogenic dystonia," examples being grinding and clenching of teeth.

Acrylic resin bite guards

Acrylic resin bite guards, or night guards, are removable splints for the treatment of bruxism and temporomandibular disorders. They are used as a palliative measure in patients who continue to "brux" after correction of occlusal disharmonies and attempts to correct psychogenic factors.

Alginate or hydrocolloid impressions are taken of both arches, and stone casts, as porosity free as possible, are made. A hinge-bow transfer is made for mounting the upper cast on an adjustable articulator, and two or three centric relation bites are taken for the mounting of the lower cast on the adjustable articulator by the split-cast method.

The casts are surveyed, and a line is drawn approximately 1 mm. gingival to the survey line or height of contour facially and lingually. This line is the borderline of the bite guard.

The area that is gingival to the borderline is blocked out with wax. A baseplate wax form is created over all surfaces above the line, the occlusal surface being almost flat. The free-way space must not be encroached upon, and the centric position must be correct.

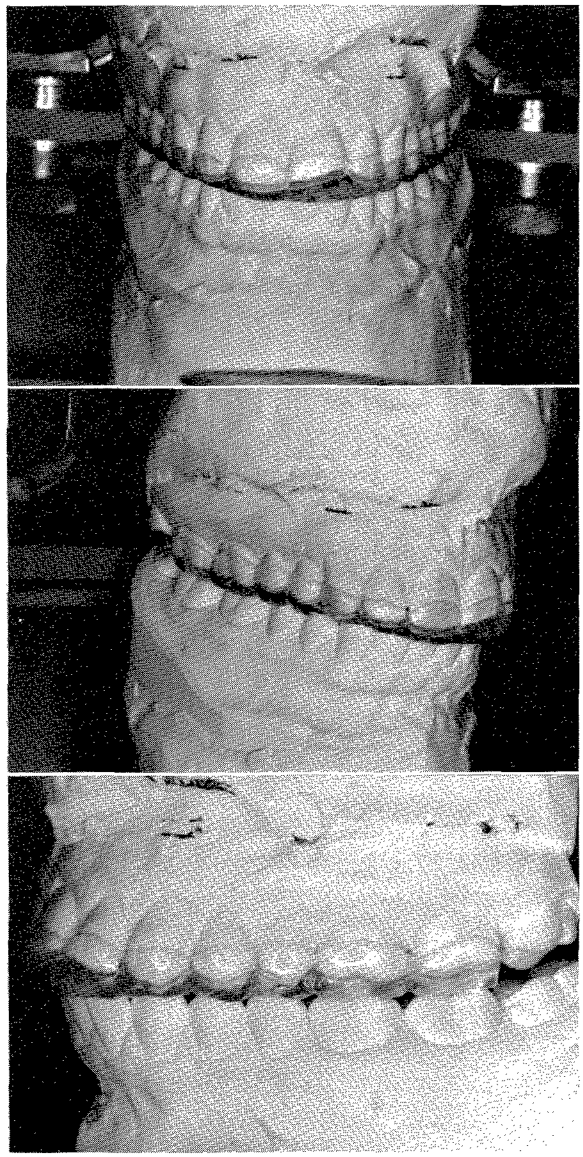


Fig. 5-29. Acrylic resin bite guard on adjustable articulator after construction for adjustments in all mandibular excursions and before being polished.

Cuspal interferences are removed by moving the articulator protrusively and through right and left lateral excursions, after which these wax forms are invested and cured in clear acrylic resin. The cured bite guard or guards then are seated on the casts and adjusted very carefully protrusively, laterally, and for centric position; then they are polished (Fig. 5-29).

By correctly carrying out these procedures the bruxing movements of the mandible are converted to gliding actions over the smooth acrylic

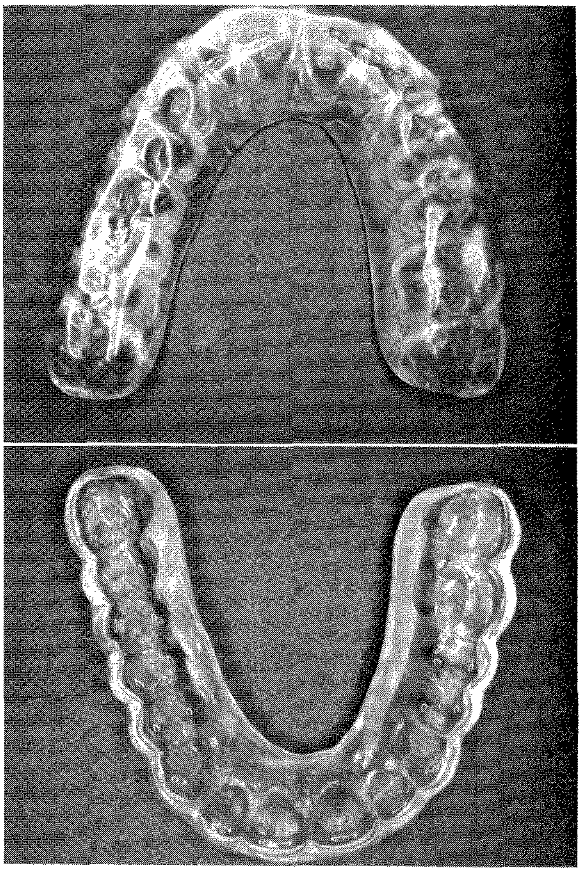


Fig. 5-30. Finished acrylic resin bite-guard splint, which is worn at night.

surfaces so that the periodontium is protected from injury by eccentric forces.

These acrylic splints are worn at night on one or both jaws, depending upon the mobility patterns and upon the patient's willingness to wear one or two plastic splints (Fig. 5-30). If one is to be worn, place it in the arch exhibiting the greatest mobility pattern.

Preliminary corrective procedures

ORTHODONTICS

By far the most common reason for the spontaneous movement of teeth in the adult is periodontal disease. In periodontal disease spatial derangements of arch form, induced by drifting, extrusion, and tipping of one or more teeth, frequently are exhibited. We must make use of orthodontics to create a situation that will allow our periodontal and prosthetic treatment procedures to succeed. If extensive tooth movement involving gross repositioning of the root base and fulcrum area of the tooth is indicated, the patient should be referred to a trained orthodontist.[27] However, minor orthodontic tooth movement can play a most important role in the comprehensive treatment plan in periodontal prosthesis and belongs in the realm of the periodontist and prosthodontist. Minor tooth movement can be accomplished with relative ease through the use of removable appliances of various types (Figs. 5-31 and 5-32). Orthodontic treatment should precede periodontal treatment, that is, after initial treatment, consisting of curettage for reduction of inflammation, removal of deposits, etc., but before osseous surgery.

Malaligned teeth should be moved orthodontically, either for better management of abutments or for better relation to the residual ridges. Many astute students of the subject feel that, barring this possibility, such teeth should be extracted regardless of their periodontal status. Utilization of gross warpage of occlusal tables to compensate for severely malposed and cross-bite situations or otherwise inadequate arch-to-arch relations causes the force recipient areas of the restored teeth to be located poorly with respect to their root support. Existing malpositions of the abutment teeth or purposeful distortion of the restored crown cannot be condoned if the resulting crown-to-root ratio is basically incompatible with the resistance of the periodontium. Tooth preparation is a poor substitute for correct tooth position.

Amsterdam[10] points out that, in our procedural objectives in periodontal prosthesis, teeth that have migrated or tilted as a result of loss of arch continuity, loss of supporting bone, occlusal stress, etc. should be so positioned and axially inclined, if possible, so that their roots are located within the confines of their periodontal structures. They should be positioned centrally within their alveolar housing for optimal distribution of force and stress to the remaining root support. Then we have correct distribution of forces over basal bone. In other words, those teeth that have migrated or tilted to unfavorable positions should be realigned so that it is possible to direct forces in a favorable direction by occlusal design. This enables the resultant forces upon the teeth to be transmitted in a more favorable axial direction. Besides providing force control, it also allows for the establishment of

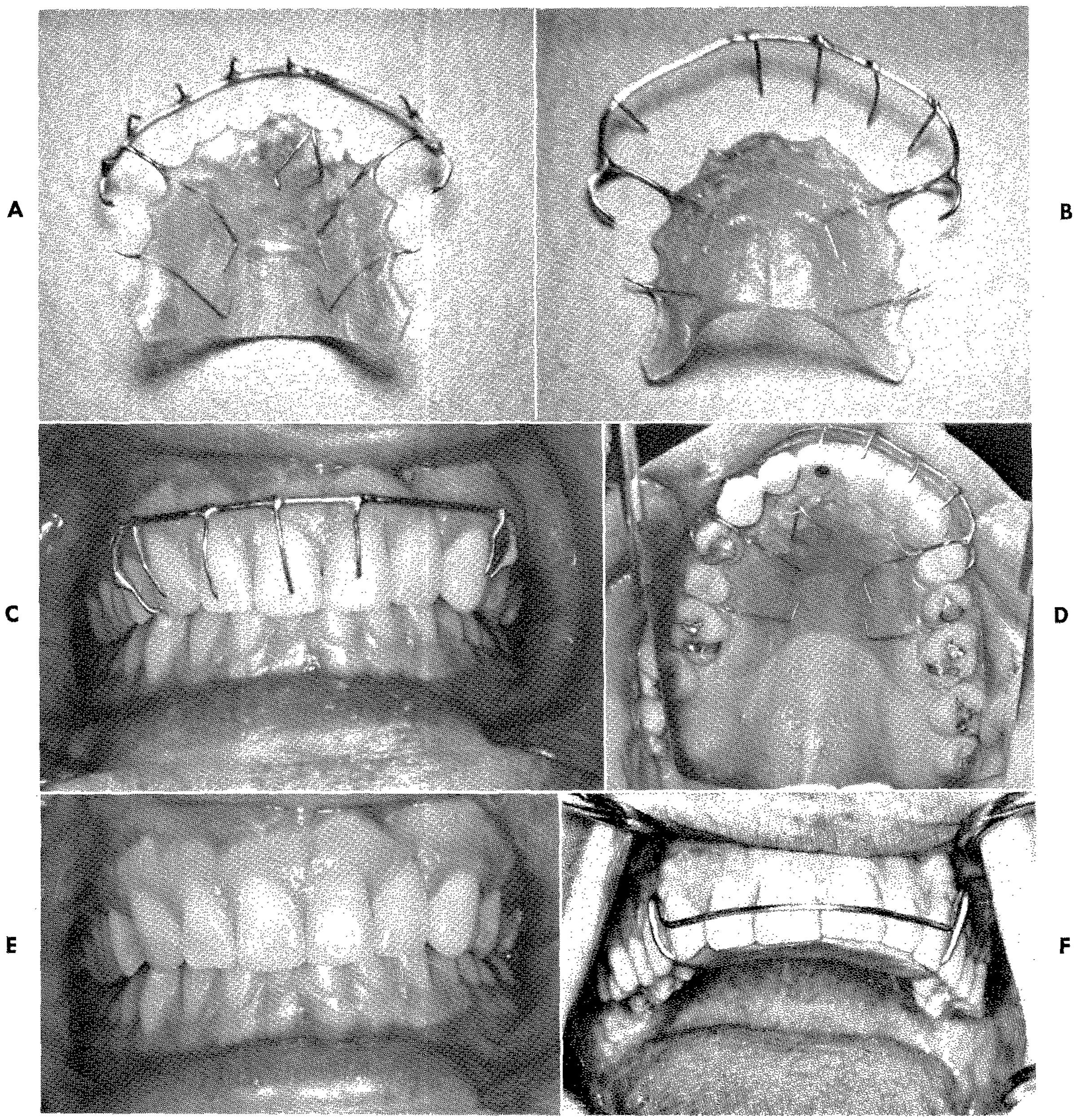


Fig. 5-31. A to **E,** Minor tooth movement can be accomplished by use of removable appliances such as Hawley retainer and its modifications. These illustrations show various views of this type of appliance in and out of mouth and result obtained. **F,** Hawley appliance with a platform area on palatal surface used in a deep overbite case. (**F** from Goldman, H. M., Schluger, S., Fox, L., and Cohen, D. W.: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co.)

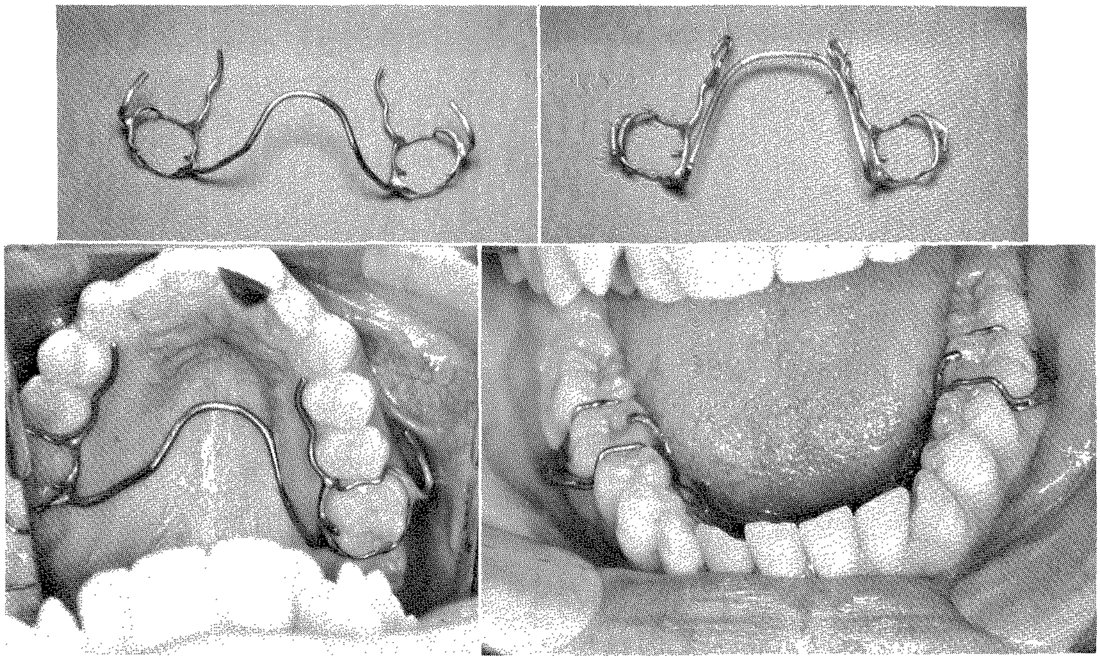


Fig. 5-32. These illustrations show Crozat appliance (primary upper appliance and primary lower appliance) in and out of mouth. Orthodontic treatment should precede periodontal treatment.

proper physiologic tooth form, gingival architecture, embrasure patterns, and esthetics. It also allows us to realign marginal ridges and cementoenamel junctions. Despite all this, there are times when asymmetry of the jaws and malalignment of the teeth in the arch may require a compromise of ideal objectives.

A Hawley retainer and rubber dam or latex elastics can be used effectively to create the movement of malaligned and tilted teeth to proper position.[28]

Arch wires, clasp arms, finger springs, hooks, for rubber or wire ligatures, reciprocal bracing, bite planes, and many other special appliances can be adapted to the removable prosthesis during the treatment period.

Certain basic concepts of tooth movement must be kept in mind, and it must be understood what types of movement of teeth must be accomplished. The three basic procedures involved are (1) rotation of teeth, (2) facial or lingual movement, and (3) mesial or distal movement.

Alteration of the position of the fulcrum area of the tooth should be done only by a trained orthodontist. Instead, a tipping action against the fulcrum is employed because usually a coronal migration has taken place with little alteration of the position of the apex of the root. Therefore, the rationale of treatment is to correctly position the coronal portion of the tooth by tipping or working against the fulcrum area.[27]

The bite plate is used extensively as a prerestorative treatment. It is a relatively simple appliance made of acrylic resin of horseshoe design, having arrow type clasps that are usually placed in the bicuspid and molar interdental buccal embrasures near the cervical region and a labial arch wire contacting the six upper anterior teeth. On the anterior palatal surface a flat bite wall is made, extending from cuspid to cuspid. The flat plane meets the incisal edges of the lower six anterior teeth at an angle of 90 degrees so that only a vertical force is exerted on them. If the incisal edges of the lower teeth are very uneven, level them so that uniform contact is made against the bite wall. Also, be sure to avoid depressions in the bite wall so as not to interfere with the free movement of the mandible. Do not encroach too much upon the freeway space.[29]

Cases exhibiting the following may be helped with this type of appliance or one similar to it.

1. Cases exhibiting deep overbite that may affect the successful treatment of periodontal disease and subsequent restorative treatment may be helped by a combination of tooth movements, including the intrusion of lower anterior teeth and extrusion of posterior teeth.
2. Upper anterior teeth can be moved lingually to place them in a more desirable position over the basal bone so that stresses upon them will result in the least amount of trauma to the supporting mechanism, with resultant decreases in food impaction areas and an improved esthetic appearance.
3. Teeth may be moved facially into a more favorable position, while moving others lingually and intruding or extruding others.

Many other cases and uses of this appliance can be cited. Elongation of posterior teeth with alveolar bone to fill defect is certainly much desired with the use of the Hawley retainer. We also move tooth to bone or bone to tooth.

Grassline ligature also can be used to bring teeth together. This type of ligature is used as the moving force, and stainless steel wire can be used as the anchor. The grassline ligature should be changed weekly.

Provisional splinting can provide anchorage for an orthodontic appliance from which the necessary force can be exerted.

Treatment should be accomplished as simply and rapidly as possible. After realignment of the teeth a period of stabilization should follow, wherein the teeth are maintained in their corrected position. Splinting in many instances provides permanent retention for the teeth that have been moved.

With a knowledge of the physiology of the involved tissues, a few basic techniques, and the application of the necessary materials, minor orthodontic tooth movement can be executed successfully, leading to the successful completion of the subsequent periodontal and prosthodontic procedures and their maximum longevity.

SELECTIVE GRINDING

Disharmony between centric relation and centric occlusion is a factor that causes improper wear and loss of the supporting structures of the teeth.

We want to establish a centric occlusion that is associated with a true centric relation, that is, the terminal hinge relation of the mandible.

If reshaping of the surfaces of the teeth is indicated, we should remember that the general anatomy of each tooth should be retained so that, when reshaped, the function of each tooth will be improved and the life and health of its supporting structures lengthened because of the relief of abnormal stress.

Occlusal adjustment by means of selective grinding is an operation of limited value in mouth rehabilitation. The displacement of the mandible anteriorly in patients in need of periodontal prosthesis is usually of a half cusp width or greater, and it is very doubtful that selective grinding can achieve a matching of the cuspal elements of the mandibular to the maxillary teeth. Proper intercuspation in these instances can be accomplished only by procedures used in periodontal prosthesis.

Never do preventive occlusal adjustment. Avoid the grinding of prematurities if clinical and roentgenographic evidence show no pathologic disorder and no joint symptoms. In these cases the patient has developed a protective proprioceptive reflex and, by all means, do not disturb it.

Contraindications

Selective grinding cannot be used for the following conditions:

1. Large displacements of the mandible anteriorly or laterally
2. Deep overbites
3. Closed bites
4. Flat, heavily abraded occlusal surfaces
5. Severe amounts of alveolar bone resorption
6. Excessive mobility of teeth
7. Numerous open contact areas, migrated teeth
8. Numerous edentulous areas

Objectives

Following are some important objectives in selective grinding:

1. Leveling of extruded teeth
2. Leveling of marginal ridge and reduction of plunger cusps
3. Establishment of proper occlusal plane
4. Bringing occlusal forces into direction of long axes of teeth

5. Reducing size of contact surfaces
6. Retaining of sharpness of cusps and establishment of smooth gliding planes
7. Elimination of balancing contacts

Technique

Upper and lower alginate, hydrocolloid, or rubber base impressions are taken for the construction of accurate study casts for mounting on an adjustable articulator so that they are on the same axis as the teeth of the patient.

The hinge axis of the mandible is determined either approximately by palpation, by an average measurement, or by a hinge axis determination. Full registrations would more than compensate for the time required to take them (Chapter 13), but axis-mounted casts will suffice.

A hinge-bow transfer for mounting the upper study cast on the adjustable articulator is made, followed by two or more correctly registered centric relation bites for mounting the lower study cast on the articulator by the Lauritzen split-cast method.

A determination of the premature contacts and interferences is the next order of business, but before this procedure is undertaken the basic principles and rules for grinding must be established.

Lauritzen[30] has called our attention to the fact that *basic principles* are absolute and inviolate, whereas *rules* are not absolute and may be violated, provided basic principles are adhered to. All rules (except the rule MU-DL) are based on a normal buccolingual relation of the occlusion; thus they do not apply for teeth in crossbite relation.

Correction of centric occlusion

"*Basic principle:* Maintain the cusps as far as possible because they are prerequisites for harmonizing the excursive motions.

"*Rule: MU-DL.* When the occlusion has to be repositioned to a more distal position, trim mesial inclines of upper cusps (the tips of the cusps are moved more distally) and distal inclines of lower cusps (the tips of the cusps are moved more mesially).

"*General cusps to be trimmed:* Buccal lowers and lingual uppers."*

*From Lauritzen, Arne: Lecture notes, Post-Graduate Study Groups, 1953, 1961.

Corrections of excursive movements (after centric occlusion has been established)

"*Basic principle:* Never take teeth out of centric occlusion.

"*Protrusion—Rule: BU-LL.* Buccal upper cusps (trim their distal inclines) and lingual lower cusps (trim their mesial inclines). In anterior region trim labially of lower anteriors and lingually of upper anteriors.

"*Lateral excursion:*

"*Working side—Rule: BU-LL.* Buccal upper cusps (trim their inner inclines) and lower lingual cusps (inner inclines).

"*Balancing side—Rule:* Select either lingual upper cusps (inner distal inclines) *or buccal lower cusps* (inner mesial inclines). Never trim both cusps."*

Premature contacts and interferences are determined with the use of typewriter ribbon† on the mounted stone casts. The plaster teeth are trimmed with a knife, following the rules of grinding, and then a grinding list is made before proceeding to chairside operations.

Grinding in the mouth is done with small stones (small inverted cone stones or diamond points), using typewriter ribbon, wax strips (as suggested by Dr. Bernard Jankelson‡), and thin carbon paper. Carbon paper is the least desirable medium to use for this purpose since it marks everything and is not definitive enough. The occlusal indicator wax is good. With the adhesive side against the tooth press the wax well in place over the occlusal, buccal, and lingual surfaces of the area. Ask the patient to wet the occlusal indicator wax with his tongue, and guide the patient's mandible into the closure until the wax is thinned or penetrated. The point of pentration is easily located with an explorer point; a mark is made through the point of penetration with a waterproof pencil. Remove the wax strip, and grind the pencilled areas with small inverted cone stones.

In grinding never leave a flat plane or surface. All articulating surfaces are rounded or parabolic because all jaw movements are rotary. Equal contact can be maintained only by rounded surfaces.

*From Lauritzen, Arne: Lecture notes, Post-Graduate Study Groups, 1953, 1961.

†Madame Butterfly Brand, No. 10 inking, ¾ inch, manufactured by Miller-Bryant-Pierce, Aurora, Ill.

‡Occlusal indicator wax, Kerr Mfg. Co., Detroit, Mich.

The decision as to where grinding is to be performed is based on the procedures of establishing an articulation.[4] A clear understanding of these procedures will reveal the shortcomings of selective grinding as a treatment, and it also will prevent the grinding away of the wrong surfaces.

Always remember that the centric contact is the most important contact and the one that must be preserved.

Before dismissing a patient restore anatomic detail and polish all cut surfaces. Make sure the patient is comfortable and has a negative occlusal perception.

TEMPOROMANDIBULAR JOINT DYSFUNCTION

The temporomandibular joint is a complex mechanism that has a precise manner of function. The occlusion of the teeth must be arranged to harmonize with the normal function of the joint. If this harmony fails to exist, the temporomandibular joints will suffer proportionately.

Occlusal malfunction can be responsible for subjective and objective symptoms in the temporomandibular joint complex. When occlusal discrepancies are responsible for abnormal muscle function, the most frequent offenders are cuspal interferences in the centric relation pathway and interferences on the balancing side in lateral mandibular glide. When this happens, a painful syndrome ensues.

A complete clinical examination following a good medical and dental history, correlated with a cognizance of the possibility of psychogenic factors, especially the centering of psychic stress in the region of the temporomandibular joint, is of the utmost importance. Stethoscopic examination can be of some help in revealing crepitation and clicking in the joints.

Treatment of temporomandibular joint dysfunction calls for concomitant therapy of three major structures—temporomandibular joint, musculature, and teeth.

Patients with acute exacerbated pain must be given symptomatic relief before any correction of occlusal disharmony is undertaken because during acute pain, trismus, and limitation of mandibular movement is not the right time to perform this procedure.

Intra-articular injection is indicated in some cases of an acutely tender temporomandibular joint. An effective agent for injecting into the joint is Prednisolene butylacetate (Hydeltra T.B.A.), and a good result usually can be expected.

Adjuvant therapy such as moist heat, analgesics, muscle relaxants, ethyl chloride spray, direct injection of procaine hydrochloride into the muscles, and intramuscular injection of B_{12} vitamins to aid in the restoration of general body nutrition is also part of the treatment.[31]

When symptoms have been relieved, selective grinding is carried out to correct the occlusal disharmony, which can produce functional temporomandibular joint disease.

NEUROPHYSIOLOGIC POINT OF VIEW

The following are some observations made by Jerge[32]:

"A strictly mechanical approach to the study of the kinesiology of the mandible based on morphology of the temporomandibular joints or the functional relationships of teeth disregards the very complex nervous system mechanism which is superimposed on this mechanical system.

"The tooth as a whole has an array of receptors around it which can receive information about pressure stimulation from any direction."*

In both the horizontal and vertical lesions of bone in periodontal disease the loss of periodontal ligament support means sensory deprivation as well as loss of mechanical support. In the case of the deeply penetrating vertical lesions of bone (which suggests a disorganized periodontal ligament in that area and that the sensory mechanism of the tooth is impaired) the tooth develops a "blind side" (Fig. 5-33). Such a tooth, deprived of its innervation on one side, cannot relate to the nervous system any information about pressure impinging on it from the side of the lesion. Sensory impulses from periodontal ligament receptors exert some control over the jaw musculature, which in turn moves the mandible. Ultimately, as the infrabony lesion becomes more circumferential the tooth becomes

*From Jerge, Charles R.: Comments on the innervation of the teeth, Den. Clin. N. Amer., pp. 117-127, March, 1965.

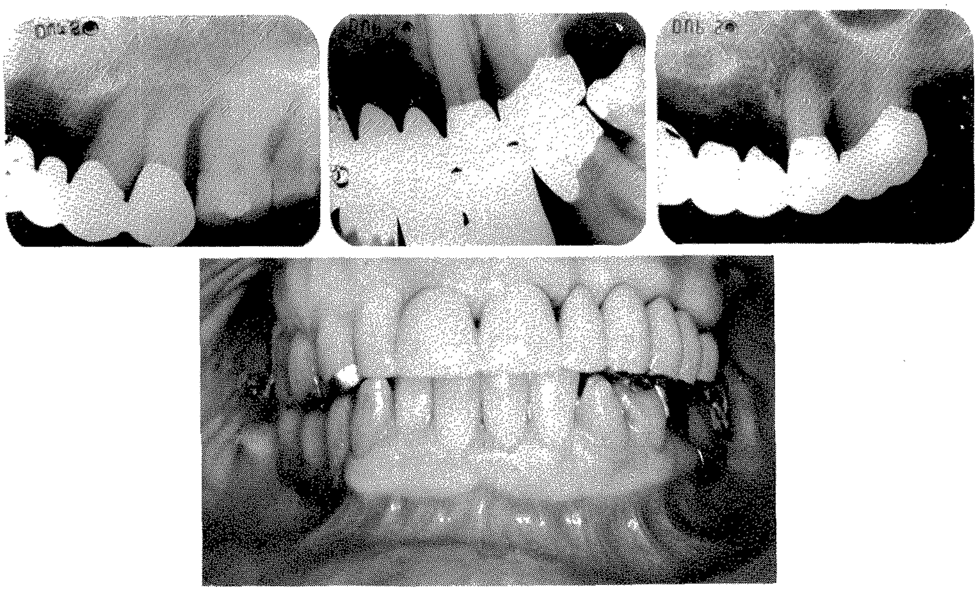


Fig. 5-33. Because of deeply penetrating bone lesion, which suggested development of a "blind side," the first bicuspid was removed. Establishment of proper occlusal relations and making use of bilateral splintage in upper arch seems to indicate that healing is taking place.

more a "passive" structure in the dental arch. It is unable to influence mandibular movements via trigeminal reflexes.

The tooth that has no sensory nerve supply will be buffeted about by the forces which impinge upon it, and it has no ability to influence the direction or magnitude of these forces. The sensory neurons of the periodontal ligament are essential components of the reflex arcs which control mandibular muscles and ultimately the force exerted on the dentition by muscular contraction.

"The extent to which the teeth have healthy periodontal ligaments and nerve supplies, and the extent to which the dentition as a whole relays coordinated information, determines the extent to which mandibular movement is coordinated with all the parts of the dentition. It is often coordinated only in relation to some or most of the parts."*

The impairment of this nervous mechanism by the lesions of periodontal disease is a factor to note.

*From Jerge, Charles R.: Comments on the innervation of the teeth, Den. Clin. N. Amer., pp. 117-127, March, 1965.

TEMPORARY COVERAGE

Inadequate, immediate, temporary measures will create marked periodontal disturbances. Overextended temporary crowns present a problem. Detachment of the gingival fibers for a short period of time is unlikely to produce permanent damage, but after approximately one month such crowns introduce the risk of gingival recession. (See Fig. 5-34.)

The temporary restoration must foster the healing of the gingival tissue and must create an environmental relationship that will keep the tissue healthy and unchanged during the period from the preparation of the tooth to the placement of the completed restoration.

The marginal fit of the temporary restoration should simulate, as much as possible, that of the finished restoration. Margins should be knife-edge, well adapted, and cover the entire prepared surface of the tooth to afford maximum protection to the preparation while offering minimal irritation to the soft tissue environment. Good contours and correct embrasure form also should be developed. (See Fig. 5-35.)

Temporary coverage also can be useful for the establishment of prognosis of questionable teeth as it affects the final treatment plan.

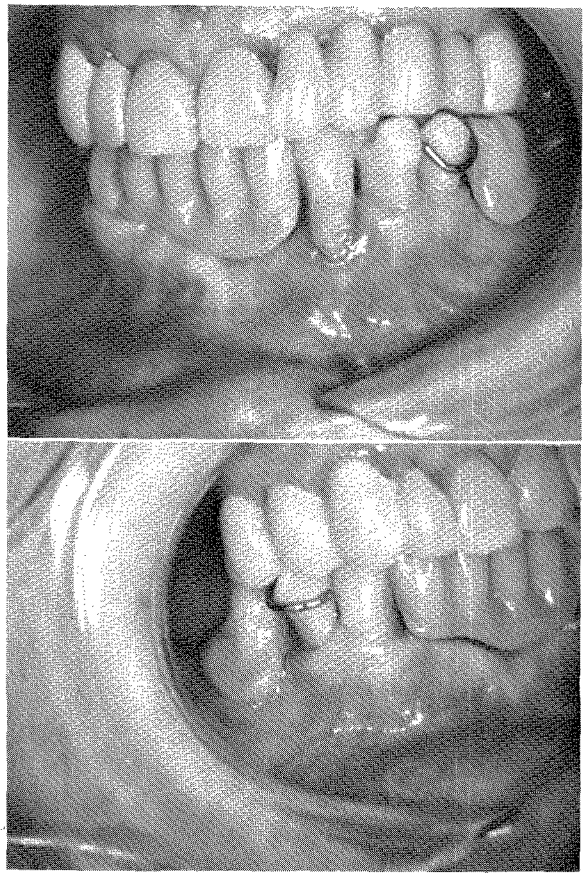


Fig. 5-34. Overextended and poorly contoured temporary crowns and pontics creating marked periodontal disturbances in upper arch.

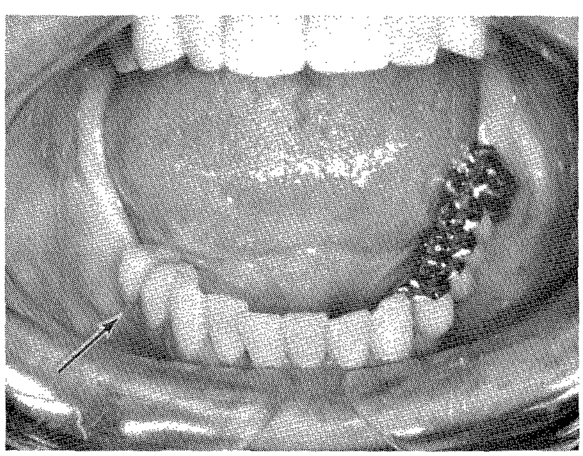


Fig. 5-35. Development of good contours, correct embrasure form, and marginal fit offers maximum protection to preparation and minimal irritation to soft tissue environment (arrow).

THERAPEUTIC SPLINTING

Principle

The principle of splinting teeth in either unilateral or cross-arch relation is a necessary adjunct to the treatment of periodontally involved teeth. It minimizes the effects of loss of support; it is necessary to establish posterior support for which there is a great need.

Splinting transforms several single-rooted teeth into a new multirooted tooth. Splinting of two single-rooted teeth not only alters the center of rotation about their root surfaces, but also allows the teeth incorporated into the splint to function as a multirooted dental unit. An increase in total root area creates a more favorable crown-to-root ratio. It is the procedure to employ when teeth must withstand forces beyond their physiologic limit; it offsets adverse factors with which we are faced. (See Fig. 5-36.)

Purpose

The purpose of the splint should be to distribute and direct the functional and afunctional forces, to bring them within the tolerance of the remaining supporting tissues, and to eliminate any mobility that may be present. Or we may say that it is a reorientation of the forces and stresses that come into play in the dental apparatus in such a way that the teeth are brought within the range of the adaptive capacity of the periodontal tissues. Fixation provides mechanical advantage and simultaneously restricts excessive tooth movements.

The primary purposes of splinting are as follows[9]:

1. Stabilization. Under stabilization we increase the resistance patterns to mesial, buccal, lingual, and distal vectors of force: (a) root area of resistance is increased and (b) reciprocal antagonism to force patterns is provided. Actually, under pure stabilization procedures the force may remain the same as before splinting, but the resistance is increased.

2. Reorientation of force and stress. Because of splinting, the unit area of resistance to force and stress is increased. The direction of force is altered, the total force may be the same, but the point of stress may be altered—its terminal direction may be rerouted.

The secondary purposes of splinting are (1) improving form and function of the teeth, (2) modifying occlusal contact patterns, (3) adjust-

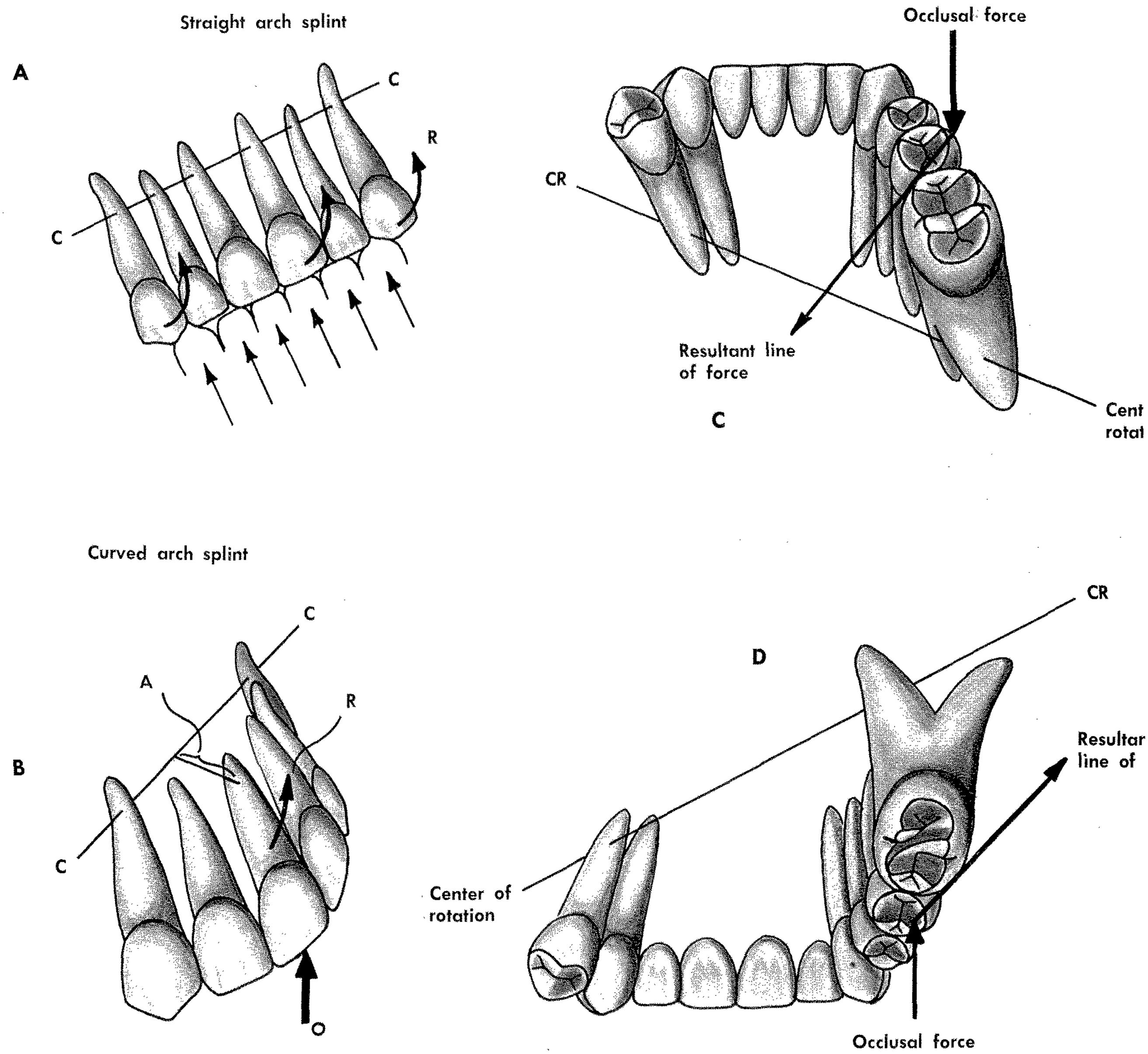


Fig. 5-36. A, Simultaneous occlusal pressure on a straight arch splint can cause whole splint to rotate; *R,* about the center of rotation; CC, passing through the area of apical third of teeth. Force on each tooth in splint is quite similar to that created by occlusal pressure on unsplinted tooth. **B,** Anterior curved arch splint. Because of curve in arch, central and lateral incisors would be *A,* anterior, to *CC,* center of rotation. This causes a change in *R,* the direction of force, which is now more apical than the tipping, which occurs when teeth are arranged in straight arch splint. **C,** In a mandibular curved arch splint occlusal force on buccal slope of posterior tooth produces lingual resultant of force. This resultant may pass through or near center of rotation, causing little or no torque. **D,** In a maxillary curved arch splint of similar design center of rotation, *CR,* usually passes near the apical third of terminal abutments. Occlusal force on upper buccal cusp incline produces a resultant line of force which is buccal in direction, while center of rotation is lingual to tooth. This results in a great deal of torque. (Courtesy Dr. L. A. Weinberg, New York, N. Y.)

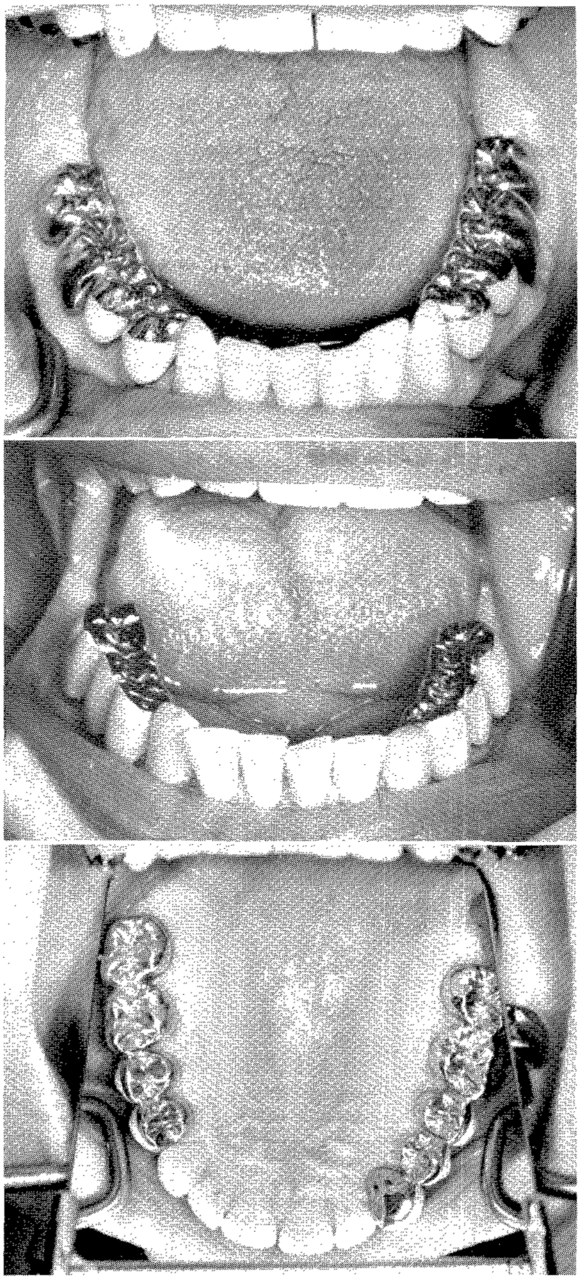


Fig. 5-37. Cases in which unilateral splinting was used to provide some stabilization and bone healing.

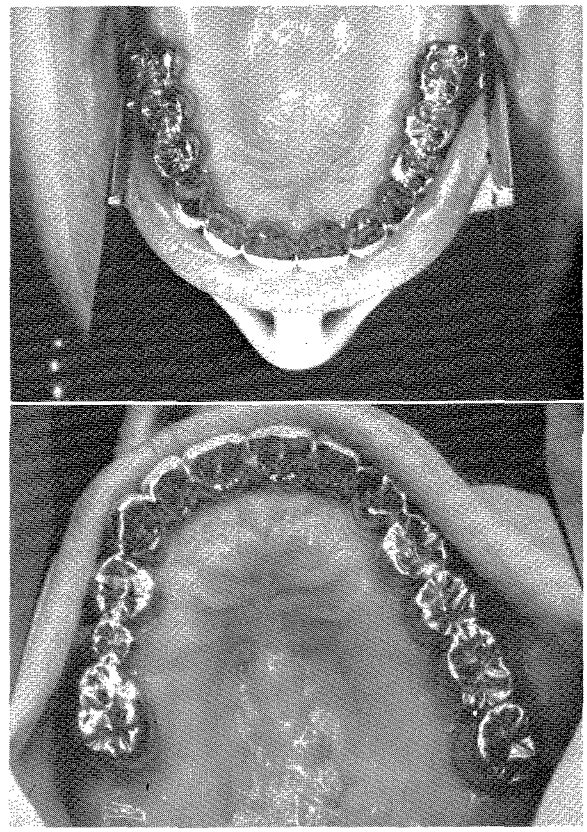


Fig. 5-38. Cases in which bilateral or cross-arch splinting was used to offer as much resistance as possible to force in all directions.

ment of jaw relations, and (4) improvement of masticatory efficiency.

Unilateral splinting[10] *is the joining of two or more teeth in one plane of an arch segment.* In this type of splint the resistance is primarily against mesiodistal force action. The only buccolingual resistance is that afforded a weakened abutment by its firm neighbors (Fig. 5-37).

As long as the patterns of mobility of two adjacent teeth are not identical, splinting two such teeth together will provide some stabilization. A concomitant of stabilization is a certain amount of bone healing.

Bilateral splinting,[10] or cross-arch splinting, involves the inclusion of teeth on two or more *segments of an arch up to and including the entire arch.* In this type of splint action the resistance to force is in all directions, and weakened or mobile teeth actually can give support to other mobile abutments. (See Fig. 5-38.)

The greatest effect is achieved from cross-arch stabilization; with such a tying together of teeth, forces, whether functional or otherwise, will be distributed among all the teeth in the arch. Because forces of occlusion are multidirectional, the ideal splint for reducing buccolingual mobility patterns is one that takes advantage of turning the dental arch; it provides maximum resistance against the multidirectional forces that occur in the mouth. Although the distribution

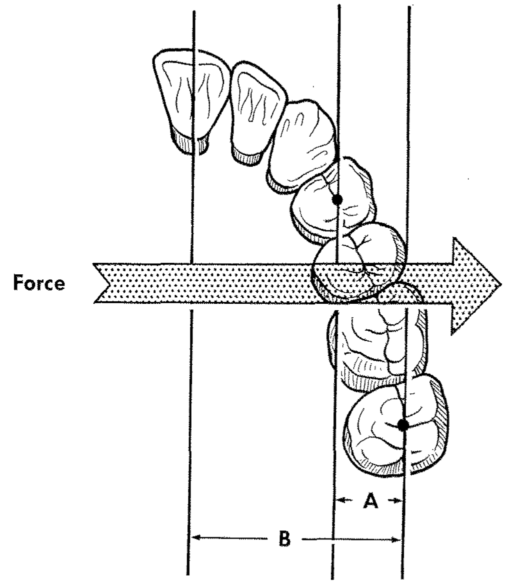


Fig. 5-39. Resistance to buccolingual force is relatively poor when splint runs from first bicuspid to second molar because of small distance, *A*, in buccolingual direction between second molar and first bicuspid. When splint is extended to central incisor, effective buccolingual distance is increased to *B*, which is much greater than *A*, and therefore provides superior resistance to force in lateral (buccolingual) direction. (Redrawn from Simring, Marvin, and Thaller, Jack L.: J.A.D.A. **53**:429-434, 1956.)

may not be equal, it may suffice to make the load tolerable for the periodontium. (See Fig. 5-39.)

In selected cases it may be possible to achieve bilateral splint action by means of a removable palatal strap, instead of the customary anterior fixed splints. This permits bilateral stabilization of the posterior segments in the absence of anterior tooth restoration. The palatal strap can be removed when stabilization takes place, and the "female attachments" can be filled in.

Types

Temporary or provisional splints

Provisional, or "healing," splints are employed for a limited period of time (1) to aid healing by limiting the mobility of the healing tissues, (2) to immobilize and relieve the periodontium about to undergo periodontal surgery, and (3) to assist in determining the prognosis of questionable teeth. Can changes in the attachment apparatus caused by occlusal traumatism be corrected and the teeth be stabilized in function by these means of periodontal surgery and stabilization and reorientation of force and stress? Will the periodontal ligament space remain abnormally wide, and will the teeth remain mobile? Even though the provisional splint has been cemented with zinc oxide-eugenol cement for a minimum of two months, has pulpal repair taken place? Will bite guards be necessary to overcome or minimize habit patterns—or can these habits be overcome? Is the patient cooperative in home care?

Above all, remember this: provisional splints tell us if the case will be a success or a failure.

Permanent splints

Permanent splints serve as constant adjuncts to the maintenance of periodontal health. They are employed when the periodontal support has been lost so that ordinary physiologic forces may not become injurious. The square area of attachment apparatus in relation to span and function must be "shored-up." Complete fixation will secure the necessary stability.

Telescopic splinting

Telescoping is the process of fitting a full coverage, primary casting, or coping, to a prepared tooth and then placing a secondary casting, or superstructure, over the primary casting.[33] It is not necessary to parallel the tooth preparations, but the copings must be paralleled. The tooth preparation is made along the direction of the inclination of the tooth without jeopardizing the pulp when teeth are tilted and it is difficult to obtain parallelism of preparations.

The telescopic principle of splinting, as explained and demonstrated to me by Morris Feder about ten years ago, has been of inestimable assistance in the handling of many cases requiring periodontal prosthesis. Frictional irritation of the dentin during removal and reseating of the permanent splint, opening and spreading of margins caused by repeated removals of the splint with the reverse hammer, etc., "wash-outs" and ensuing caries and even complete destruction of the coronal portion caused in great part by lack of parallelism of abutment teeth and improper occlusal relations, but also by the fact that temporary cement lacks the rigidity and durability to meet conditions of stress and flexure to which long multiunit restorations are subjected, etc., have been some of the drawbacks to the one-piece bilateral splint. It must be remembered, too, that permanent cementation of this type of splint is quite a task to accomplish, and, even if this is possible, the problem of removal after permanent cementation can be done only with almost complete mutilation of the splint. In patients requiring periodontal prosthesis, removal of the splints at times for alleviation of symptoms or for repair to individual teeth or tissues is not only probable, but also very possible in many cases of recent date or of many years' standing.

PRIMARY CASTING OR COPING

Fabrication of coping

This coping affords tooth protection because it is permanently cemented, thereby avoiding some of the bad effects of the one-piece, temporarily cemented splint as aforementioned. However, for the prepared tooth to be protected from sensitivity and caries the primary coping must be constructed and fitted properly.

These copings are constructed with parallel vertical walls to ensure accurate seating of the superstructure and to prevent movement of the teeth to conform to the prosthesis. This coping is critical since it must fit the tooth accurately and must create a receptive condition for the superstructure (Fig. 5-40).[34,35]

A shoulder is made around the gingival margin of the coping. On proximal surfaces the shoulder is coronal to the gingival papilla, which is protected by the contour and position of the shoulder and the solder joints. On the lingual surface the shoulder is coronal to the gingival margin, and this holds true for the facial surface, with the possible exception of the upper anterior teeth where the margin extends to, or slightly under, the gingiva.

In other words, the shoulder in the coping is supragingival on the lingual and interproximal surfaces, and in some instances on the facial surface a chamfer, which blends with the interproximal shoulder is developed. A shallow groove is made around the coping at the junction of the vertical walls and the shoulder to obtain better interlocking (Fig. 5-41). Because of the parallel

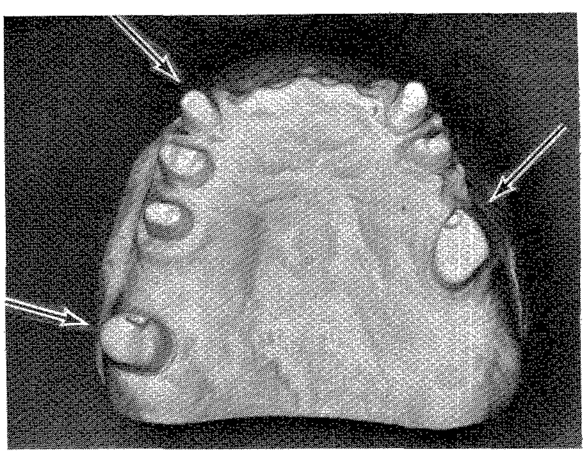


Fig. 5-40. Copings (arrows) constructed to aid in parallelism. Cervical third area must be properly contoured and marginal fit must be accurate.

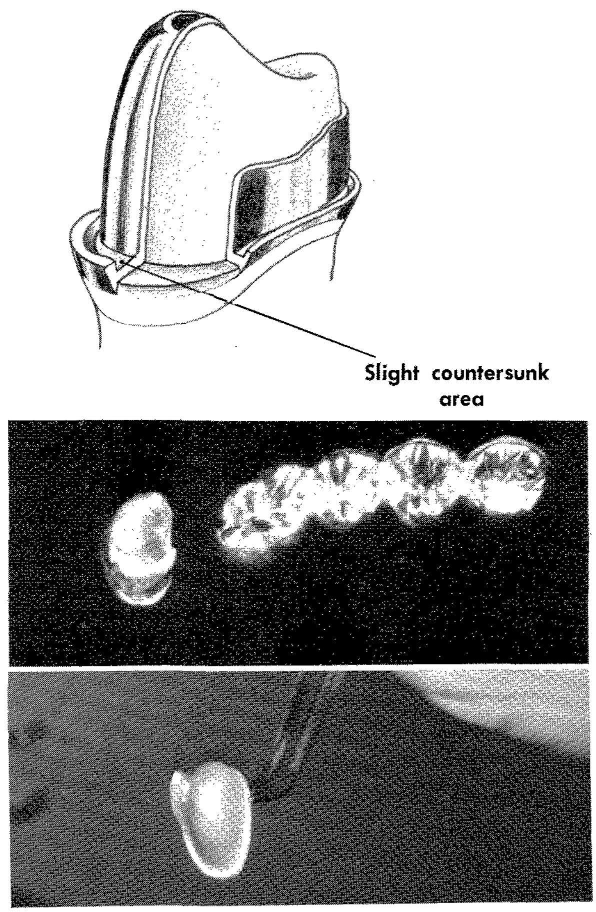


Fig. 5-41. A, A shoulder is made around gingival margin of coping. A shallow groove is made around coping at junction of vertical walls and shoulder to obtain better interlocking. **B,** A fixed splint requiring use of a coping for proper seating of bridge to prevent movement of teeth to conform to prosthesis. **C,** Proper development of proximal surface to avoid impingement on interdental papilla and still obtain good solder joint.

walls of the copings and the slight groove in the shoulder, likelihood of rotation of the superstructure on the copings is prevented and retention is provided.

The primary copings are waxed as thin as possible, the cast, with waxed dies, is positioned on the surveyor table, and the surveyor, with appropriate tools, is used to obtain the correct taper of the waxed copings for adjacent parallelism. Marginal limits should be established and the correct anatomical form should exist at the cervical third so that the recreation of pathology is avoided.

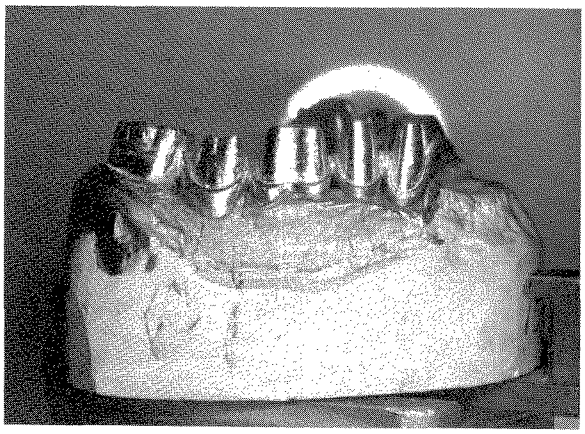


Fig. 5-42. Copings being milled for paralleling of walls and development of shoulder. Note proper positioning of solder joints to avoid crowding out of interdental papillae. (Courtesy Morris Feder, Philadelphia, Pa.)

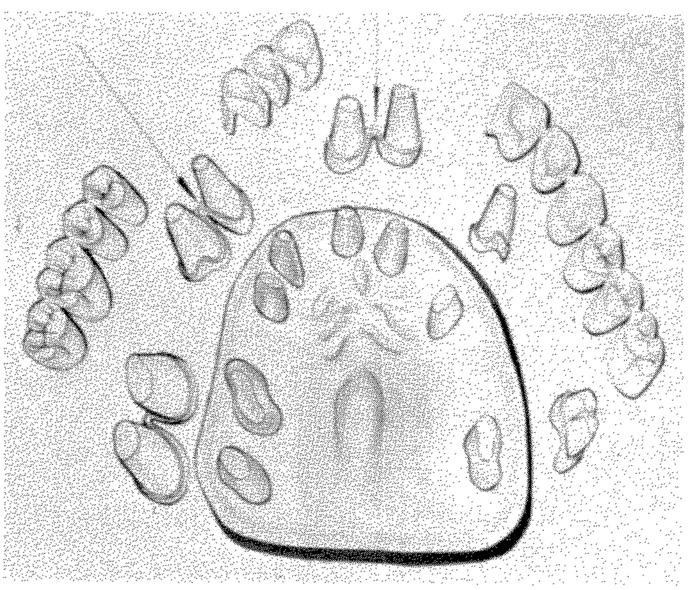


Fig. 5-43. Principle of cross-linkage. A bilateral splint divided into several small units and still retaining advantages of fixed splinting around arch. (Courtesy Morris Feder, Philadelphia, Pa.)

The wax patterns are then sprued, invested, and cast. After the castings are recovered and placed on their respective dies in the "working cast," they are rechecked on the surveyor for possible undercuts, parallelism, and correct amount of taper, and any corrections are made by drilling with the proper bur or stone, which is aligned in the handpiece holder attached to the surveyor.

Recheck the anatomic contour of the finished castings at the important cervical third area, finish the margins with great care, and polish this area very thoroughly. Copings are left as individual units, splinting being provided by the superstructure. However, the soldering of adjacent copings allows for additional support for mobile teeth. (See Fig. 5-42.)

The copings are then seated on their respective tooth preparations and checked out for marginal fit and gingival contour, after which hinge-bow transfer, centric relation bites, and overall plaster impressions are taken for construction of casts and mounting on an adjustable articulator for the construction of the superstructure.

The superstructure is constructed in sections, making use of the principle of "cross-linkage" (Fig. 5-43). By cross-linkage of abutments over soldered copings, a bilateral splint can be divided into two or three small units and still retain the advantages of fixed splinting around the arch. "Three separate overlays effectively unite the entire arch by overlapping the copings that are soldered where the sections of the superstructure are not soldered."* The path of insertion of these sections are developed in the laboratory on the "working cast."

This type of splinting permits stabilization when teeth are in malposition and not parallel, provides effective resistance to occlusal forces in all directions, and allows for any section of the splint to be removed for repair and maintenance, such as renovation of veneer facings, creation of pontics if and when it becomes necessary (extraction site is permitted to heal and then the

*From Prichard, John, and Feder, Morris: A modern adaptation of the telescopic principle in periodontal prosthesis, J. Periodont. 33:360-364, 1962.

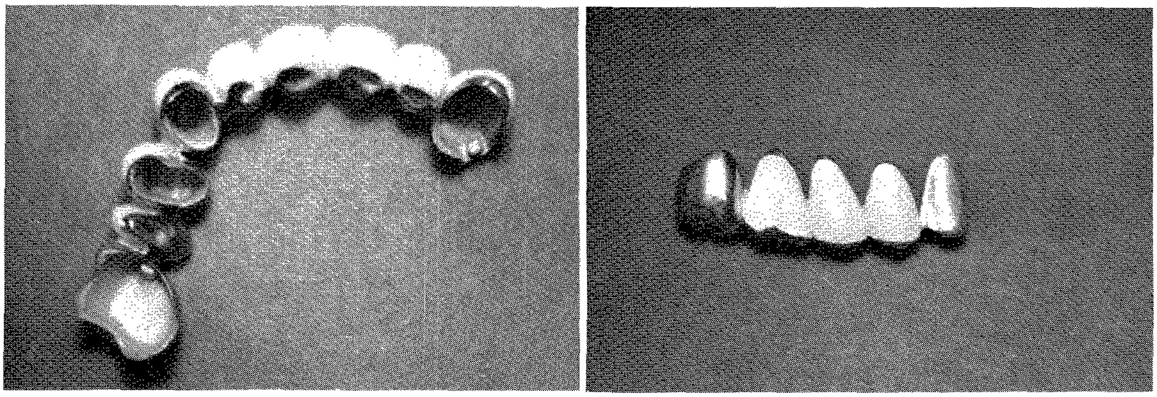
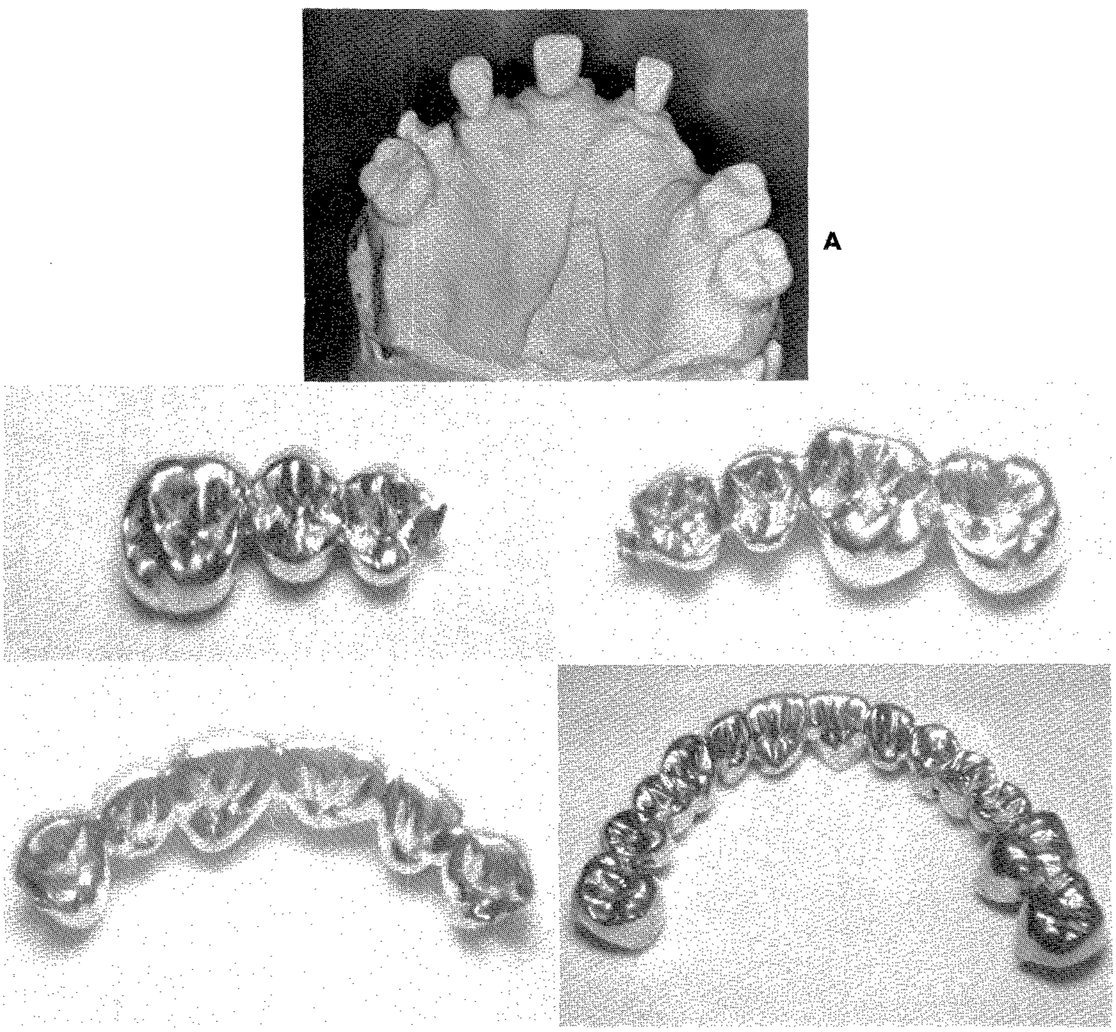


Fig. 5-44. Entire arch was splinted with two components in which a solderless joint was used to unite sections.



A

B

C

D

E

Fig. 5-45. A to **E,** Semirigid joints provided by precision attachments. **F** to **I,** A key and key-way.

superstructural crown is modified into a pontic by reshaping it and processing acrylic into it), in endodontic therapy, etc.

SECTIONAL SPLINTS

It is difficult and hazardous, as previously mentioned, to cement full arch splints in one piece, regardless of whether partial or full coverage retainers are used. Therefore, the entire arch should be splinted with two or three components in the splint (as pointed out in section on telescopic splinting) where a solderless joint can be used to unite the components (Fig. 5-44). Use also can be made of a semirigid joint provided by a key and key-way, or a semiprecision or precision attachment in cases requiring the union of components of a splint, in which the support is adequate and the mobility of the teeth is not marked (Fig. 5-45).

Some very capable dentists feel that in full arch splinting, when indicated, there should be a stress-breaker behind each cuspid so that the anterior teeth may be used without disturbing the posterior teeth and the posterior teeth can be used without pumping and rocking the anterior teeth.

CEMENTATION

The primary copings are cemented with permanent cement as individual or coupled units, but not before the superstructure has been completed and the whole case has been fitted and checked out for all necessary periodontal and restorative conditions. This is accomplished by seating the case (copings and superstructure) with zinc oxide powder (Moyco) and petroleum jelly for at least a period of two weeks. If on removal of copings and superstructure this paste is white and intact in all castings and gingival tissues appear healthy, the cementation of the primary copings with a permanent type of cement (oxyphosphate of zinc cement, Temerex,

F G H I

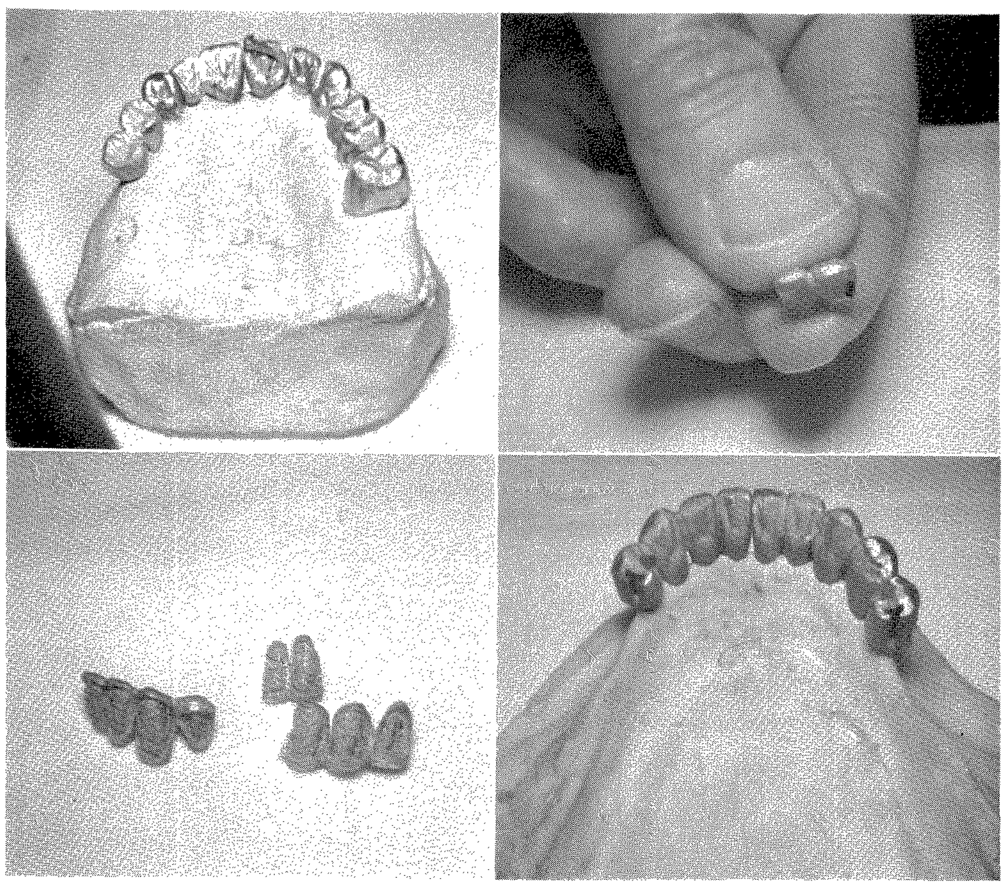


Fig. 5-45, cont'd. For legend see previous page.

E.B.A., Caulk's) can be done (see discussion on cementation in Chapter 10).

The superstructure is cemented with a zinc oxide-eugenol temporary cement.

Ample vertical space for better retention of the primary copings and space for two castings, as well as ample tooth reduction facially to accommodate two castings and veneering material, must be considered seriously. This requirement presents a problem with patients with short teeth or with crowded, small, lower anterior teeth.

Splinting of any nature creates a problem of maintaining good oral hygiene. The most thorough practice of oral physiotherapy must be utilized by the patient, with constant appraisal by the dentist.

Thorough clinical and roentgenographic examinations are necessary for a continual evaluation of the situation and its progress and prognosis.

If all of this—diagnosis and treatment planning, treatment procedures, postoperative care—is done thoroughly, the patient can and does in many, many instances retain his teeth for a number of years, making it worthy of the expenditure of time, energy, worry, and money involved in these cases of periodontal prosthesis.

In summation let us remember that, in splinting, the stabilization and fixation of mobile teeth occur. The teeth act together in such a way that they support one another and distribute and redirect forces among themselves. The shape of the dental arch, the position of the teeth within the arch, and the quality and amount of remaining alveolar bone are other important factors influencing the effectiveness of this procedure, which also includes the mobility patterns of the teeth, crown-to-root ratio, shape and size of the roots of the teeth, length of the edentulous space, and occlusal requirements. Buccolingual, mesiodistal, vertical, and rotational movements can be counteracted.

Splinting should not be visualized as complete elimination of functional movements because, even though in the most rigid of splints we have eliminated forces in the horizontal direction, we still have not eliminated forces in the direction of the long axes of the teeth. The functional stimuli that are exerted in the long axes are enough to keep the supporting tissues in good functional condition, and splinting does not stop functional stimulation.

But by all means keep foremost in your mind that, although the concept of splinting is a very important adjunct in therapy, its advantages should not be abused nor should its presence be substituted for proper occlusal relations. This principle of splinting should be combined, for maximum benefits, with altered coronal surfaces, and the teeth should be in functional harmony with the mandibular movements.

Jerge[32] has told us that splinting teeth imposes a totally unnatural condition on the sensory mechanism of the teeth. Under ordinary conditions periodontal ligament receptors of one tooth are not excited by pressure on another tooth 3 or 4 cm. away or by one on the opposite side of the dental arch. The need of more research along these lines is certainly urgent.

Promiscuous use of splinting is not recommended. If mobile teeth can be retained in proper position and function without splinting, in spite of the excessive loss of supporting bone, well and good, but in cases categorized as in need of periodontal prosthesis, which I have seen and treated, this is not possible. The entire dental mechanism has been interfered with, and experience has taught us that the dental mechanism can survive in a different environment. Both full coverage and splinting are indicated in these cases.

Therapy must be focused on measures that will aid in the recovery to health of the periodontal tissues and in the minimizing of the overall loss of support as it affects function on the teeth.

Restorative procedures

ACRYLIC RESIN MASKS

Value of masks

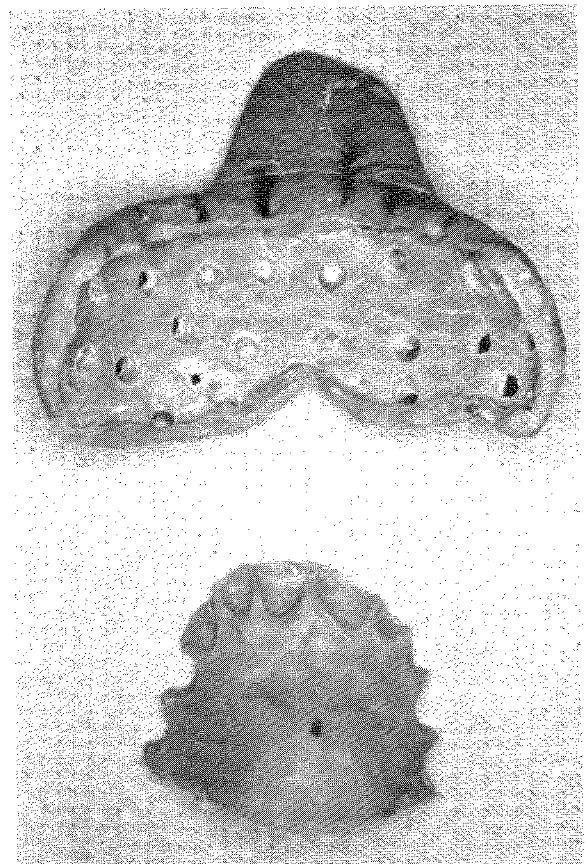
The removal of gingival tissues and alveolar bone, with its aftermath of exposed roots, lengthened clinical crowns, and enlarged interproximal embrasures, in the treatment of periodontal disease can leave, in many instances, unsightly oral structures, especially in the upper anterior region, from upper right second bicuspid to upper left second bicuspid. Besides the difficulty in the maintenance of proper mouth hygiene, the problem of esthetics, which is of such psychologic importance to the patient, cannot be taken lightly.

The solution to this problem is an acrylic resin mask, which is not difficult to construct and which serves the following purposes: (1) Provides good esthetic effect and psychologic comfort, (2) gives the lengthened clinical crown a more normal appearance by covering the exposed roots, (3) prevents tendency of upper lip from being caught in the concavity produced by the abnormally long incisors, (4) prevents excessive accumulation of foodstuffs in the enlarged interproximal embrasures, and (5) can be inserted and removed with little effort and is easily cleaned.[36]

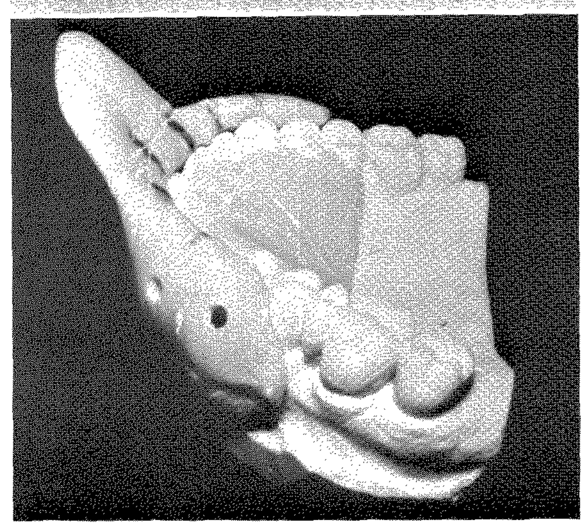
Technique of construction

1. After a thorough prophylaxis, take an alginate impression of the upper arch, being sure to obtain an accurate reproduction of the labial and buccal gingival tissues, especially in the area of the right second bicuspid to the left second bicuspid. Pour a stone cast (Fig. 5-46, *A*).
2. Make an acrylic palatal core that extends slightly into the interproximal embrasures from the lingual side to prevent the impression material from entering the embrasures from the labial and buccal sides too deeply when the final impression is made.
3. An acrylic resin impression tray is made (Fig. 5-46, *B*) for the labial and buccal surfaces. This is the tray that will give us a detailed impression of the teeth, the interproximal embrasures, and gingival tissues. Both the palatal core and impression tray are made of cold-cure acrylic resin.
4. With the palatal core in position, a proper mix of alginate impression material is placed in the specially constructed acrylic resin tray, and an impression is taken, positioning the tray facially. Examination of the completed impression should record in exact detail the labial and buccal surfaces of the teeth, including the incisal and occlusal edges from right second bicuspid to left second bicuspid, the interproximal embrasures, labial and buccal gingival tissues, and frenum. An accurate stone cast is made from this impression (Fig. 5-47).
5. The acrylic resin mask is waxed and carved (Fig. 5-48) and processed in heat-cured acrylic resin, after which it is refitted on a duplicate cast, stippled, and thoroughly polished.

The projections of the plastic mask into the embrasures hold the appliance in position without the aid of any other form of retention (Fig. 5-49).



A



B

Fig. 5-46. Construction of an acrylic resin mask. **A,** A stone cast, which has been made from good alginate impression, is used to make palatal core, which extends slightly into interproximal embrasures from lingual side to prevent impression material from entering embrasures from labial and buccal surface too deeply when final impression is made. **B,** A facially positioned acrylic resin impression tray is made also.

A

B

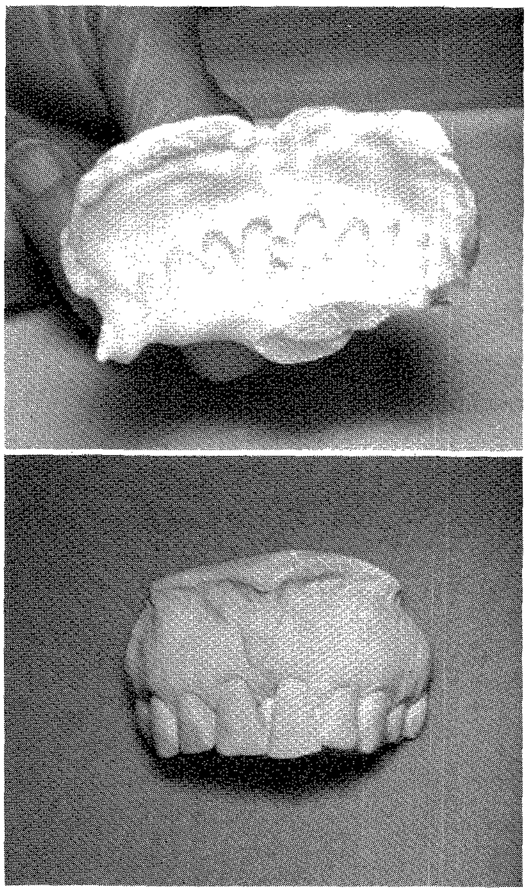


Fig. 5-47. A, Alginate impression taken in specially constructed tray (be sure palatal core is in position). **B,** An accurate stone cast made from impression.

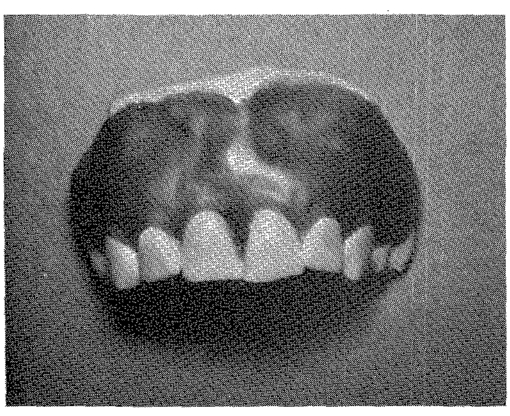
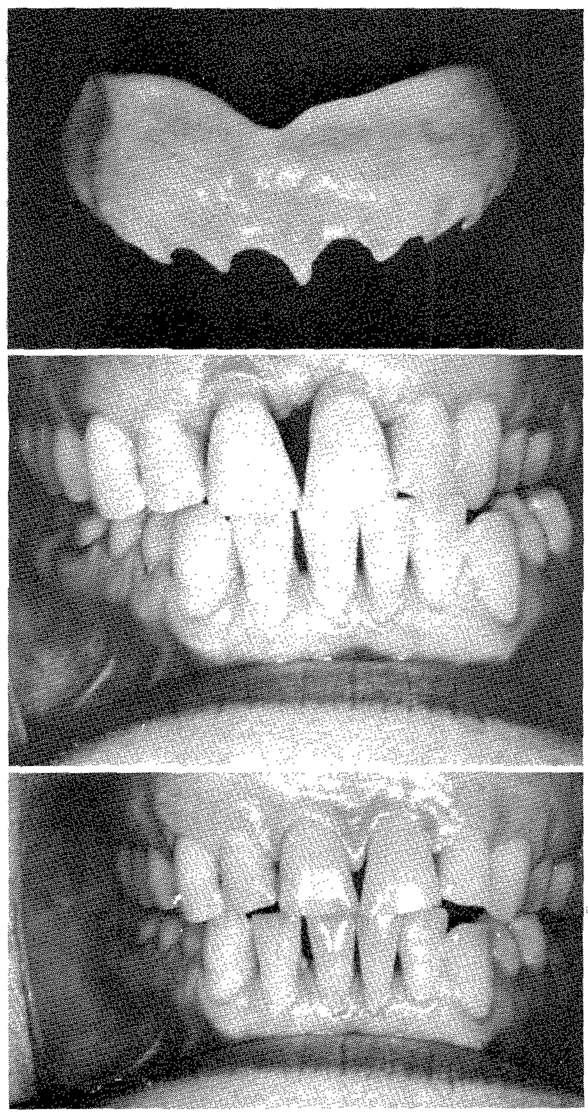


Fig. 5-48. Acrylic resin mask waxed and carved.



A

B

C

Fig. 5-49. A, Completed mask—projections of mask slip into embrasures and hold it in place. **B** and **C,** Preoperative and postoperative photographs of case.

PONTICS

Basic requirements of pontic design

A pontic not only restores a missing tooth, but also maintains oral function in a physiologic and esthetic manner.

Pontic form is very important. It must include in the topographic anatomy of the restoration the basic convexities, concavities, cusp form, and groove outlines. In other words, proper contour and form of the entire pontic must be developed. Its contour and form must ensure proper sanitation and stimulation of the mucosa. Conformation of the gingival contacting area of the pontic must not deny access of stimulation to the underlying gingival tissue because this tissue must be subjected to stimulation to have its health maintained. This is provided by the contact of food, tongue, cheek, and oral hygiene aids if embrasures are incorporated properly for the passage of this food and the mechanical stimulation of the edentulous mucosa.

Stein[37] has the following to say as to the basic requirements that must be met in the design of pontics:

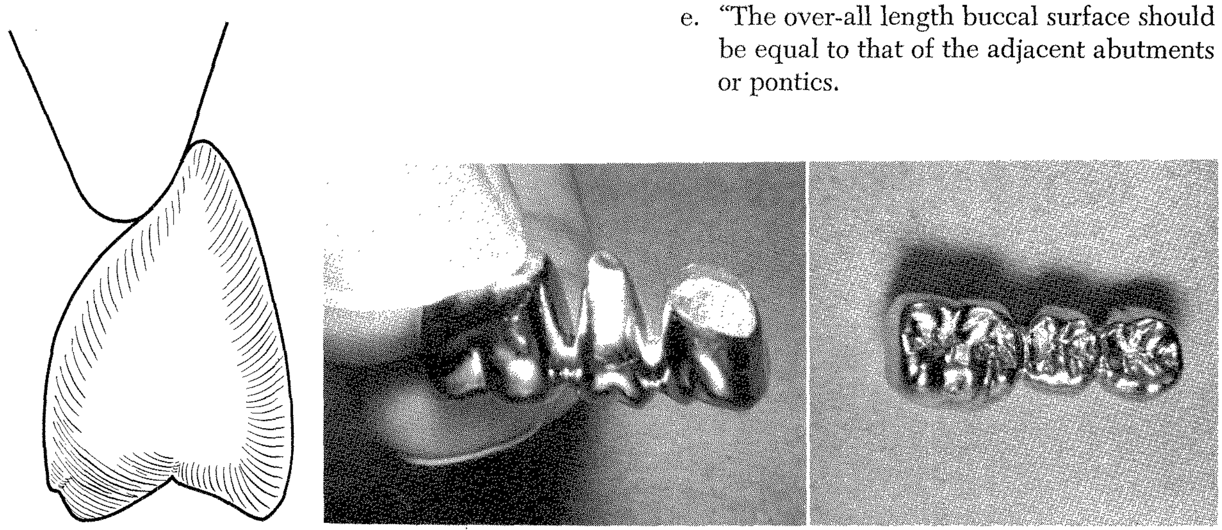
1. Pontics must restore the proper degree of function. The functional relationships of the cusps is the most critical consideration in the design of the occlusal surface of pontics. Because of the fact that the cusps should be in harmony with the functional pattern of the entire dentition, the necessity for the proper recording and transferring of mandibular relations becomes more obvious. It is to obviate the need to narrow or limit the coronal width, that is make it arbitrarily two thirds or less of the faciolingual occlusal width even when the periodontal support and the resultant leverage to the roots is not ideal. Reduction in occlusal width would come at the expense of centric contact, which, by all means, should not be sacrificed. The fixed splint should be constructed anatomically and physiologically correct thereby allowing for a meticulous distribution and direction of stress to all the roots of the teeth and to the residual ridges.

2. The secondary functional demands of esthetics, phonetics, and the protective role of food deflection must be satisfied by the conformation of the faciolingual surfaces.

3. Specific posterior pontic design (Fig. 5-50):

"A correctly designed posterior pontic should have the following characteristics:

a. "All surfaces should be convex, smooth, and properly finished.
b. "Contact with the buccal contiguous slope should be minimal (pinpoint) and pressure-free (modified ridge lap).
c. "The occlusal table must be in functional harmony with the occlusion of all of the teeth.
d. "The buccal and lingual shunting mechanisms should conform to those of the adjacent teeth.
e. "The over-all length buccal surface should be equal to that of the adjacent abutments or pontics.



A B C

Fig. 5-50. **A,** Modified ridge-lap type of pontic. **B** and **C,** Properly developed posterior pontic—lingual and modified ridge-lap view and occlusal view.

4. Specific anterior pontic design:

"A correctly designed anterior pontic should have the following characteristics:

a. "All surfaces should be convex, smooth, and properly finished.
b. "Contact with the labial mucosa should be minimal (pinpoint) and pressure free (lap facing). Esthetics may require a long area of contact to prevent the 'black space' appearance if the residual ridge is excessively resorbed.
c. "The lingual contour should be in harmony with adjacent teeth or pontics."*

The design of the pontic is the important factor in preventing inflammatory reactions beneath pontics, provided, in addition to design all surfaces are properly polished so that surface smoothness is attained. Pontics should have minimal contact with the ridge and should cover as little of the ridge as possible within the demands of esthetics and comfort. Where multiple pontics are to be placed, use ridge-lap type instead of bullet-nose pontics because there is less food retention. The ridge-lap type of pontic follows the facial contour of the ridge to the crest, where it joins the lingual surface. The lingual surface of the pontic should follow the normal tooth form for a distance of approximately half of its occlusogingival length and then should taper in a convex line to meet the facial portion at the crest of the ridge.

Never relieve the cast to get better pontic adaptation. It may result in pressure atrophy of the underlying ridge as well as periodontal breakdown on the teeth adjacent to the edentulous areas.

Inflammation from periodontal pockets into the adjacent edentulous mucosa is another important factor to be taken into consideration. This inflammation can extend for varying distances into this area, making it necessary to eliminate the inflammatory processes of both the diseased gingiva and edentulous mucosa. When this treatment has been carried out, it will reestablish the healthy contour of the gingiva and adjacent mucosa. In other words, periodontal treatment should not be limited to only the elimination of periodontal pockets and the restoration of gingival health. It should also create the gingival-mucosal environment that is necessary for the proper function of fixed and removal partial prostheses.[37]

*From Stein, R. Sheldon: Pontic-residual ridge relationship: a research report, J. Prosth. Dent. 16:251-285, 1966.

Sanitary type pontic

The sanitary type pontic reduces the risk of periodontal involvement. It consists of a cast occlusal surface, the undersurface of which is rounded faciolingually. Food passes under this surface, cleansing the surface of the mucosa and gingiva. The rounded undersurface of the pontic and surrounding tissues also can be cleansed by rubbing it with a folded dental napkin. Because of esthetics, its use should be limited to the posterior region of the mouth.

Porcelain veneers

Porcelain is resistant to abrasion, dimensionally stable, and insoluble in oral fluids. It is biologically acceptable.

The elastic limit of porcelain is so low that fractures occur from extremely small shearing and impact forces.

A porcelain facing in combination with a gold backing creates the best pontic from a biome-

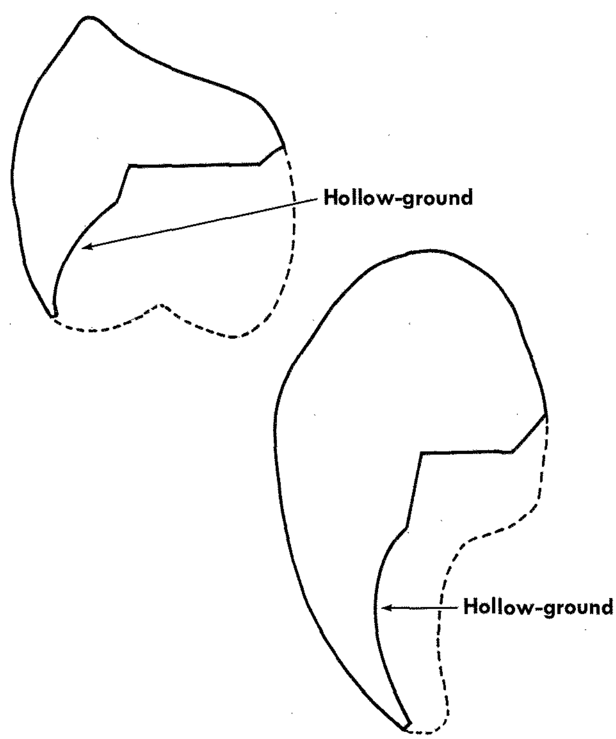


Fig. 5-51. Cross sections of hollow-ground facings showing bulk of metal with minimum display of gold.

chanical standpoint. The porcelain must be in an area where there is neither tension nor compression. An optimal biomechanical design is our objective; facings break because basic principles of good design are violated. It is necessary to have sufficient gold to rigidly resist occlusal forces. Incisal and occlusal edges must be treated correctly. The gold backing must have sufficient bulk, distribution, strength, hardness, and correct shape to resist distortion in function, and all this is possible without an undue display of gold (Fig. 5-51). A properly formed backing prevents shearing forces from being transmitted to the facing and thus eliminates failures caused by breakage. Use a gold that is sufficiently hard, such as a type 3 gold.

Reverse pin facing

The reverse pin facing is fabricated from a porcelain denture tooth by means of a special porcelain drill press (Fig. 5-52).[38]

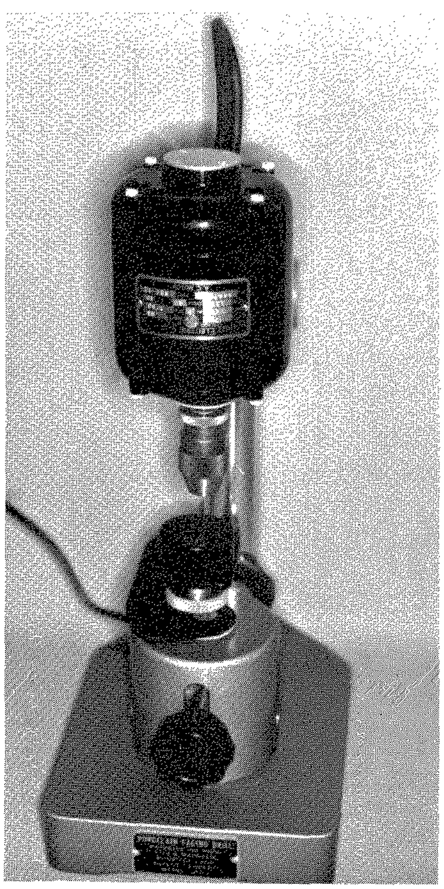


Fig. 5-52. Special drill press used in fabrication of reverse pin facing.

Since this type of facing is inserted into the backing from a horizontal direction, it can be modified on all six surfaces. Excellent design and esthetics can be obtained when using this type of facing. Many molds and shades are available. Porcelain can be added to the ridge-lap surface.[40]

Retention is secured over the entire lingual surface of the facing instead of by one or two pins that have porcelain fused to them, which allows for more chance of creating lines of fracture (Fig. 5-53).

Acrylic resin veneers

Acrylic resin falls short in its ability to resist wear and abrasion and is not tolerated as well by the soft tissues as is porcelain. However, many periodontal prosthesis cases require the use of the best type of acrylic resins because of length of spans, mobility patterns, torque, etc., and the telescopic principle of splinting, which allows for ease of renovation of facings, is the answer to this big problem (Fig. 5-54).

Fundamental principles for cantilevered pontics

A pontic no wider mesiodistally than the average bicuspid may be cantilevered off the end of a multiunit bridge to prevent extrusion of opposing teeth (Fig. 5-55). Proper contour of such terminal pontics is most important because of the absence of protection from a proximal tooth, which increases the risk of food accumulation under the pontic. It is preferable for the cantilevered pontic to fit against the mucosa of the alveolar ridge—it is fairly easy to keep clean and comfortable to the tongue.

A minimum of two abutment teeth (if a cuspid or first molar can be one of the abutments so much the better) should be used to support the pontic. The exception is a winged lateral from a cuspid or a small space from a molar. (See Fig. 5-56.) Some prosthodontists are of the opinion that one or two pontics between the abutment teeth are preferable because this will increase the lever arm support (Fig. 5-57).

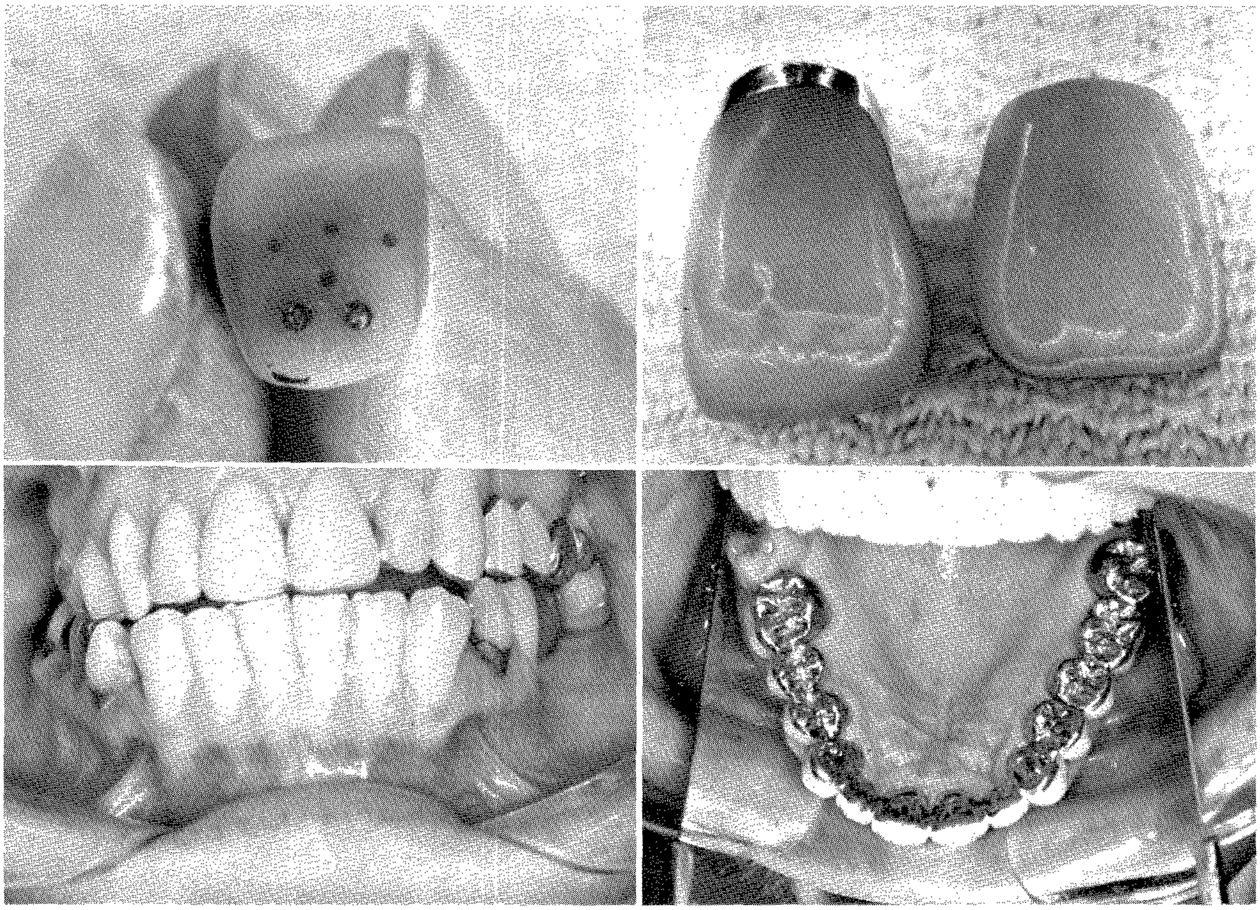


Fig. 5-53. Retention is secured over entire lingual surface of facing. Perlon pins are inserted into prepared holes (which are cut at an angle), wax-up completed, and casting made. This method is excellent for both pontics and veneer facings for crowns.

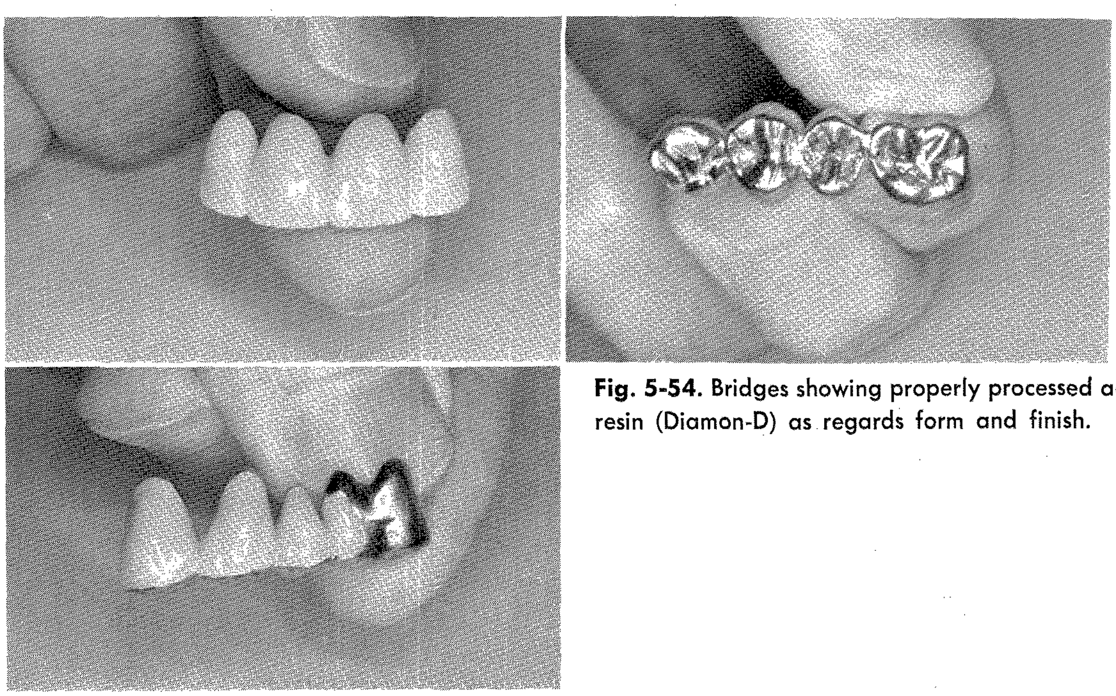


Fig. 5-54. Bridges showing properly processed acrylic resin (Diamon-D) as regards form and finish.

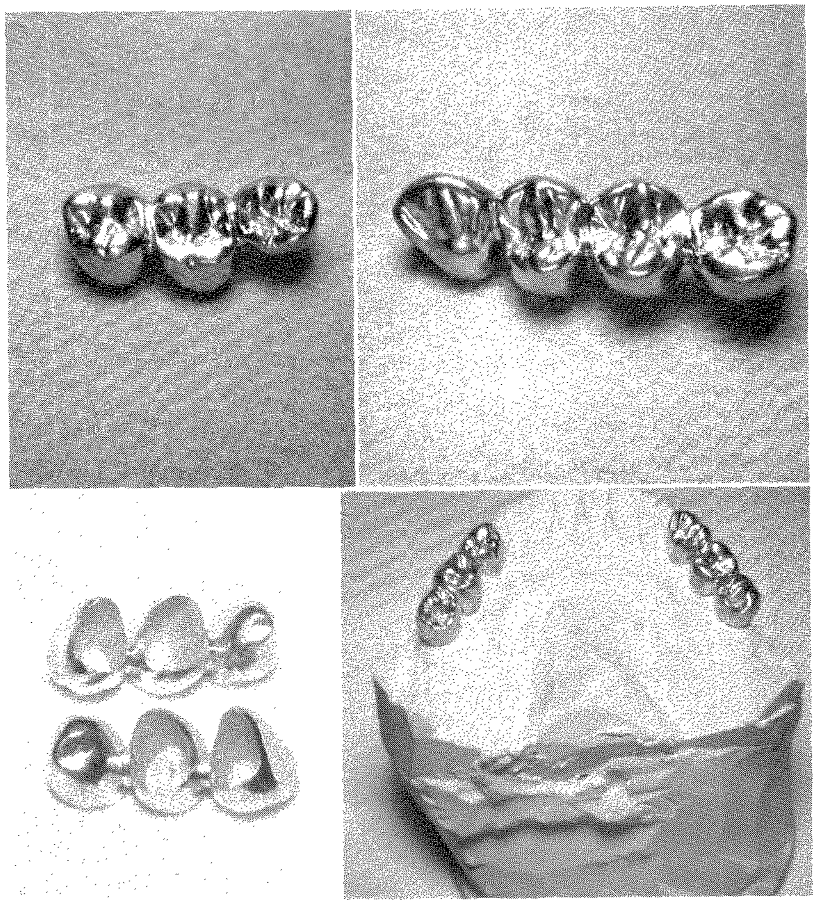


Fig. 5-55. Cantilevered pontics. Pontic is no wider mesiodistally than average bicuspid. Good contour is necessary, and in these cases cantilevered pontic should fit against mucosa of alveolar ridge since it is fairly easy to keep clean. It also will be comfortable to tongue.

Fig. 5-56. Minimum of two abutment teeth should be used to support cantilevered pontic with exception of a winged lateral from a cuspid or very small space.

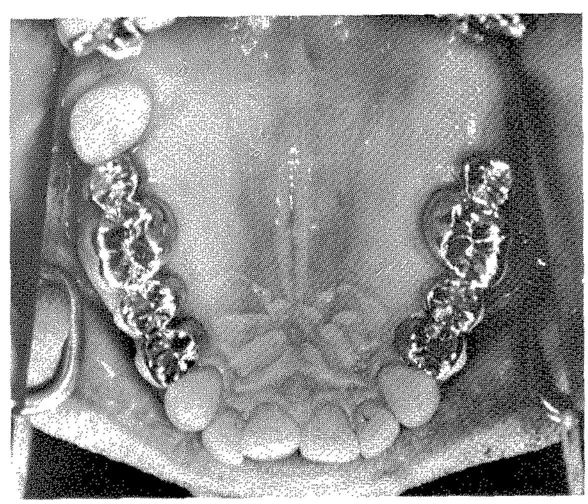


Fig. 5-57. One or two pontics between abutment teeth are preferable since this will increase lever arm support.

Prosthetic-periodontal treatment planning

PROCEDURAL INTEGRATION

In many instances the nature of the procedures dealing with the treatment of deeply involved debilitated dentitions calls for a coordinated teamwork approach as regards the prosthodontist, periodontist, oral surgeon, orthodontist, and endodontist. Careful planning is of the utmost importance, and the prosthodontist, who should have an overall concept of these specialities, must assume the full responsibility of the supervision of the treatment and outcome of the case. This necessitates not only a logical sequence of treatment, but also a complete agreement of the procedural plan by all specialists that are involved in the case.

The ability to correlate diagnosis, pathology, and etiology to therapy is of paramount importance. An oral examination, medical history, complete series of roentgenograms, evaluation of psychogenic factors, and properly oriented study casts on an adjustable articulator are indispensable aids for a competent diagnosis and treatment plan. Correction of any nutritional deficiencies and other general health disturbances is undertaken with the assistance of the physician.

Carefully timed restorative and periodontal procedures can augment each other to provide superior treatment. A working plan following the outline below may be formulated[9]:

1. Scaling and/or curettage
2. Minor orthodontic movement
3. Occlusal adjustment of gross occlusal interferences
4. Temporary fixed splints
5. Periodontal surgery
6. Periodontal prosthesis
7. Bite guards (if indicated) for minimizing habit patterns
8. Oral hygiene program
9. Maintenance care

The dentition is to be restored to as nearly normal position and function as possible by construction of all restorations and replacements that may be required, giving careful consideration to the impaired supporting tissues of each tooth as well as the entire dentition.

INITIAL TREATMENT

It is necessary to prepare the mouth for restorative procedures by creating the proper periodontal environment.

Initial periodontal therapy consists of a thorough scaling and/or curettage. All gross calcareous accumulations are removed, and as thorough a job as possible is done with root debridement of these deposits. Diseased cementum is removed, and curettage of the tissue side of the pocket is accomplished so that an environment that will promote healing is obtained. This is followed by a polishing of the tooth surfaces and the institution of physiotherapy. In some instances diastemas have closed after this initial treatment.

Although in involved cases this treatment may be only of a marginal nature, it is an important procedure because it reduces inflammation and allows for a better evaluation of the problem at hand. It, in conjunction with the roentgenograms and study casts, tells us if surgical procedures are necessary to fully eradicate any residual periodontal involvement. Probing of pockets and interradicular areas allows us to determine which teeth are hopelessly involved and are to be condemned to extraction, which can be treated by advanced periodontal methods, which may need root resection and endodontics, and whether elective endodontics can help us with the problems of parallelism, crown-to-root ratio, etc. Also, much can be learned about the patient's healing capacity, indications of rapidity of calculus formation and sordes accumulation, and his ability and motivation to carry out necessary home care. Another important factor to consider is that a field debrided of local irritants such as coronal and root calcareous deposits gives us an environment that allows for better and quicker healing after surgery, be it periodontal or removal of teeth.

MINOR ORTHODONTIC CORRECTIONS

Teeth that present a deficient axial relationship to basal bone, not allowing for correct distribution of forces over basal bone or poor contact relationships to adjacent teeth, should be corrected by orthodontic means before instituting any further periodontal therapy. Teeth must be positioned correctly to basal bone.

As previously stated (see discussion on orthodontics), when mass anchorage is required for proper alignment of the teeth, the patient should be treated by a trained orthodontist, but, when a tipping movement will suffice, malposed teeth often may be treated successfully by using a Hawley retainer or some modification of it, a Crozat appliance, grassline or steel wire ligatures, or rubber dam elastics.

SELECTIVE TOOTH GRINDING

Next in procedural sequence is selective tooth grinding for the relief of gross occlusal disharmonies. If orthodontic aids have not been used or are limited in their possibilities, the extent and nature of occlusal adjustment, which was indicated prior to tooth preparation, is directly related to tooth position. Extruded and drifted teeth must be corrected.

TEMPORARY ACRYLIC RESIN SPLINTS

Temporary acrylic resin splints are constructed in advance of the contemplated periodontal surgery.

Impressions (alginate, hydrocolloid, rubber base) are taken for the construction of casts, as are a hinge-bow transfer for correct orientation of the upper cast on the adjustable articulator and centric relation bites for the mounting of the lower cast by the split-cast method. The stone teeth on the casts are prepared (with burs and stones) for the construction of temporary acrylic resin splint "shells," which will be rebased upon completion of tooth preparations (Chapter 7).

This type of appliance (temporary splint) is necessary in many instances before advanced periodontal therapy for elimination of architectural deformities of the periodontum is started because it stabilizes mobile teeth and affords an immediate opportunity to improve the functional tooth relations of the dentition by changing the direction and distribution of stress on the teeth. It can serve also as a matrix for holding a surgical pack following periodontal surgery.

Osseous resection also can be used, at the time of surgery, to lengthen clinical crowns so that better retention is provided for the retainers, but only if a favorable crown-to-root ratio will still obtain.

PRELIMINARY TOOTH PREPARATIONS

In cases of advanced periodontal disease the full-coverage preparation and restoration is the one of choice because of the many requirements it is able to fulfill. Despite the importance of tooth structure conservation, the preservation of the supporting structures of the teeth is of prime importance. With changed embrasures, architectural form, and gingival position, only full coverage can be considered.

However, in cases exhibiting mild or moderately advanced periodontal involvement, showing facial and lingual contours that are intact and physiologic and not in need of bilateral splinting, indications and contraindications for the use of full coverage restorations has to be considered. In my opinion these are not the type of cases designated in the category of periodontal prosthesis (a widespread devastating generalized loss of the supporting periodontal structures accompanied by extensive pocket depth and varying degrees of mobility patterns calling for restorative treatment as an adjunct to periodontal therapy), but this is a matter of personal opinion, and I do not care to leave the impression that all patients in need of mouth rehabilitation call for the use of full coverage.

The teeth should be carefully prepared, ending the preparation just short of the gingival line. Retentive preparations should be made (Chapter 6). The preparation of the final marginal finish line and other necessary preparation alterations will be made after complete periodontal healing and before impressions for the final restorations are made.

TREATMENT OF PREPREPARED ACRYLIC RESIN "SHELL" SPLINTS

Preprepared acrylic resin "shell" splints, made from preoperative casts (Chapter 7), are fitted, and any necessary adjustments for complete seating and occlusion are made prior to the rebasing procedure.

Make a mix of acrylic resin, place this material, when ready, into the splint, and reseat the splint, having the patient close in centric closure —on a piece of tinfoil if there is an opposing acrylic splint—to prevent the surplus acrylic resin material from uniting the two splints. Press the facial and lingual excess material in a gingival direction, molding it to the prepared tooth surfaces with moistened fingers. As the material begins to set adapt it more densely subgingivally and interproximally to the prepared teeth with a flat-bladed instrument, which is coated with splint lube to assure accurate registration of the marginal areas. Keep moving the splint up and down on the prepared teeth during the setting of the rebase material to break away from any undercut areas, especially in areas beyond the preparations. After complete set has taken place remove the splint and contour it very carefully, not only coronally but interproximally as well for correct anatomic form.

Reestablishment of correct coronal form will help in gingival protection. Crown-to-root ratio can be improved, and reduction of the incisal guide angle will tend to decrease the horizontal overloading of the anterior teeth. The splints also provide necessary rigidity for mobile teeth and seem to help in maintaining the organizing blood clot intact for optimum healing after surgery. Carelessly constructed temporary splints, however, will not promote proper healing of the tissues.

The acrylic resin splints are then cemented with a zinc oxide-eugenol temporary cement.

A word of caution is in order at this point. It is the prosthodontist's obligation to periodically inspect and maintain the fit and function of the splints during the various phases of treatment for protection of the periodontium and pulp. This holds true during the surgical healing phase, after the placement of a new set of splints or additional revamping of the old ones after periodontal healing (the finalized provisional splints), and in many instances after placement of the permanent splints.

After cementation of the temporary splints the patient returns to the periodontist for final periodontal treatment by surgical means, soft tissue and osseous. During this phase of the treatment the periodontist can remove the splints, facilitating his approach to inaccessible areas. A reorientation of the mucogingival tissue may have to be resolved for maintenance of periodontal health.

FINALIZED PREPARATION

With the supporting structures completely healed, the preparations are refined and extended, impressions are made, and restorations are completed. The general rule is that preparations should not be finalized until the gingiva is healthy and its position on the root has been established.

The way in which the tooth is prepared and the restoration contoured is important. Sufficient tooth substance must be removed, and shoulder and chamfer preparations must be executed properly to allow for a correct replacement with the restoration. Particular care must be taken at the proximal line angles, where the width of the shoulder or chamfer is often inadequate and where added bulk in the restoration is needed to achieve a desirable esthetic effect, at the same time avoiding a displacement or crowding of the

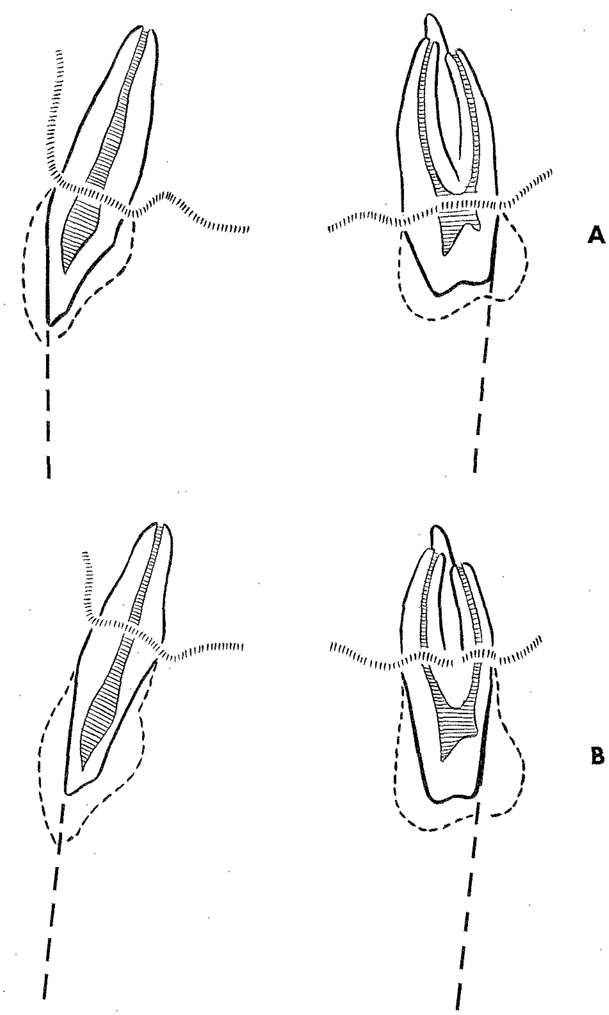


Fig. 5-58. A, In cases that do not have lengthened clinical crowns because of periodontal surgery, paralleling of anterior abutment tooth, even with its labial inclination, to posterior second molar abutment tooth can be done with comparative ease and safety. The distoproximal slice may have to be angulated slightly. **B,** Same situation with lengthened clinical crowns requires acutely angulated distoproximal slices of maxillary molars so that they are in same parallel plane with prepared labial surface of maxillary anterior quadrant of teeth.

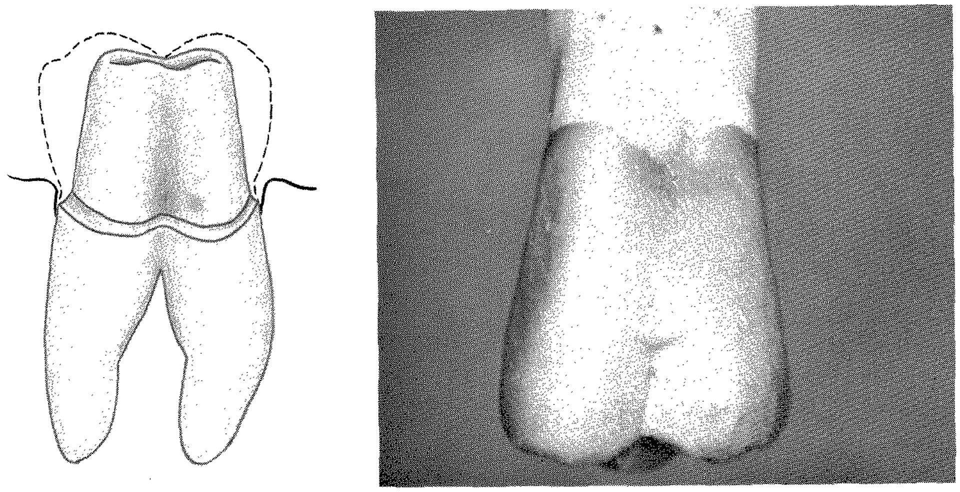


Fig. 5-59. "Barrel-out" preparations in furcations.

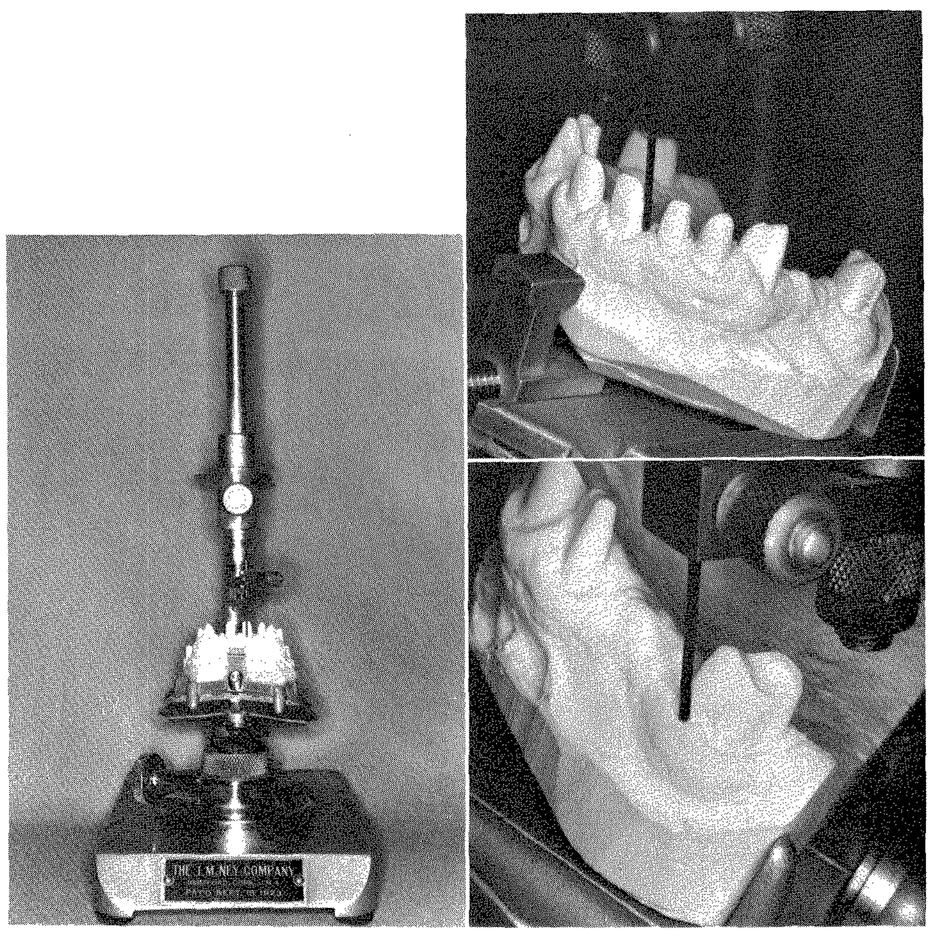


Fig. 5-60. In cases of periodontal prosthesis, after teeth have been prepared (with many *lengthened clinical crowns), take a hydrocolloid impression, pour a cast, and survey* various angulations of preparations for parallelism or learning which teeth or group of teeth can be splinted following telescopic principle. If changes are indicated, mark with a colored pencil and make these changes on preparations. The small amount of time necessary to make this survey pays good dividends.

interdental papilla. In other words, sufficient space for the restorative material is created by an adequate preparation, and thus it is possible to carve ideal contours.

Distoproximal slices of maxillary molars must be angulated acutely so that they are in the same parallel plane with the prepared labial surface of the maxillary anterior quadrant of teeth (Fig. 5-58). It is necessary to "barrel-out" preparations in furcations (Fig. 5-59).

"Principles of parallelism must be adhered to when anterior and posterior teeth are to be included in the same bridge. At times, even after orthodontic aid in repositioning of abutment teeth, parallelism is impossible because of the direction of the root areas. Telescopic copings and crowns may be used as an aid in paralleling and in seating and interlocking sections of fixed bridges. Teeth prepared for the reception of a telescopic crown must sometimes be tapered slightly more than a normal preparation. (See Fig. 5-60.)

"When preparations extend onto root surfaces or end at the cemento-enamel junction and the areas almost touch the corresponding area of the adjacent tooth, it is necessary to try to chamfer up to that area of contact. This is done to provide space for internal bulk, to give marginal strength to the crown, better gingival esthetics to the veneer, and provide interproximal embrasure space for the tissue to be located in health."*

Rosen and Gitnick[23] use a procedure in finalizing the preparations that I have found to be very successful in my cases. The preparations are made just after epithelization of the gingiva has taken place, which is usually in six to eight weeks after completion of the periodontal surgery. Since no gingival sulcus exists during early stages of maturation, a subgingival margin cannot be established. Visibility and access in the cervical region are best before the complete maturation of the gingival tissues, which takes place in approximately three months. At this particular time "the tissue matures, connective tissue is laid down, the surface becomes stippled and keratinized and a shallow knife-edged gingival sulcus develops."† As the gingival tissues mature, a shallow crevice develops and the supragingival restorative margin becomes one that is subgingival (Fig. 5-61).

In endodontically treated teeth a cast post or an endo-post with cast gold cores is constructed and cemented with oxyphosphate of zinc cement. These post-anchorage cast gold cores are made parallel to the adjacent preparations by making use of the surveyor.

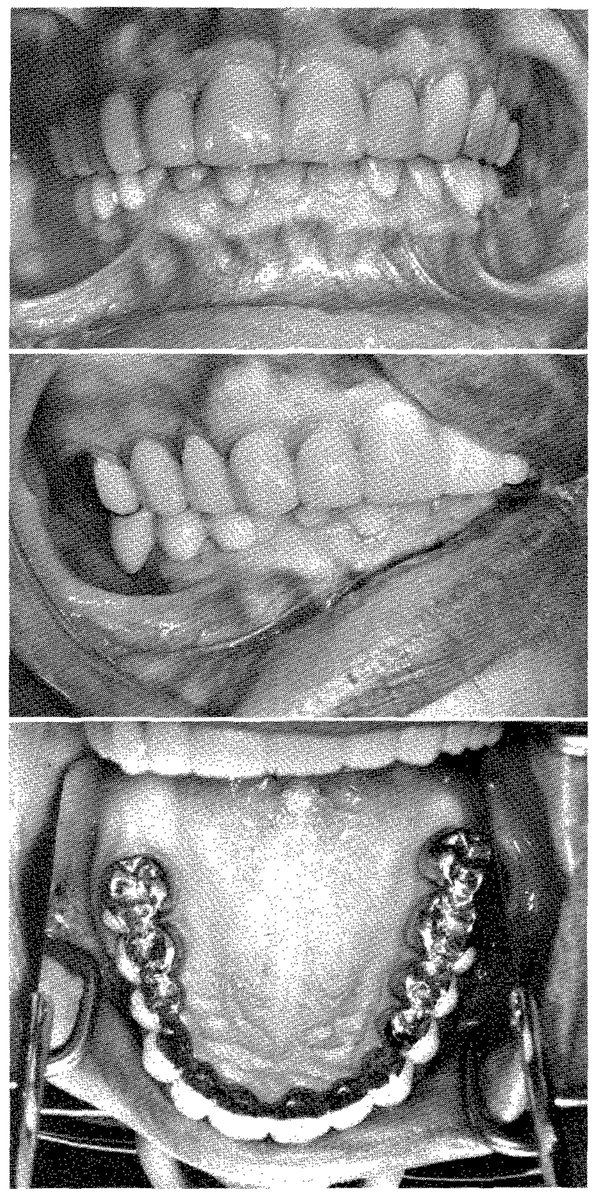


Fig. 5-61. Preparations made just after epithelization of gingivae following periodontal surgery. Case seven years postoperatively shows mature gingival tissues and supragingival restorative margins have become subgingival.

*From Minker, Jules S.: Simplified full coverage preparations, Dent. Clin. N. Amer., pp. 369, 371-372, July, 1965.
†From Rosen, H., and Gitnick, P. J.: Integrating restorative procedures into the treatment of periodontal disease, J. Prosth. Dent. **14**:343-354, 1964.

PROVISIONAL AND PERMANENT RESTORATIONS

After finalization of tooth preparations full upper and lower hydrocolloid impressions (since no subgingival margins exist), a hinge-bow transfer, and centric relation bites are taken for the construction of the working casts and for the proper orientation of these casts on an adjustable articulator. At this stage we can construct well-made provisional splints (gold-acrylic veneer), provided we feel our objectives such as assurance of the retention of repositioned teeth, roentgenographic evidence indicating a return of a physiologic width of the periodontal ligament and definitely defined lamina dura and trabeculae of bone, proper keratinization of the periodontal tissues, firm and stippled gingival tissues with good color and contour, reduction of mobility, clarification of prognosis on doubtful teeth have now been achieved. Biologic crown form, rigidity for stabilization of mobile teeth, improved functional tooth relations to promote the completion of the healing of traumatic lesions, and a more conducive environment for the reorganization and stabilization of the surrounding bone around the orthodontically moved teeth must be given prime consideration. The case must be solved and evaluated properly in the provisional stage, and all procedures must be executed with the utmost care and thought so that all can benefit from present-day knowledge.

A change in the vertical dimension of occlusion may be necessary occasionally because of the collapse of the dental apparatus, especially posterior bite collapse.

Any increase in an existing vertical dimension of occlusion must be made with extreme prudence. If you wish to avoid trouble, do not impinge upon the interocclusal space. Skurnik[42] says that "this position is an anatomic and functional entity differing greatly among individuals. . . . Some individuals require more and others less of this arbitrary space [2 to 3 mm.] for optimum efficiency in mastication, speech, esthetics, and neuromuscular adaptation."*

When we are satisfied that our objectives have been achieved, which may take some time in certain cases, we are ready for the completion of the case. In some cases in which gold-acrylic veneer restorations have been used, these restorations can be used as the permanent ones. In some instances a completely new permanent case has to be made. The procedures followed in the construction of these cases at this stage is thoroughly covered by a step-by-step procedure of a practical case in Chapter 13.

REMOVABLE PARTIAL DENTURES

If a removable appliance is indicated, only the internal precision attachment or telescopic partial denture should be used (Fig. 5-62). Since the center of rotation of a tooth carrying an attachment is much closer, compared to a circumferential clasp, to the actual center, functional stress is resolved into a vertical intrusive force. Without circumferential pressure, supporting structures are under stress only during function. The insertion and removal are limited to one exact path, which places no stress on abutment teeth during these operations.

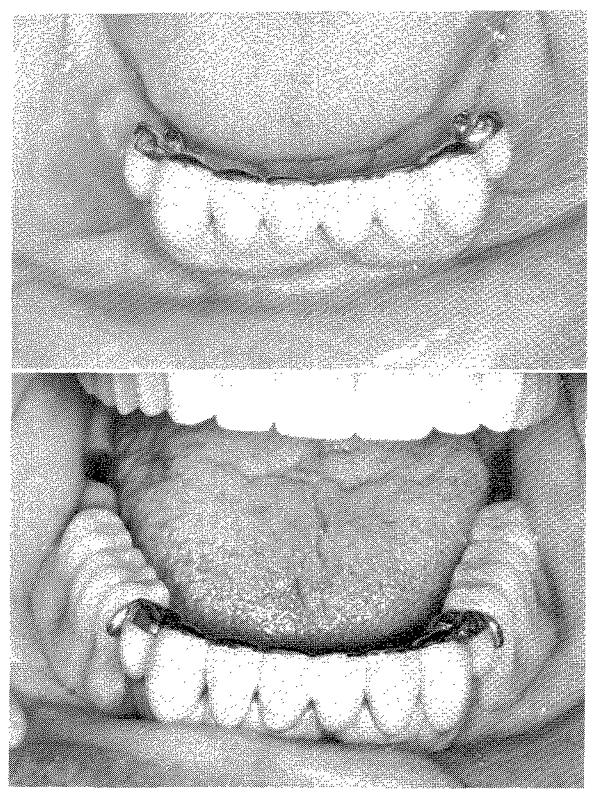


Fig. 5-62. If a removable appliance is indicated, make use of internal precision attachment or telescopic partial denture. Case in which internal precision attachment was used is shown.

*From Skurnik, Harry R.: Treatment planning for occlusal rehabilitation, J. Prosth. Dent. 9:988-1000, 1959.

CEMENTATION

The permanent case is cemented temporarily with Moyco powder and petroleum jelly, be it a telescopic case with copings and superstructure or otherwise constructed, for a minimum of two weeks. On removal of castings, if a "wash out" has taken place, rest assured that the same will be true of permanent cementation. This is caused by torquing due to a lack of parallelism or an occlusal factor. If, however, on removal of the castings (crowns, copings, superstructures) the powder has a pure white color, one can proceed to "hard cement" the case; for telescopic restorations the copings are cemented permanently (oxyphosphate of zinc cement, EBA, Temerex, Caulk Fynal), and the superstructures are cemented temporarily with Moyco zinc oxide–eugenol cement.

Remove all excess cement with great care, using a sickle-shaped explorer or worn curettes, to ensure against gingival irritation. Traces of temporary cement adhering to the surfaces of the acrylic veneers and natural teeth may be removed with Orange solvent.

If indicated, a bite guard or guards can be constructed for minimizing habit patterns (see discussion on parafunctions).

HOME CARE

The final phase of any mouth rehabilitation case is adequate instruction for home care—suitable toothbrushing, flossing, interdental stimulation, and use of the Water Pik.

The dentist must observe how and what the patient does with this important assignment—his ability and motivation to carry out home care. Without real motivation for a systematic regimen of toothbrushing and gingival stimulation, the case, regardless how well executed, will "go down the drain."

The periodic recall system must be instituted and carried out by all means.

ORAL PHYSIOTHERAPY

Proper instruction and supervision of oral care at home is as important as any service we render our patient in mouth rehabilitation. We must make a supreme effort to motivate the patient to conscientiously perform the necessary cleansing procedures, which must be maintained properly. However, without cooperation of the patient in this respect all other therapy seems unwarranted.

Recurrence of periodontal disease and caries at the margins of restorations may well be evident if properly instituted care is not taken to ensure routine massage of supporting tissues and the thorough cleansing of all the surfaces of the teeth. A caries-susceptible patient must understand the plaque concept of incipient caries and how to cope with it. *Let us reiterate—home care is most essential.*

Colbern,[43] in summarizing Arnim's[44] lecture, has this to say:

"Dr. Arnim states that dental plaque is one of the causes of the most common dental diseases, dental caries and periodontal disease. The microcosm is located between the teeth, in the gingival crevice, in pits and fissures, and all habitually unclean areas. The microcosm is a composite of the dental plaque or zooglea (slime-layer), the bacteria, food, and the products of metabolism. The zoogleal (living glue) gel forms a semipermeable layer under which the bacterial colonies can multiply to cause disease. *In the carious lesion,* the bacteria form the acid to dissolve the teeth in areas where the microcosm is not removed from the habitually unclean areas of the tooth surface. *In the periodontal lesion,* the microcosm is located in the gingival crevice and the end products of protein degradation produce gingival inflammation which causes the breakdown of the circular and other connective tissue fibers in the gingivae at the neck of the tooth. This causes the gingivae to lose its purse string-like adaptation to the tooth and the gingivae becomes flabby, irritated, and swollen. Upon further progress of this situation, the microcosms in the crevice causes calculus to be formed in the pocket, the pocket becomes deeper due to the continuing inflammation, the bony support is destroyed, the tooth becomes loose and is finally lost. The problem, as Dr. Arnim sees it, is then to control the microcosm effectively so that the disease does not have a chance to occur. Once the microcosm is removed it takes 24 to 48 hours for the microcosm to grow back in quantity, and the longer the microcosm is present, the harder it is to remove."*

*Colbern, Robert: Effective oral hygiene for full mouth rehabilitation, Second International Congress of Gnathology, San Diego, Calif., 1965.

Arnim is largely responsible for innovations in methodology, implementation, and techniques of patient motivation, leading to a more realistic and effective approach to oral physiotherapy.[45]

The aids advocated by Arnim are (1) disclosing wafers, (2) soft, nylon toothbrush, (3) unwaxed dental floss, and (4) water spray.

1. Disclosing wafers: This type of wafer is used to measure tooth cleanliness. It consists of a water-soluble, vegetable dye compounded into a flavored tablet (a palatable food color tablet of F.D.C. red No. 3 (Erythrocin). It stains the dental plaque red so that it is visible and can be removed. It does not color the teeth or restorations if free of plaque. The cervical and interproximal areas exhibit the heaviest staining pattern. Since the common denominator of the causes of dental diseases is plaque, it is readily seen that if it can be removed promptly, the disease cannot exist. At recall visit, the teeth should be restained, and, using a large hand mirror, the patient should be shown the bacteria on his teeth that is associated with inflamed gingiva.

The patient should use a disclosing wafer daily until he becomes very proficient in the cleansing of the teeth, after which once a week will probably be sufficient to act as a check-up on his oral physiotherapy efficiency.

2. Toothbrush: The primary objective of brushing the teeth is removal of coronal accretions such as food debris, soft deposits, bacterial clumps, and stains. Regular removal of adherent microorganisms from the surfaces of the teeth and the prevention of calculus formation in the cervical regions are of particular importance in avoiding cariogenic activity and periodontal pathosis.

An Oral B30 or Oral B40 soft nylon toothbrush or a Butler toothbrush with rounded bristles are my choices. The toothbrush removes dental plaque from three surfaces of the tooth—facial or cheek side, lip side, lingual or tongue side, and occlusal or biting surface. The procedural steps for correct use of the toothbrush are as follows:

a. The brush is placed with the side of the bristles flat against the attached gingiva and the handle parallel to the occlusal surfaces; the side of the bristles is pressed firmly against the gums.
b. The brush is moved along the attached gingiva to the marginal gingiva.

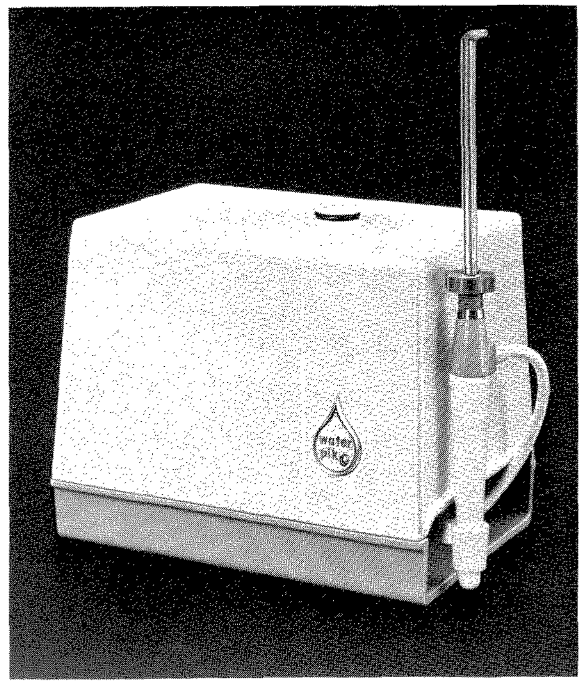


Fig. 5-63. Water Pik for forced irrigation to remove dental plaque from crevice between tooth and gum.

c. As the brush moves onto the tooth surfaces, it is rotated slightly to about 45 degrees, and the stroke is continued until the entire facial or lingual surface has been passed over with the brush.
d. The occlusal surfaces are scrubbed with a rotary and a forward and backward movement of the bristle points. Brushing of the tongue is advocated in many cases.[46]

3. Dental floss: Interproximal surfaces are relatively inaccessible to the toothbrush; retention of disclosing stain after careful toothbrushing is proof of this fact. A thin, unwaxed floss should be used regularly for consistently effective results in these areas. Removal of stained microorganisms is attained also.

4. Water spray: Cohen and Bohannan[45] have told us that the gingival sulcus and the interdental col usually harbor bacteria and debris, and the toothbrush and floss fail to reach the depths of these areas consistently.

Forced irrigation removes the dental plaque from the crevice between the tooth and the gum, it being necessary to pass the water spray (Water Pik*) around each tooth and between the teeth,

*Aqua Tec Corp., Denver, Colo.

under pontics, and into "female" attachments in precision removal partial dentures, to thoroughly flush and cleanse these areas.

This type of appliance should be an integral part of daily oral physiotherapy, and it is excellent for use in compromised results when some residual depth remains and in cases where pocket elimination is contraindicated. The water spray has proved to be the answer to the elimination of subgingival microcosm.

The Water Pik (Fig. 5-63) produces a gentle intermittent compression of the gingival tissues, twenty times each second, as evidenced by momentary blanching at the height of the pulse. It thoroughly irrigates the gingival sulcus by lifting the free gingival margin and flushing out the crevice. Deep periodontal pockets are irrigated thoroughly with cyclic surges of water pressure.

Interdental stimulators

Interdental stimulation (rubber tip, Stim-u-dents, round toothpicks) is imperative. Most gingival problems start interproximally where the toothbrush cannot reach.

Insert the stimulator interproximally until it is wedged tightly, and then massage the tissues with a pumping motion, up and down and in and out several times. At first this procedure may be painful and produce hemorrhage. However, by so stimulating the swollen pathologic tissues, it allows them to repair themselves and return to a state of normalcy. The tenderness and hemorrhaging will disappear.

Bodkins (zon dental bridge cleaners*) are used to pass the dental floss beneath the pontics of a bridge so that it can be kept clean; pipe-cleaners are handy for cleansing of furcations.

Dentrifices have polishing qualities and detergent action, but are of no therapeutic value to the periodontium. Use one with as little abrasiveness as possible.

The use—the "why" and "how"—of the disclosing tablet, toothbrush, unwaxed floss, interdental stimulators, water spray, bodkins, and other aids is the basic information to be communicated to the patient. He must clean his teeth frequently to prevent accumulation of adherent masses that cause dental disease. The gingival tissues must assume and maintain a normal healthy tone, color, and form.

Good dentistry is of little value unless the patient controls recurrent caries and periodontal disease in his mouth.

*Johnson & Johnson, New Brunswick, N. J.

CONCLUDING REMARKS

The preservation of the integrity of the individual dental unit is of the utmost importance—it is part of a self-protecting mechanism.

The function and future life of the restoration depend upon the preservation of the epithelial attachment and the normal form of the crown—physiologic form and function.

When splinting is necessary, additional stability is obtained by the correct posterosuperior position of the mandible.

In periodontal prosthesis we can modify the anterior guidance and the vertical dimension, working within the limits of the established freeway space. It is also possible to establish favorable or acceptable esthetic, phonetic, and masticatory patterns.

This method of treatment, periodontal prosthesis, should not be used as an excuse to justify poor occlusal relations. All of the occlusal elements should be restored, and they should be arranged to suit the lateral border movements and centric relation.

If not executed properly, restorative dentistry can be an etiologic factor in periodontal disease or recreation of this condition after periodontal therapy. Gross to subtle errors in restorations can be responsible for pocket formation and loss of alveolar bone. A great deal is dependent on the way in which the tooth is prepared and the restoration is contoured.

The patient must have, on completion of the mouth rehabilitation, a negative occlusal perception.

Caution is necessary to prevent the definition of the "normal" to exclude individuals with an abnormal dental biomechanism in appearance, which may be functioning in a good physiologic state (Figs. 5-64 to 5-66).

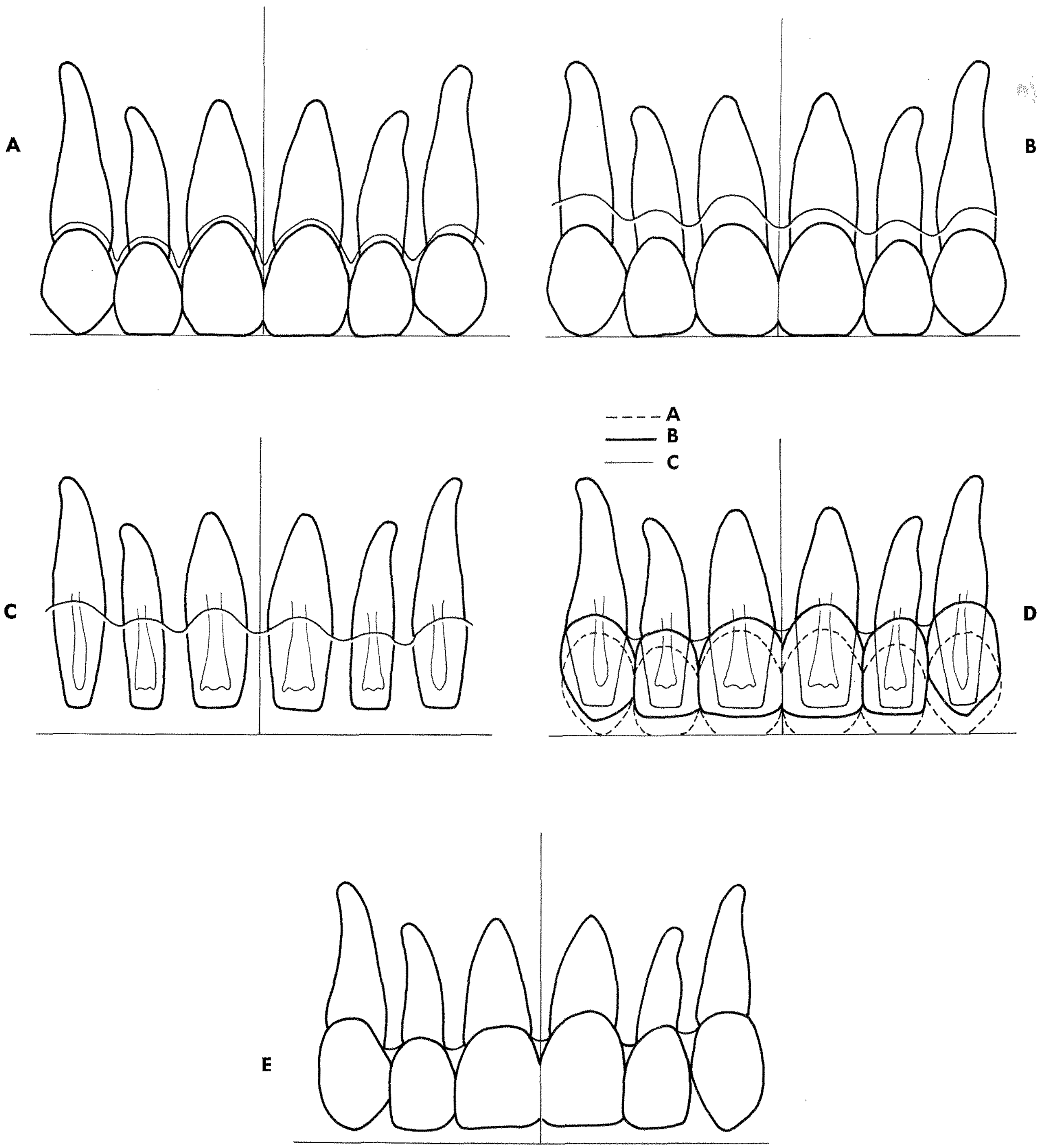


Fig. 5-64. Schematic drawings showing development of biomechanical restoration beginning with **A**, condition as presented by the patient, **B**, after periodontal surgery, **C**, preparations, keeping in mind parallelism, elective endodontics, crown-to-root ratio, etc., **D**, teeth before preparation *(A)*, after preparation *(C)*, and biomechanical restoration *(B)*, and **E**, biomechanical restoration. (Redrawn from illustrations courtesy Morris Feder, Philadelphia, Pa.)

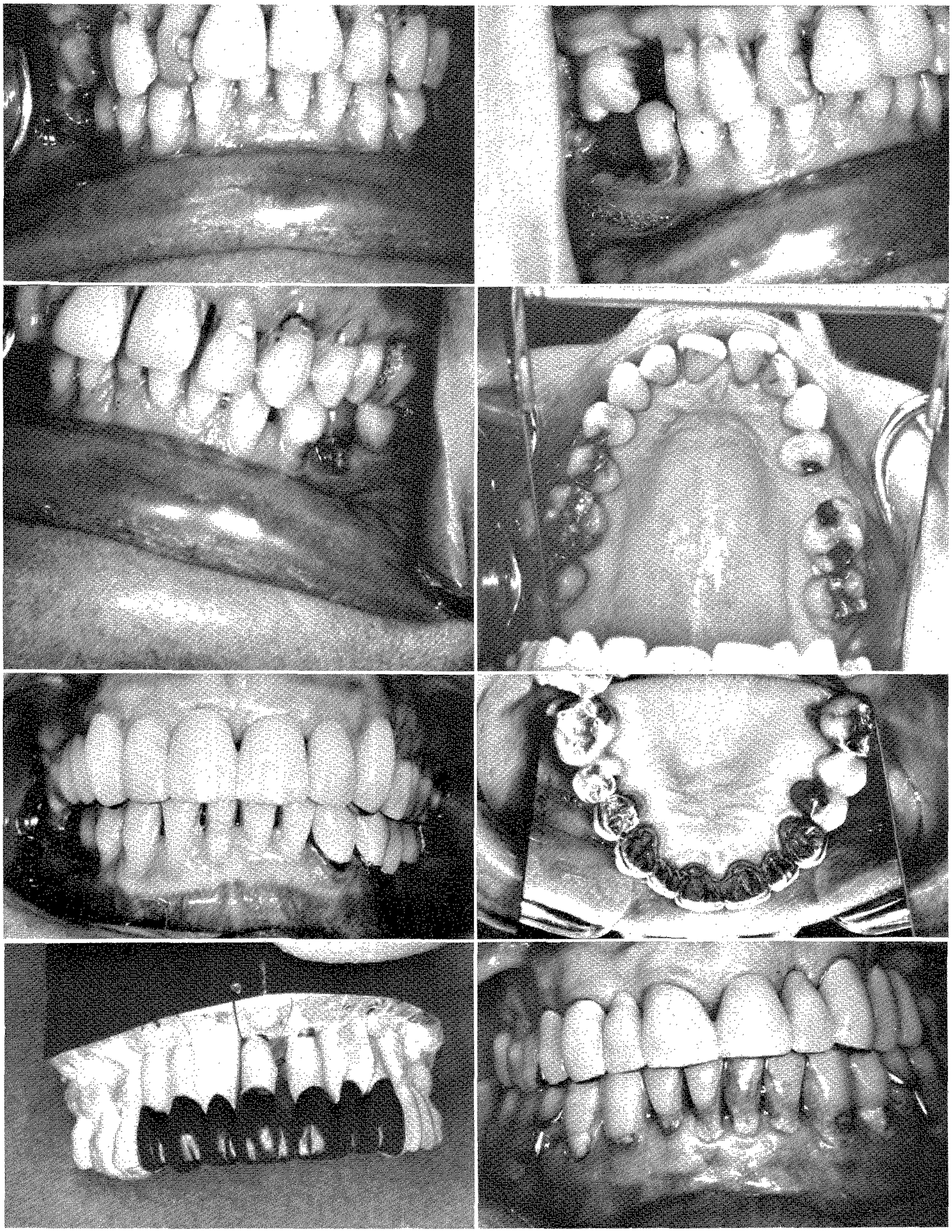


Fig. 5-65. Illustrations of cases (preoperative and postoperative) that were referred for correction of coronal form and splinting. They were considered terminal cases, but clinical study and observation were desired to evaluate procedures in relation to gingival health.

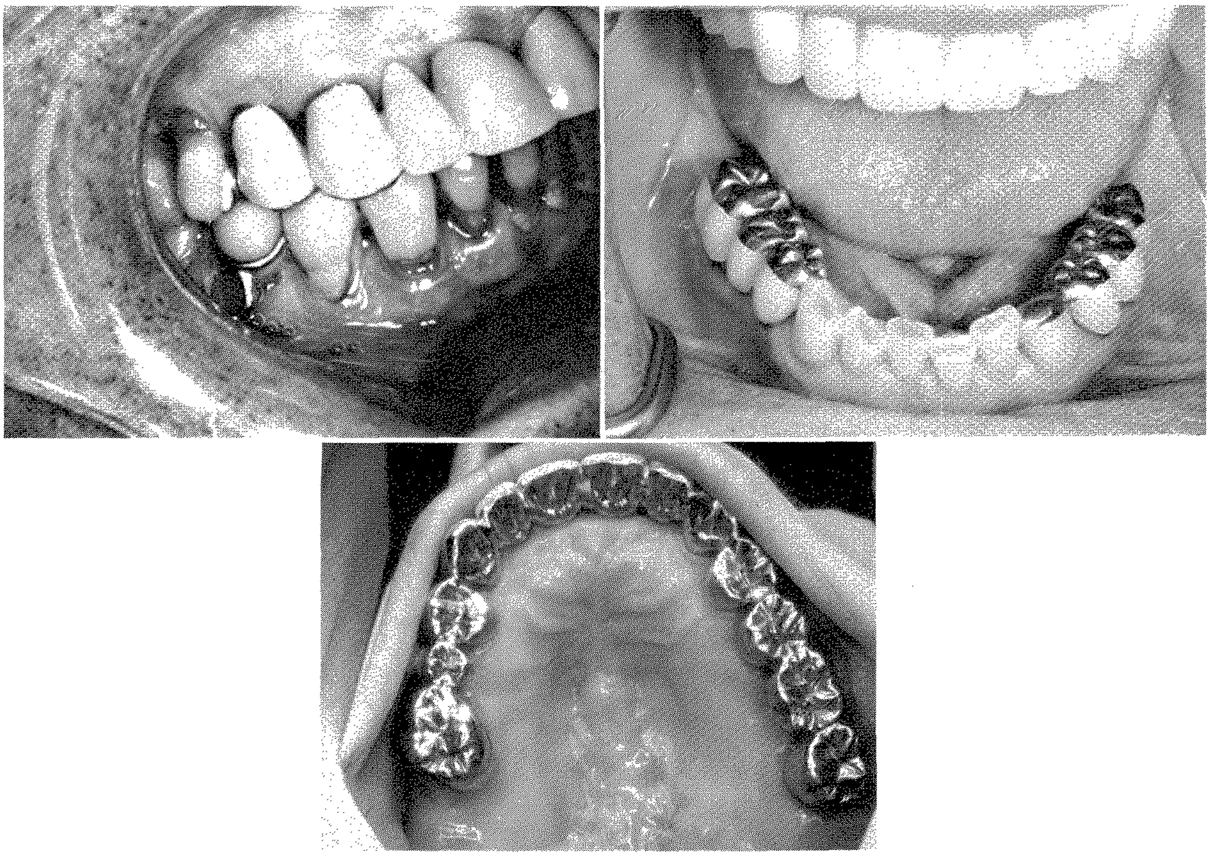


Fig. 5-65, cont'd. For legend see previous page.

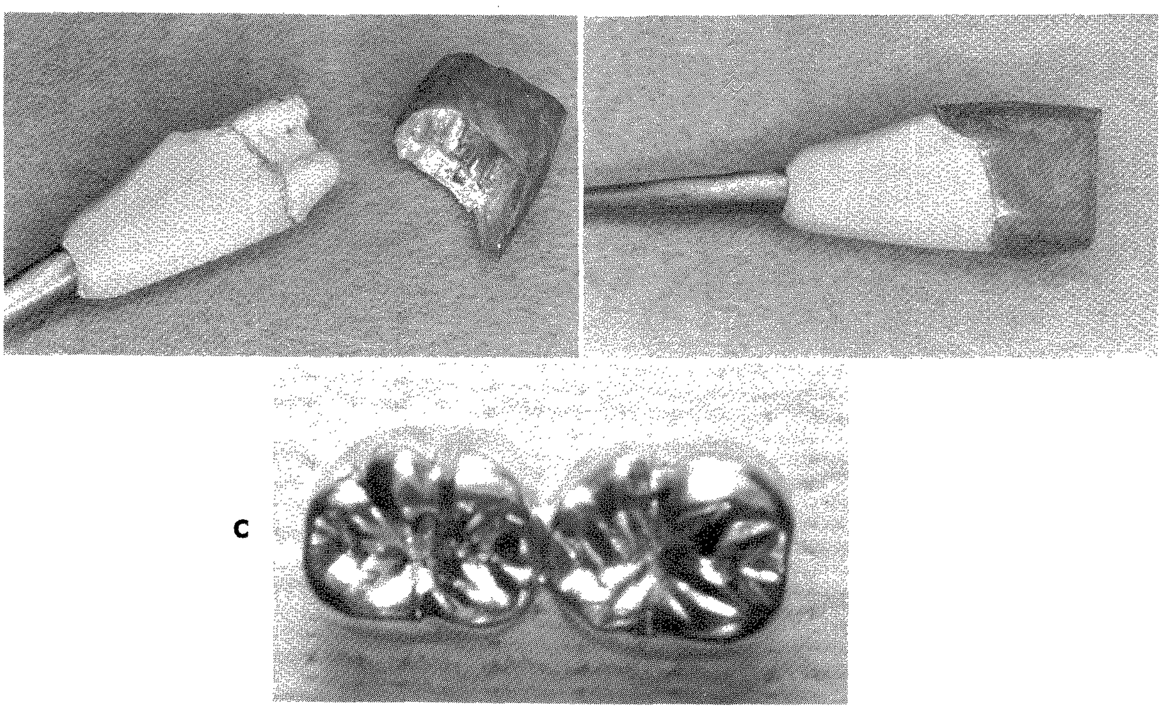


Fig. 5-66. A and **B,** Stone die and DuraLay coping for purposes of "transfer" when taking impression for working cast. **C,** Two-tooth splint showing correct positioning of soldered contact area—anatomically and vertically.

REFERENCES

1. Glickman, Irving: Lecture notes, Mid-Atlantic States Conference on Dentistry, Buck Hill Falls, Pa., 1964.
2. Fox, Lewis: The occlusal factor in periodontal disease, Alpha Omegan **43**:124-133, 1949.
3. Fox, Lewis: Operative dentistry in the atomic age, Alpha Omegan **51**:75-79, 1958.
4. Lucia, Victor O: Modern gnathological concepts, St. Louis, 1961, The C. V. Mosby Co.
5. Granger, Ernest R.: Practical procedures in oral rehabilitation, Philadelphia, 1962, J. B. Lippincott Co.
6. Lucia, Victor O.: A technique for recording centric relation, J. Prosth. Dent. **14**:492-505, 1964.
7. Weinberg, Lawrence A.: Physiologic objectives of reconstruction techniques, J. Prosth. Dent. **10**:711-723, 1960.
8. Stuart, Charles E., and Stallard, Harvey: Principles involved in restoring occlusion to natural teeth, J. Prosth. Dent. **10**:304-313, 1960.
9. Goldman, Henry M.: Lecture notes, Mid-Atlantic States Conference on Dentistry, Skytop, Pa., 1956.
10. Amsterdam, Morton, and Abrams, Leonard: Periodontal prosthesis. In Goldman, Henry M., Schluger, Saul, Fox, Lewis, and Cohen, D. Walter: Periodontal therapy, ed. 3, St. Louis, 1964, The C. V. Mosby Co., pp. 762-813.
11. Bohannan, Harry M., and Abrams, Leonard: Intentional vital pulp extirpation in periodontal prosthesis, J. Prosth. Dent. **11**:781-789, 1961.
12. Wagman, Sydney S.: Tissue management for full cast veneer crowns, J. Prosth. Dent. **15**:106-117, 1965.
13. Wheeler, Russell C.: Complete crown form and the periodontium, J. Prosth. Dent. **11**:722-734, 1961.
14. Morris, Melvin L.: Artificial crown contours and gingival health, J. Prosth. Dent. **12**:1146-1155, 1962.
15. Amsterdam, Morton, and Rossman, Samuel R.: Techniques of hemisection of multirooted teeth, Alpha Omegan **53**:4-15, 1960.
16. Lloyd, Ralph S., and Baer, Paul N.: Periodontal therapy by root resection, J. Prosth. Dent. **10**:362-365, 1960.
17. Stahl, S. S.: Morphology and healing pattern of human interdental gingiva, J.A.D.A. **67**:48, 1963.
18. Smith, Joe H.: The interdental gingival topography and its role in periodontal disease, Tex. Den. J. **82**:20-25, 1964.
19. Kohl, J. T., and Zander, H. A.: Morphology of interdental gingival tissues, Oral Surg. **14**:287-295, 1961.
20. Ritchey, Beryl, and Orban, Balint: The crests of the interdental alveolar septa, J. Periodont. **24**:75-87, 1953.
21. Weinberg, Lawrence A.: Esthetics and the gingivae in full coverage, J. Prosth. Dent. **10**:737-744, 1960.
22. Gordon, Irving: The danger zone—use and abuse of full coverage, Alpha Omegan **54**:126-131, 1961.
23. Rosen, H., and Gitnick, P. J.: Integrating restorative procedures into the treatment of periodontal disease, J. Prosth. Dent. **14**:343-354, 1964.
24. Walsh, J. P.: The pyschogenesis of bruxism, J. Periodont. **36**:417-420, 1965.
25. Beaudreau, David E.: The role of the posterior fixed bridge in occlusion, Dent. Clin. N. Amer., pp. 13-24, March, 1965.
26. Fenichel, Otto: The psychoanalytic theory of neurosis, New York, 1945, W. W. Norton & Co., Inc.
27. Rhoads, John E.: Repositioning of malposed teeth prior to oral rehabilitation, J. S. Calif. Den. Ass. **31**:346-354, 1963.
28. Sternlicht, Harold C.: Tooth movement in periodontal disease, J. S. Calif. Den. Ass. **27**:324-332, 1959.
29. Tylman, Stanley D.: The use of the bite plate as a prerestorative measure, J. Canad. Den. Ass. **23**:134-140, 1957.
30. Lauritzen, Arne: Lecture notes, Post-Graduate Study Groups, 1953, 1961.
31. Shore, Nathan Allen: Temporomandibular joint dysfunctions, J. Prosth. Dent. **10**:366-373, 1960.
32. Jerge, Charles R.: Comments on the innervation of the teeth, Dent. Clin. N. Amer., pp. 117-127, March, 1965.
33. Gordon, Theodore: Telescope reconstruction—an approach to oral rehabilitation, J.A.D.A. **72**:97-105, 1966.
34. Abrams, Leonard, and Feder, Morris: Periodontal considerations for removable prosthesis, Alpha Omegan **55**:123-136, 1962.
35. Prichard, J. F., and Feder, Morris: A modern adaptation of the telescopic principle in periodontal prosthesis, J. Periodont. **33**:360-364, 1962.
36. Schweitzer, Jerome M.: Esthetics and hygiene after extensive periodontal treatment, J. Prosth. Dent. **10**:284-287, 1960.
37. Stein, R. Sheldon: Pontic-residual ridge relationship, a research report, J. Prost. Dent. **16**:251-285, 1966.
38. Shooshan, E. D.: The reverse pin-porcelain facing, J. Prosth. Dent. **9**:284-301, 1959.
39. Shooshan, E. D.: A pin-ledge casting technique; its application in periodontal splinting, Dent. Clin. N. Amer., pp. 189-206, March, 1960.
40. Staffanou, Robert S., and Thayer, Keith E.: Reverse pin-porcelain veneer and pontic technique, J. Prosth. Dent. **12**:1138-1145, 1962.
41. Minker, Jules S.: Simplified full coverage preparations, Dent. Clin. N. Amer., pp. 371-372, July, 1965.
42. Skurnik, Harry R.: Treatment planning for occlusal rehabilitation, J. Prosth. Dent. **9**:988-1000, 1959.
43. Colbern, Robert: Effective oral hygiene for full mouth rehabilitation, Second International Congress of Gnathology, San Diego, Calif., 1965.
44. Arnim, S. S.: Microcosms of human mouth, J. Tenn. Den. Ass. **39**:3-28, Jan., 1959.
45. Cohen, D. Walter, and Bohannan, Harry M.: Current periodontal therapy. In Goldman, Henry M., Forrest, Stephen P., Byrd, D. Lamar, and McDonald, Ralph E.: Current therapy in dentistry, vol. 1, St. Louis, 1964, The C. V. Mosby Co., pp. 60-67.
46. Mesrobian, Armen Z.: Simplified oral physiotherapy or gingival home care, J.A.D.A. **63**:98-99, 1961.

Chapter 6

Functional preparations

General considerations

In considering functional preparations the type and form of tooth preparation will depend to a great degree upon the relationship of the teeth to each other and to their opposing members. Some of the problems are (1) crossbite relations, (2) relations of the long axes of the teeth, and (3) insufficient overjet of posterior teeth, extruded teeth, tipped teeth, versions, and rotations.

The type of retainer to be used depends on the functional demands of the case on hand, and this implies that an accurate set of study casts must be oriented correctly upon an adjustable articulator so that a complete study can be made of the cuspal relationship necessary to make the mouth function properly.

This study also will allow for a visualization of the finished articulation, which enables one to develop a harmonious interplay of cooperating cusps that constitutes function and equitable stress distribution. A study of function and stress distribution is impossible without casts correctly mounted on an articulator that reproduces the mandibular movements of the individual (Figs. 6-1 to 6-3).

It is well worth the time and effort to prepare and mount a second set of casts and to prepare the plaster teeth with burs and stones. Then the occlusal surfaces are worked out in wax, determining in advance not only the type of preparation necessary for all of the involved teeth, but also which areas are to be removed or built up, which teeth have to be warped for proper interdigitation with opposing teeth, the position of the cusps, etc. The problem of esthetics, especially in the anterior part of the mouth, also can be evaluated properly. Above all, by these means it usually is possible to determine in advance if the case can be successfully corrected.

Always remember that the functions of a tooth are contained in its dynamic anatomy and its position in the jaw and also that its cusps must cooperate harmoniously to produce efficient function with equitable stress distribution. Time spent in preoperative study before starting extensive rehabilitative treatment pays big dividends.

Proper cavity preparation is of prime importance. We must always keep in mind not only definitive retentive form and marginal outline, but also proper tooth form and function.

One of the commonest causes of small type casting failures is haphazard cavity preparation. It is not necessary to cut the cavities very deeply, especially since experience has taught that parallel walls, judicious use of pits, wells, or pin anchorage, and proper selection of the gold alloy will give adequate retention and will maintain as much frictional adaptation as possible with less probability of degenerating pulps.

The extent and depth of an abutment cavity should be determined carefully in relation to the pulp, and only sufficient tooth substance should be sacrificed to obtain adequate retention, resistance, strength, and outline form.

Abutment preparations employing unneces-

Figs. 6-1 to 6-3. *Casts correctly mounted on adjustable articulator.*

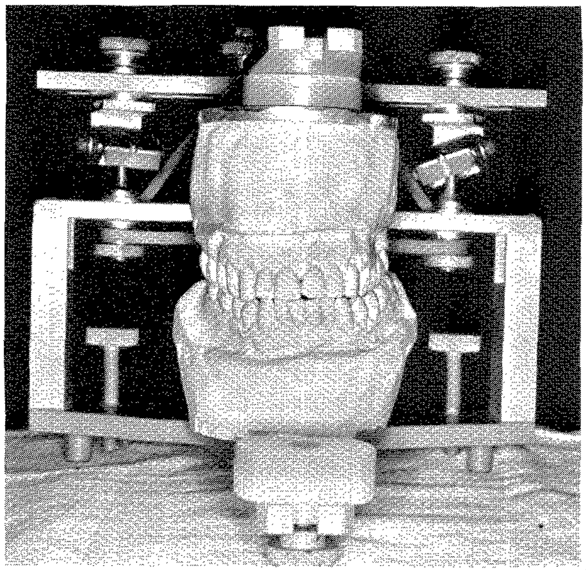


Fig. 6-1. Relation of teeth—anterior view.

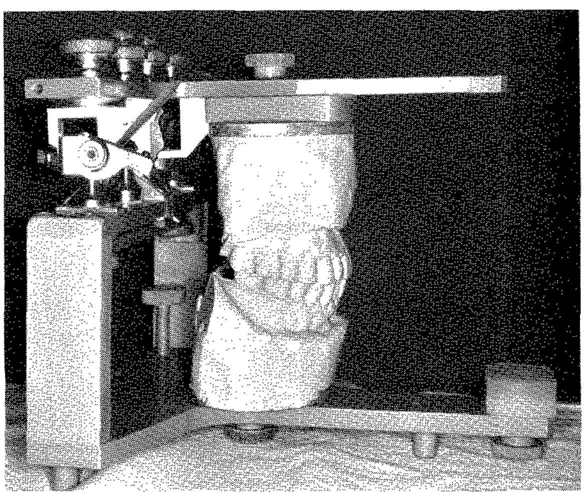


Fig. 6-2. Relation of teeth—right side.

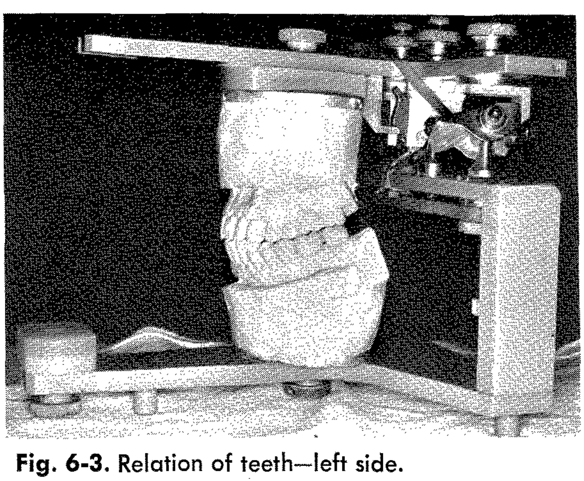


Fig. 6-3. Relation of teeth—left side.

sarily complicated designs that increase the cavosurface length, which in turn increases the hazard of poor margins, should be avoided. The amount of retention and strength required in a retainer varies with, and under, different conditions. The degree of torque and strain to which a retainer will be subjected depends upon the length of the span, the occlusion, the mobility of abutment teeth, the musculature of the individual, etc. Retainers should be self-retentive since the function of cement is to hermetically seal it to the prepared tooth.

The question of what constitutes an ideal retainer is asked frequently. An ideal retainer requires the least amount of destruction to the abutment tooth, least destroys the outline form of the tooth, can be finished about its periphery with great accuracy, will be so rigid that it will withstand the requisite load without distortion and will have frictional adaptation, least destroys the cervical marginal ridge, can be prepared without trauma to the pulp or surrounding tissues, is an accurate complement to the lost tooth structure, and fulfills the requirements of esthetics.

What requirements must be observed when preparing teeth for retainers? A few requirements will be given now, and more will be listed as the types of retainers used in mouth rehabilitation are discussed. Retainers should offer a series of angles and surfaces best suited to resist stress or the tendency to fracture the tooth, Black's principle of extension for prevention should be observed, they should present margins so prepared as to conserve the enamel structure of the tooth and not expose it to injury during stress of occlusion, and they should offer a retentive receptacle.

Keys[1] has shown with photomicrographs and diagrams from well-known texts on metallography and physical metallurgy that sharp corners and acute angles in castings tend to produce planes of weakness and areas of porosity because of their influence on the rate of cooling of the cast metal as it freezes. From this he concluded that in small type castings results can be improved by modifying the cavity preparation so that all sharp and abrupt angles are eliminated and a cove effect at all lines and points within the cavity is formed.

It can be added that modifications in cavity preparation that reduce the detrimental effect of failure to balance the variables in casting include beveling of margins, maintaining as nearly as possible uniformity in thickness of the various parts of the casting, and avoiding irregular angles and sharp curves.

A repertoire of designs for cavity preparation must be available, and the one best adapted to meet the requirements of the case under consideration should be selected. Types of retainers that do not encroach upon the terrain of the marginal gingiva must be used, when at all possible. The more we can stay away from the attachment apparatus, the more favorable will be the end result. Some of us have one type of preparation for all teeth, which, despite the precision used in its preparation, is a definite handicap.

Fox[2] has made the following pertinent statements:

"Clinical evidence clearly demonstrates that subgingival extensions of full coverage margins produce an environment unfavorable to the health of the marginal gingiva. In the area adjacent to full coverage, it is difficult to maintain marginal gingiva which are thin and acceptably contoured for physiologic function and flood flow.

"In contrast to the maintenance of healthy gingiva around enamel and cementum of natural tooth substance, the gingival tissues around full coverage seem to be more thickened, more rolled, and generally more inflammatory in character.

"Even with the most careful techniques of tooth preparation and tissue handling during preparation of tooth, impression taking, temporization, and final cementation, the full coverage extended subgingivally limits the opportunity for the marginal gingiva to achieve maximum patterns of health.

"This is not an indictment of full coverage. There has, however, been a tendency to utilize this procedure without definitive indication. Where indicated and demanded in the therapeutics of restorative dentistry, it can be utilized to advantage. Where full coverage is therapeutically utilized with finesse and understanding and precision technique, it offers much in many clinical circumstances"*

*From Fox, Lewis: Letters to the editor, Dent. Times 3:6, 1961.

Tripodal stabilization

All of my retainers, with the exception of some full coverage, have a basic retentive feature in common, the principle of the tripod. Tripodism is the most stable system in mechanics. It has been found that this principle, when carefully followed, simplifies tooth preparations and at the same time gives maximum stability and retention.

The tripod principle is applied by placing three pin retention areas or grooves (or combinations of the two) at strategic points not in the same line. When possible, they are placed equidistant from each other. Thus, by joining them, an equilateral triangle would be formed. (See Fig. 6-4.)

Retainers having these three points, when cemented on the abutment teeth, effectively resist torque and thrust. These three locking devices further serve to prevent the slightest displacement of the castings on the abutment teeth in taking the impression and bite registration.

Stabilization is best effected by a minimum of three points, as in the case of a common three-legged stool. Then, too, the surface on which a

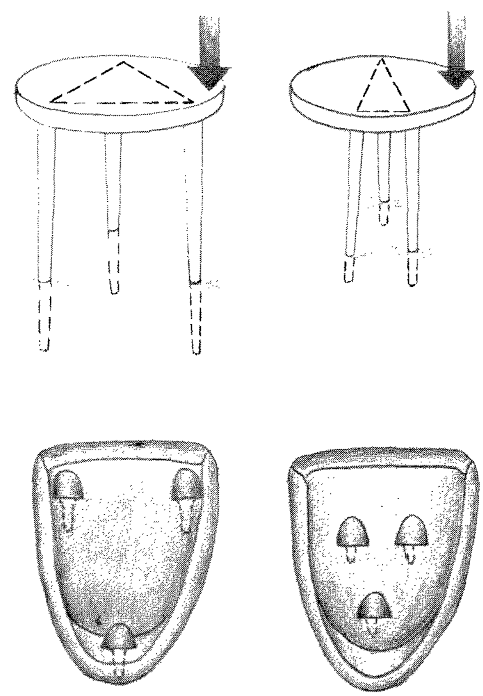


Fig. 6-4. Principle of tripodism. The larger the boundary of the triangle created by connecting the pins, the more retentive the retainer.

three-legged stool rests does not necessarily have to be smooth as in the case of a four-legged one. It is very likely that only three points ever are useful.

Pin retention is one of the strongest retentive forces, mechanically, that can be used in dentistry.

Frictional wall retention (parallel walls) and the interlocking of the cement between the prepared surface of the tooth and the casting also should be considered. It is the opinion of a number of excellent dentists that the surfaces of the prepared tooth should not be polished, with the exception of the margin area, and that all castings within 1 mm. of the margins should be roughened with a small bur before cementation.

In other words, retention is obtained by the use of grooves (regular and locked), pins, and by close adaptation to nearly parallel walls, with the variation from absolute parallelism being sufficient only to permit the withdrawal of the wax pattern and the subsequent seating of the restoration.

The Kyprie tapered keyed groove, or lock groove, is one whose inner diameter is larger than the entrance to it (Fig. 6-5).

It is sound practice to remove all old fillings and cement bases. Experience has shown in a high percentage of cases that this operation is justified because of conditions found under these circumstances, and therefore it is highly desirable that the restorations be placed on teeth that are known to be absolutely free of caries and that every effort be put forth to preserve the pulp in a normal healthy condition.

Pulpal considerations

Another important factor to take into consideration during tooth preparations is the avoidance of permanent injury to the pulp. The maintenance of vital functional teeth is to be desired, as is the conservation of tooth structure and preciseness in cavity preparation. The teeth being prepared should never be overheated. A coolant should be used copiously, with warm water either as a spray with air or as a stream, to reduce frictional heat. The coolant must always be directed where needed, and adequate aspiration should be available.

What must be uppermost in our minds during tooth preparation is conservatism, being sure not to overcut the teeth and realizing that the damage inflicted on the pulp is not always reversible—it can be irreversible. Also, a thorough study of the speed, type, and handling of the cutting tools used in tooth preparation should be made. For gross reduction of tooth structure the ultrahigh-speed equipment is used with very light pressure, and for the preparation of wells, pits, pinholes, tapered keyed grooves, and the finishing of margins the conventional lower speed equipment is used. Diamond stones and carbide burs should be kept free of debris for greater

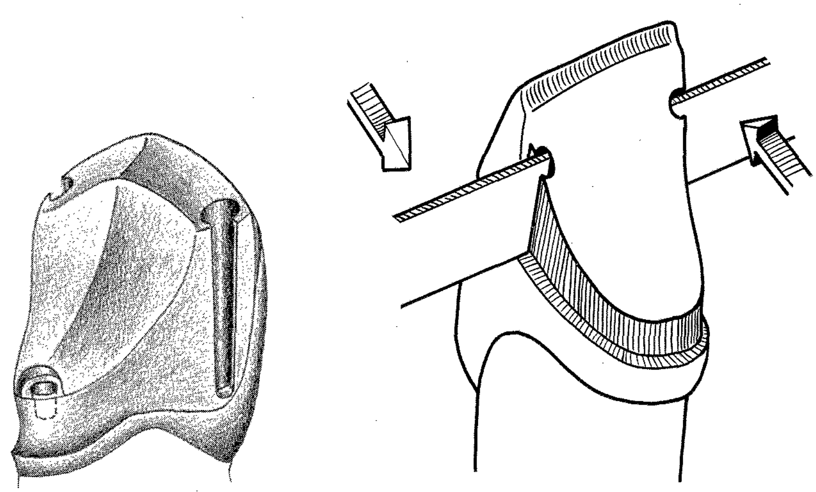


Fig. 6-5. Kyprie tapered keyed groove or lock groove, a great aid in resistance to displacement both faciolingually and mesiodistally.

cutting efficiency, and they should run true and be kept under control at all times.

Unfortunately, in many instances pulpal damage cannot be detected through clinical signs of pain and discomfort until months or years later. Trauma can be the cause of this trouble, and the main source of this trauma is heat. In these cases, there is probably a hastening of evaporation of fluid from the dentinal tubules, and in turn this serves to suck dentin odontoblasts into the tubules. This certainly points up the importance of avoiding heat damage.

Shallow preparations, intermittent periods of drilling on teeth with a washed-field technique for cooling the tooth and the cutting tool, and the proper treatment and protection of the cut dentinal surfaces, with the minimum use of chemical agents, will reduce the amount of irritation to a point where the chance of pulp degeneration is almost negligible.

A review of the research work of Weiss[3] is in order at this time:

(1) "Histologically there are three zones of the dental pulp which are affected by injury [Fig. 6-6].

"The most superficial zone affected is the odontoblastic layer which is in reality an extension of the dentin. The mildest reaction is the disarrangement of those cells and aspiration of the nuclei into the dentinal tubules [Fig. 6-7].

"If only a few of these odontoblastic cells are affected, the pulp will recover in about 14 days with the regeneration of new cells, provided the tooth does not sustain any further injury such as thermal shock.

"A protected pulp will differentiate new odontoblasts from the embryonic mesenchymal cells that are present in the pulp.

(2) "More traumatic injury will extend the damage to the zone of Weil which is normally a cell-free zone [Fig. 6-8]. Histologically, cells of inflammation and new capillaries are seen in this area. This type of injury is still reversible if proper sedative protection is given to the pulp. Recovery time is approximately thirty (30) days.

(3) "Irreversible damage is sustained by the

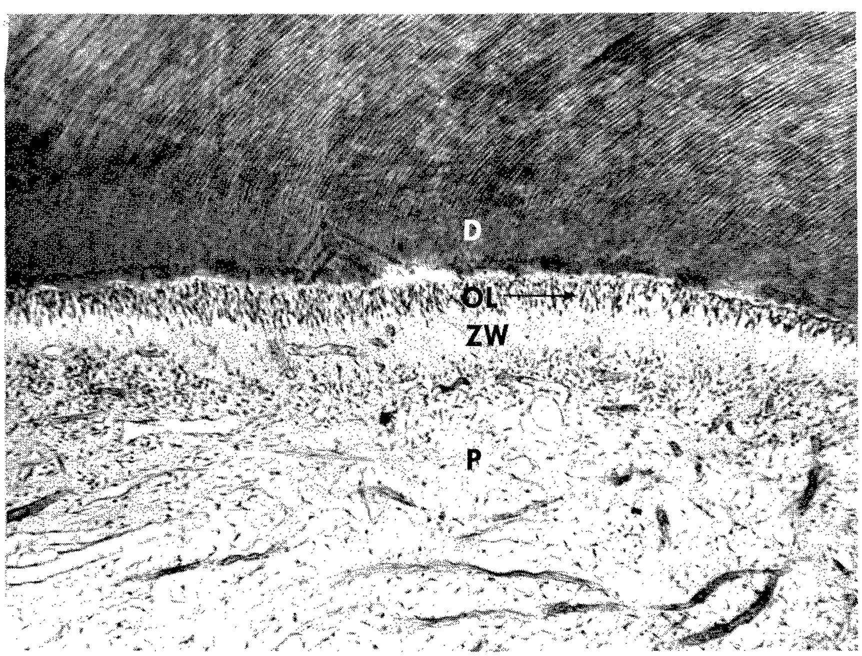


Fig. 6-6. No reaction to operative procedures is seen in section forty-eight hours after cavity preparation by carbide bur revolving at 250,000 r.p.m. with water-spray coolant. The three levels of pulp inspected for changes are indicated. (1) *D* plus *OL*, dentin plus odontoblastic layer, considered as one level, (2) *ZW*, the cell-free zone of Weil, and (3) *P*, main body of pulp. (From Weiss, Marvin B., Massler, Maury, and Spence, John M.: Dent. Progr. **4**:10-19, 1963.)

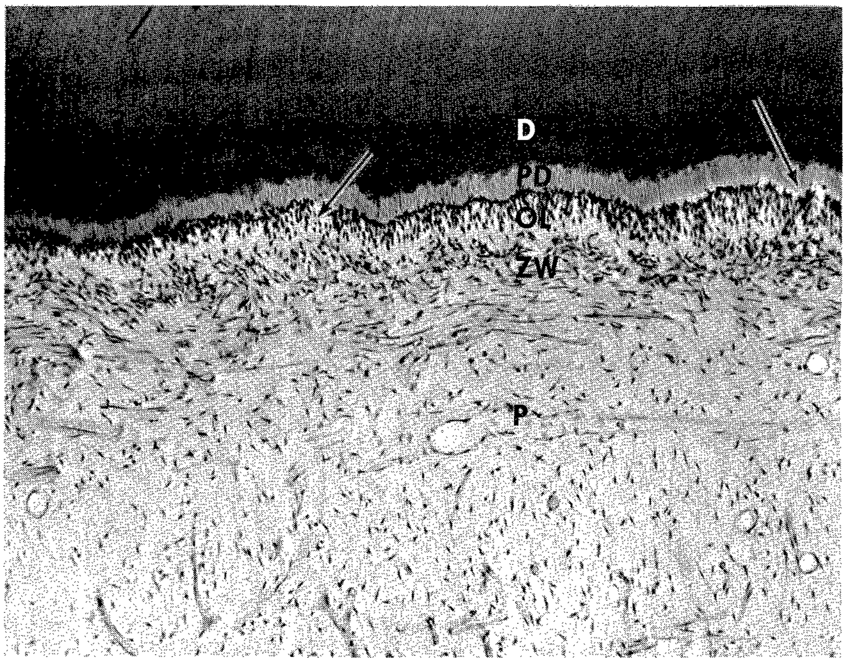


Fig. 6-7. A mild reaction in which disarrangement of odontoblasts has persisted for thirty-five days. Note displaced nuclei (black) and small vacuoles (white) indicated by arrows near predentine border *(PD)*. Remainder of section appears normal. Cavity cut with carbide bur at 30,000 r.p.m., water-spray coolant. (From Weiss, Marvin B., Massler, Maury, and Spence, John M.: Dent. Progr. **4**:10-19, 1963.)

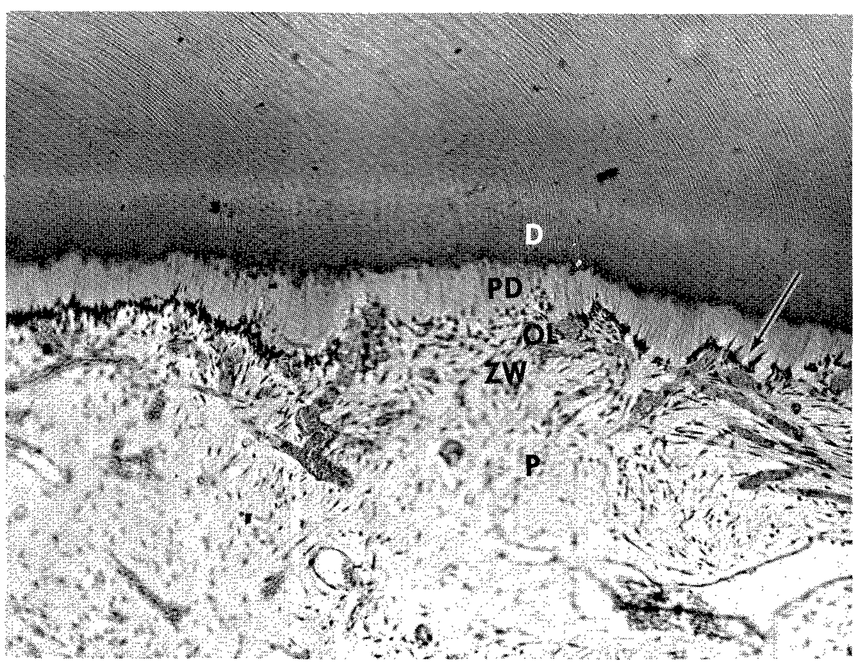


Fig. 6-8. A moderate reaction seen nine days after cutting with new steel bur at 3,000 r.p.m. without use of coolant. Odontoblastic layer is greatly disturbed and invaded by capillary loops (dark gray streaks, arrow). The zone of Weil also is infiltrated by blood, but main pulp level *(P)* remains normal. (From Weiss, Marvin B., Massler, Maury, and Spence, John M.: Dent. Progr. **4**:10-19, 1963.)

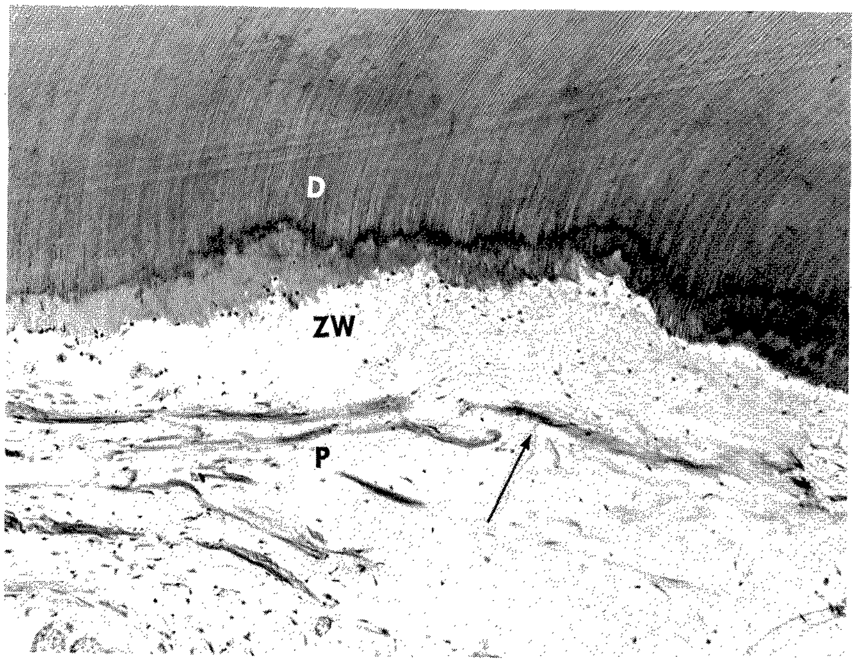


Fig. 6-9. Severe reaction produced by cutting at 70,000 r.p.m. with steel bur under dry conditions, seen forty-eight hours postoperatively. Few odontoblasts are present, and these are shrunken so that only the nuclei are seen, scattered among large vacuoles and coagulated material that stained eosinophilic. The zone of Weil shows heavy influx of cellular material from pulp. At both this level and in deeper pulp appear enlarged blood vessels (gray streaks, arrow), largely filled with coagulum. (From Weiss, Marvin B., Massler, Maury, and Spence, John M.: Dent. Progr. **4**:10-19, 1963.)

dental pulp when the injury takes the form of a massive invasion of cells of inflammation into the pulp, thrombosed blood vessels and hemorrhage [Fig. 6-9]. The climax is either a necrotic pulp or abscess formation which may occur over a long period of time with few clinical symptoms to signify that it is occurring."*

Pulpal insult must be kept to a minimum.

Margin placement

Where to place the margin of the restoration in relation to the gingival sulcus is a controversial subject.

Whenever possible, it is advantageous to lay the peripheral margins on sound enamel with a definite abrupt bevel and slightly above the gingival margin, since it not only facilitates accurate marginal adaptation of the gold, but also prevents gingival tissue irritation.

However, the need for a longer retainer on short abutment teeth and the periodontally involved tooth poses a problem of margin placement quite different from a normal noncarious tooth.

The finalized position of the gingival margin of the preparation and, in turn, the crown margin must never be determined until a healthy gingival sulcus is present. This is especially important for teeth that have undergone extensive periodontal treatment. In other words, pocket elimination must be completed, and the tissue must be returned to a state of health before the final marginal placement position is made. When this is done, be sure that any rough marginal areas created by high-speed instrumentation is made smooth for accurate impression taking, resulting in good fitting restorations.

Many times, because of the importance of esthetics, especially in the region of the upper

*From Weiss, Marvin B., Massler, Maury, and Spence, John M.: Operative effects on adult dental pulp, Dent. Progr. 4:10-19, 1963.

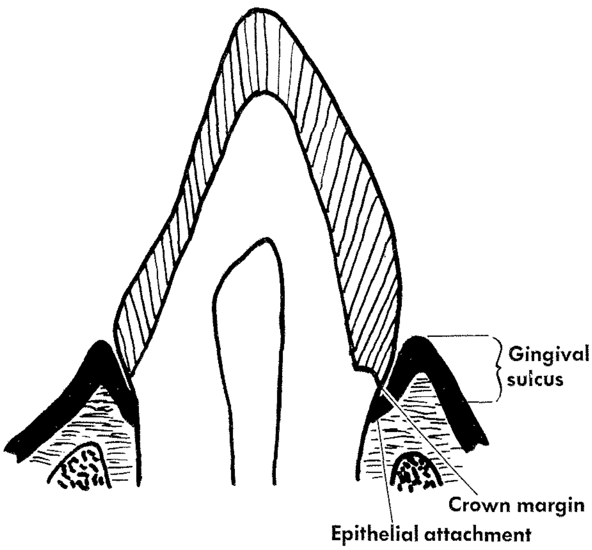


Fig. 6-10. Crown margin should finish short of epithelial attachment, which means that it should not be more than 1 to 1.5 mm. subgingival, depending upon depth of sulcus. (Courtesy Dr. Irving Gordon, Miami Beach, Fla.)

right bicuspids around the arch to the region of the upper left bicuspids and the lower anterior teeth, and also because of carious, decalcified, or highly sensitive spots in the gingival area, the margin must be positioned in the gingival sulcus.

The answer to the question of how far subgingivally should the crown margin be placed would be that it should finish short of the epithelial attachment—in most cases approximately 1 or 1.5 mm. in the sulcus. Usually this would mean an extension of the finished margin of the retainer slightly more than halfway into the gingival sulcus, which also will cover all prepared tooth structure. If the proper form is given to the cervical third of the restoration, gingival health maintenance is assured also. (See Fig. 6-10.)

Stein[4] has this to say: "Ideally the margin of the crown should be located at the base of the sulcus at the coronal level of the epithelial attachment. Otherwise we can get involved in an area which is not self-cleansing and vulnerable to caries because of plaque accumulation at the margin of the restoration."*

*From Stein, R. Sheldon: Periodontal-prosthetic interrelationships. In Glickman, Irving: Clinical periodontology, Philadelphia, 1964, W. B. Saunders Co., p. 756.

Certainly we should not go subgingivally into areas where the gingival tissues would not be receptive to this transgression.

Bevels

Proper bevels should be used to enhance the life of the restorations. Bevels protect the enamel rods and facilitate marginal adaptation of the gold.

A butt joint is most difficult to cast to precisely. The end result is a cement line, which eventually washes out, leading to plaque formation and its sequelae—decay and gingival irritation. Therefore, a slight bevel is needed on all shoulder preparations, with the exception of the porcelain jacket crown.

Parallelism

Parallelism is another acute problem in extensive restorative work. Its need is very obvious, but its accomplishment is not executed as easily as it is verbally expressed.

In some instances minor orthodontic tooth movement may be needed. In other cases gold copings on some strategic teeth paralleled to themselves or to other preparations around the arch may be very helpful.

Excellent equipment such as the Parallaid, the Pontostructor, and the Chayes Loma Linda paralleling device has been a great help in solving this problem (Fig. 6-11). Learning to be proficient in the use of these tools makes a difficult task much easier.

If one desires to do paralleling of teeth freehand, a few simple rules must be observed. First, paralleling of slices as well as grooves or pinholes can be obtained by using some line or plane such as the plane of occlusion as a guide. If the operator holds the handpiece parallel to this definite plane, then any slice on any tooth regardless of its inclination or rotation will be parallel to any other slice on any tooth at any inclination or degrees of rotation. Watch the plane of the straight handpiece or the head of the contra-angle.

I was told a number of years ago to follow a rule borrowed from elementary geometry—two lines perpendicular to the same plane are parallel.

Another good point to remember in parallel-

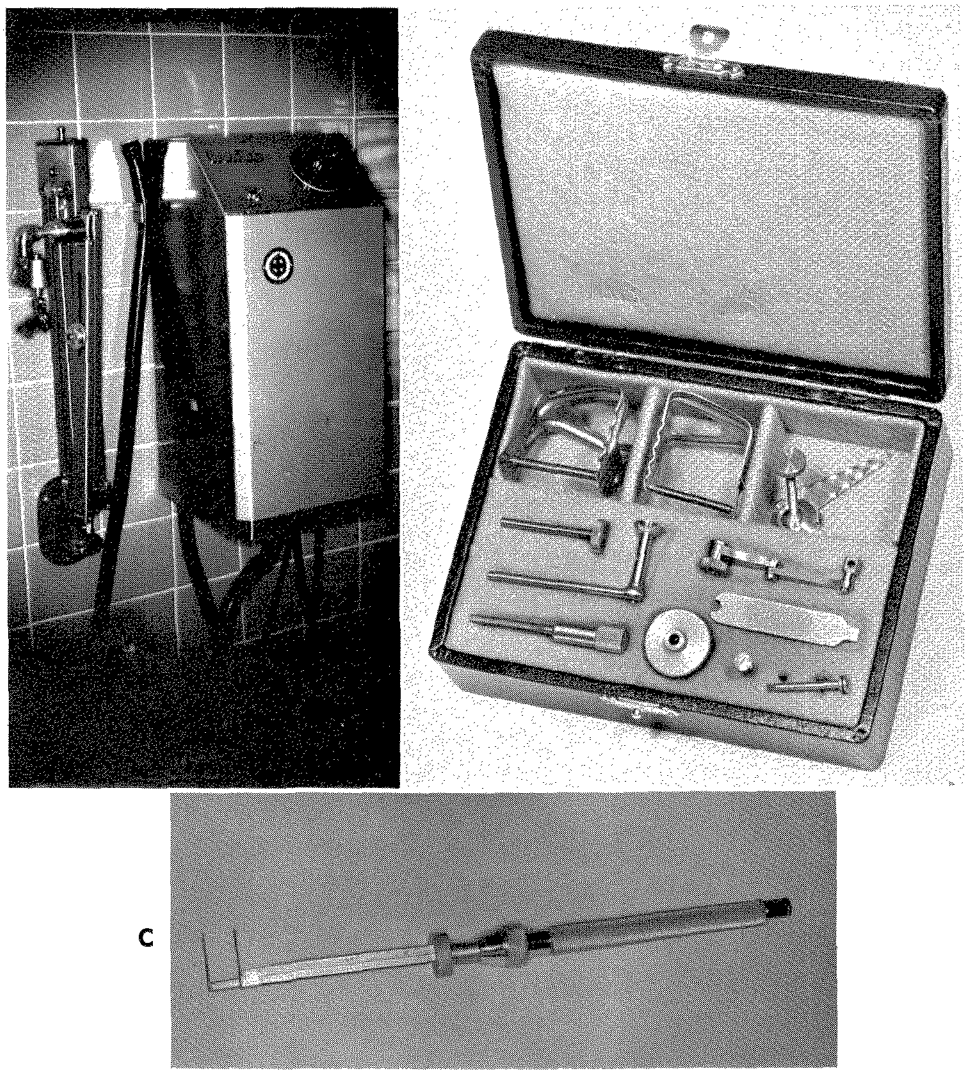


Fig. 6-11. Paralleling aids. **A,** Parallaid. **B,** Instruments composing the Pontostructor set. **C,** Evslin Bridge-o-Meter.

ing abutments is to keep the fingers, wrist, and forearm rigid. The handpiece then can be held constantly in the determined line of shed. Principles of parallelism must be adhered to when anterior and posterior teeth are to be included in the same fixed bridge or splint.

Sit-down dentistry

A book of this nature should record a few remarks of the ways and means of making the very difficult tasks encountered in this type of work as easy and as least fatiguing as possible to both the dentist and the patient.

First, the auxiliary personnel must be well trained, and the office should have properly designed equipment, especially for operating room efficiency. Learning to work in the correct seating position on a comfortable and properly designed operating stool will lead to more production with less physical and emotional effort. Kilpatrick[5] has pointed out that under these circumstances production can continue over a longer lifespan.

Making use of preoperative sedation medication, modern anesthetics, good lighting facilities, pre-prepared instrument tray set ups, a good contour chair or correct positioning of the patient,

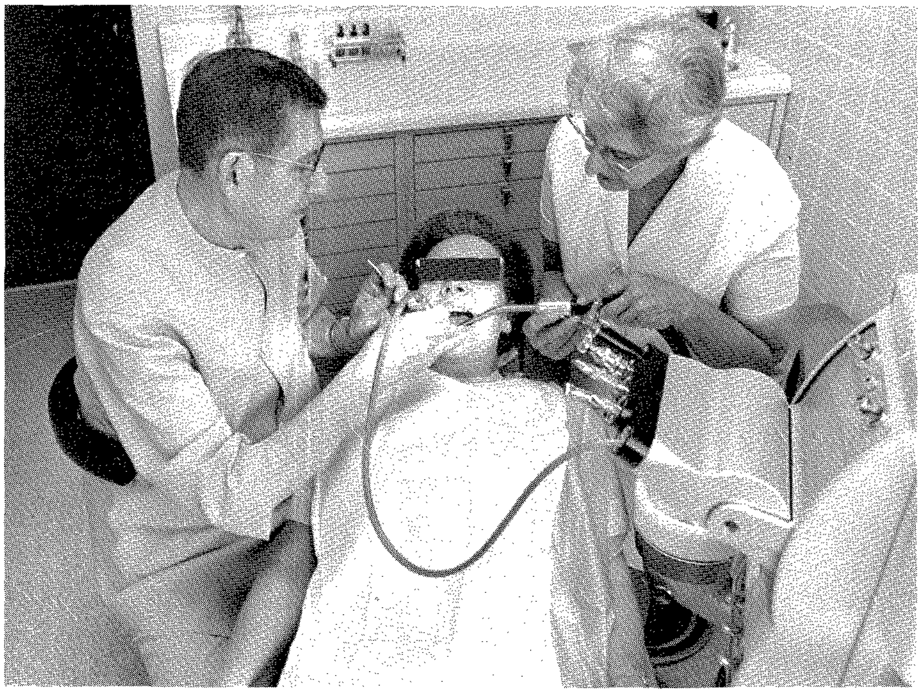


Fig. 6-12. Sit-down dentistry leads to less fatigue, frustration, and extended lifetime of practice.

Fig. 6-13. An essential aid in operatory.

comfortable seating and properly designed equipment for the dentist and his carefully trained assistant, high-speed cutting tools with washed field techniques, etc. will create the proper climate for less fatigue and frustration to all concerned in the performance of concentrated dental procedures. It also will lead to an extended lifetime of practice. (See Figs. 6-12 and 6-13.)

Anderson[6] has told us not to be afraid to change habit patterns. What I have discovered —that has proved to be very beneficial—is changing bad postural operating habits for good ones.

And, above all, the dentist must be in good health—both physically and emotionally.

Cavity design and preparation

As I have said previously, we must have at hand a repertoire of designs for cavity preparation (basic and modifications of the basic form) in this type of work, and a discussion of these preparations now will be undertaken in much detail. This section will deal with procedures of cavity design and preparation that have been proved satisfactory and stable in my hands.

It is essential that the finished product be visualized before operating and that close attention be paid to detail from start to finish. Use must be made of sharp burs, clean true-running diamond points, and well-sharpened hand instruments. The cutting of sound tooth structure should be limited to the amount of substance required for a proper outline form, retention, resistance form, and parallelism of the walls of the abutment teeth of 2 to 5 degrees from the perpendicular to permit the placing of the retainers from a common direction and also to give the right amount of draft so that retention is not affected. All preparations must have smooth walls and polished margins. A roentgenogram of the tooth or teeth involved must be in full view.

DENTO-METRIC SYSTEM

I use the Starlite Dento-Metric sized system, as developed by Amsterdam, and diamond points used in the various types of preparation will be designated by this system.

This system for straight cylinders, tapered cylinders, and flamed shaped diamonds introduces (1) uniform progression of lengths and diameters to encompass exactly any surface length of any crown or cavity, (2) uniform shank length, (3) a numbering system that indicates shape, head length, and diamond form of the instrument, and (4) tapered cylinders having uniform tapers, permitting one instrument to follow another without altering the cutting angle.

In the numbering system the scale below illustrates how Starlite Dento-Metric numbers indicate a full description of the instrument:

Instrument No. 700 - 7 P

- 700 → Shape (Like a No. 700 bur)
- 7 → Head length (7 mm.)
- P → Diamond form (P: Prestressed)

In the diamond form there is also available the micro-grain (M) and the superfinishing (F) that indicates the fineness of the diamond particles, which in turn determines the speed of cut.

MODIFIED ONLAY PREPARATION

In many cases of mouth rehabilitation the lower mandibular first premolar is only in need of a modified type of onlay—a D.O. type, with a slight mesial bevel above the contact area, provided the mesial surface is not carious or filled and has a good contact area.

The first premolar is a particularly difficult tooth to prepare, and conservation of tooth structure must be stressed. The occlusal floor of the preparation should not be too deep; it must be sloped lingually to avoid pulpal encroachment and the path of withdrawal is usually in a linguo-occlusal direction. A shallow box preparation is

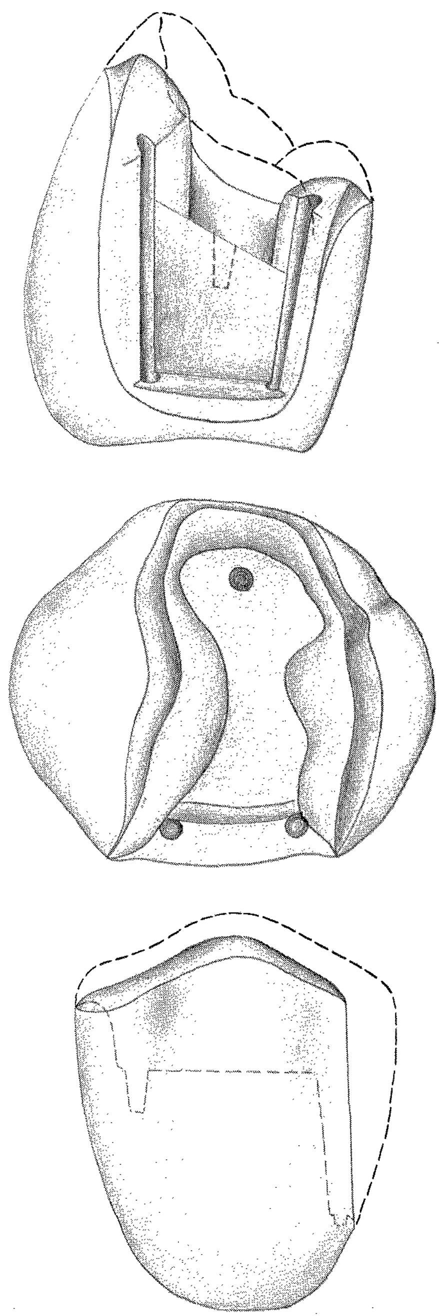


Fig. 6-14. Modified onlay preparation (for lower first premolars).

made distally after the occlusal surface has been dressed down properly keeping in mind a reduced reproduction of the anatomic form of this surface instead of a flat one, with buccal and lingual extensions in the form of a reverse bevel. A slight mesial bevel is incorporated in this preparation to avoid a "bunchy" or grotesque effect to the finished restoration and to give the necessary aid sometimes needed in the development of a cusp-fossa occlusion. Two pin retentions are made in the point angles of the distal box, one at the gingivobucco-axial angle and the other at the gingivolinguo-axial angle. These pin retentions are made with a No. 700 tapered fissure bur, not more than 0.5 mm. deep. During this operation, grooves also are being made on the buccal and lingual walls. A well is developed in the mesial fossa to a depth of 0.5 to 2 mm., or a pinhole can be made with the same No. 700 tapered fissure bur to the depth of 1.5 to 2 mm. for greater retention. This gives the basic tripodal balance that was discussed previously (Fig. 6-14).

The gingival margin is finished with sharp gingival trimmers, being sure that a definite gingival bevel has been established (Fig. 6-15). An axial undercut should be avoided because it is impossible to make a casting fit accurately in a cavity with axial undercuts. The axial and gingival margins should join in a graceful curve and all margins finished and polished very carefully.

A

B

C

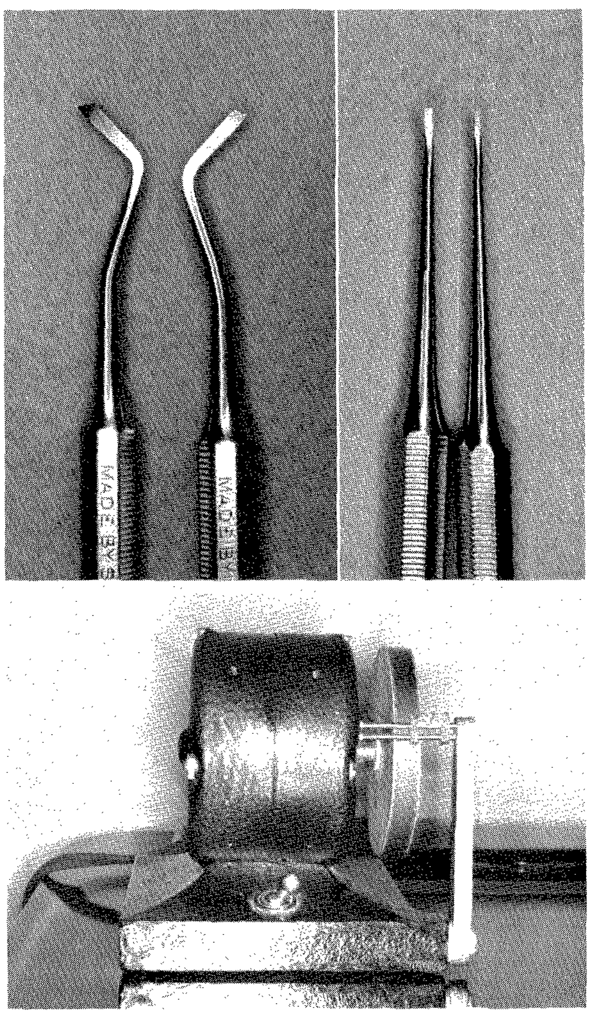


Fig. 6-15. A, Gingival trimmers used to finish gingival margin. **B,** Chisels used to plane cavity walls. **C,** Sharpener for hand instruments.

ONLAYS

In the preparation of a tooth for an M.O.D. onlay, all functioning surfaces should be covered or "shoed" completely so that fracture or shearing of a cusp is prevented. This is accomplished by covering the occlusal surface with buccal and lingual extensions (giving the shingle-roof effect) beyond the functioning range of contact with the opposing teeth, which also allows the restoration to blend harmoniously into the remaining contours of the tooth, thereby negating an otherwise grotesque effect. The buccal and lingual walls are contained, the buccal and lingual extensions are beyond any occlusal facets, and some portion of the outer walls always remains, which acts as an excellent guide to a more nearly correct anatomic reconstruction. Because of these guidelines, we can do a better job in developing our functional carvings. (See Fig. 6-16.)

The occlusal surface should not be dressed down flat, for in so doing the pulp horns are approached unnecessarily. The reduction, following the cusp planes, should be sufficient to provide adequate metal protection and strength in all mandibular excursions when the restoration is completed (at least the equivalent of the thickness of two pieces of blotter paper) (Fig. 6-17).

The convergence of the mesial and distal walls from gingival surface to occlusal surface should be in the area of 2 degrees from the perpendicular if possible. If a group of teeth are to be splinted and the M.O.D. onlay is the restoration of choice, the walls of the preparation may need a taper of slightly more than 2 degrees from the perpendicular.

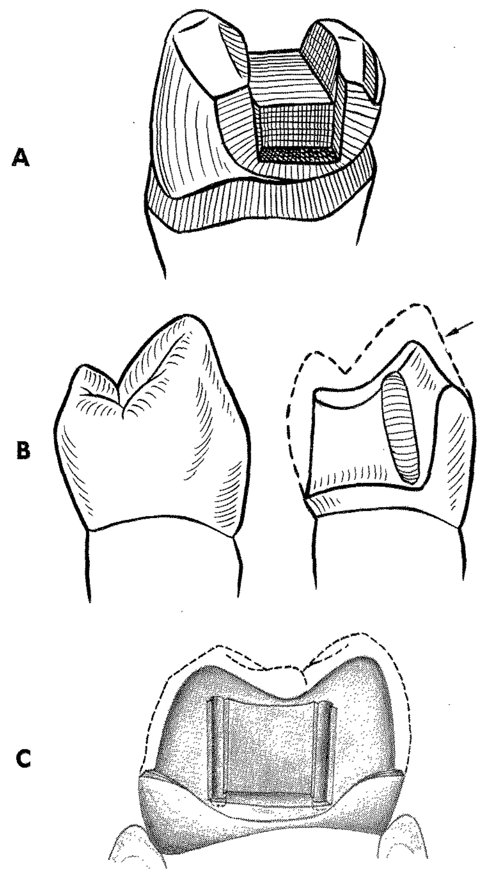


Fig. 6-16. Outer walls (unprepared) act as excellent guidelines in developing functional carvings. **A,** M.O.D. onlay. **B,** Three-quarter crown (shingle-roof effect). **C,** Modified onlay preparation.

The occlusal depth should be at least 1 mm. into the dentin, and the floor of the cavity should be flat and rather wide. Shallow modified box retention with flat or axially inclined gingival seats, square walls, and properly beveled gingival margins, both mesially and distally, is essential. The axiopulpal line angles should be slightly coved to strengthen the casting. The use of grooves mesiobuccally and mesiolingually as well as distobuccally and distolingually with pin retentions made in the point angles to the depth of 0.5 mm., one at the gingivobucco-axial angle, the other at the gingivolinguo-axial angle (mesially and distally), and of an auxiliary pin positioned on the occlusal surface either buccally or lingually to the depth of 1.5 to 2 mm. is indicated many times especially in teeth that are shorter than normal. (See Fig. 6-18.)

Undercuts, which result from removal of last traces of decay, are avoided by leaving the caries until the impression is made, after which the carious dentin is removed while the anesthesia is still effective.

Finish the gingival margin with sharp gingival trimmers and be sure that a definite gingival bevel has been established. Avoid an axial undercut because it is impossible to make a casting fit accurately in a cavity with axial undercuts. The axial and gingival margins should join in a graceful curve. Finish cavity walls by a final

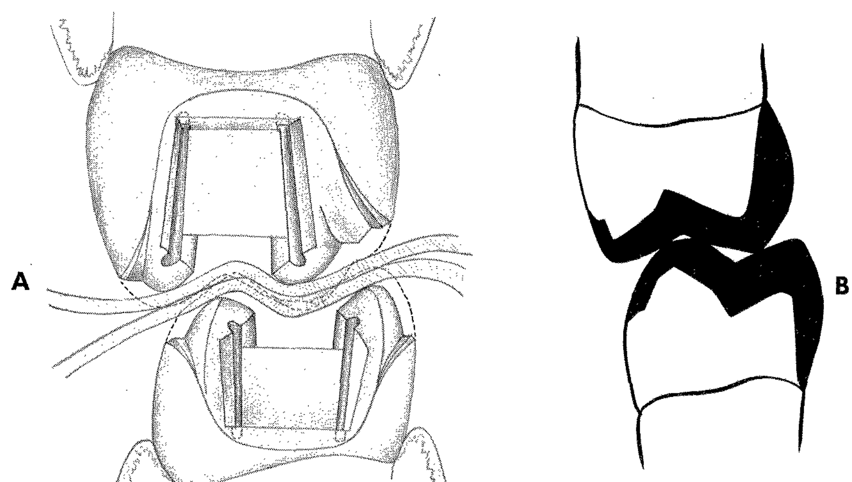


Fig. 6-17. A, The thickness of two pieces of blotter paper is used to provide adequate metal protection. **B,** Showing adequate metal protection and correct placement of facial margins.

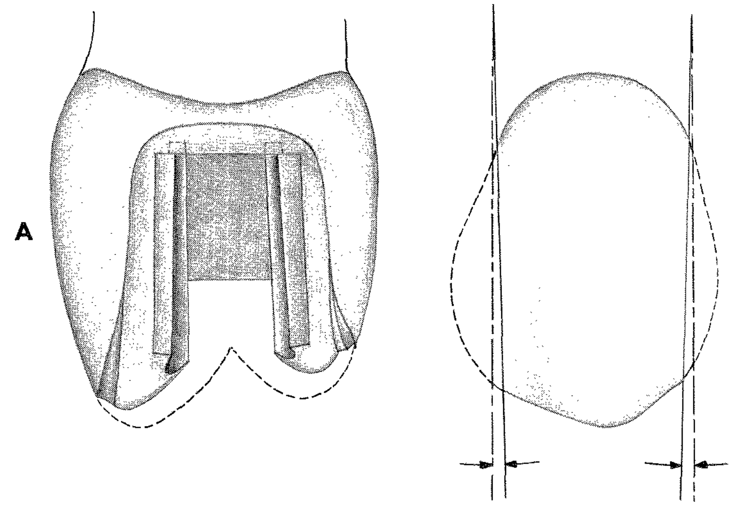


Fig. 6-18. A, Floor of cavity should be flat and rather wide. Shallow modified box retention, use of grooves mesiobuccally, and mesiolingually as well as distobuccally and distolingually with pin retention in point angles to at least depth of 0.5 mm. **B,** Convergence of mesial and distal walls from gingival to occlusal surface should be in the area of 2 degrees from the perpendicular if possible.

planing with freshly sharpened instruments, cuttle disks, and fine diamond points, which results in smooth walls and polished margins.

The principle of tripodism also has been carried out in this type of preparation with resultant stability.

THREE-QUARTER CROWNS

The veneer type of retainer can withstand heavy functional stresses. It ties the structural elements of the crown more tightly together, thus preventing fractured walls and cusps.

Willey[7] has aptly told us that in the veneer type of retainer the entire functioning surface, incisal or occlusal, should be covered.

"By the use of long bevels, the margins are carried out beyond the facets of wear, to achieve three definite ends:

"(a) grinding or wear is never allowed to exert destructive force on the margin between metal and tooth;

"(b) the sweep of food over this margin during function is similar to the shedding of water by a shingle roof; the action tends to close the margin rather than open it; and

"(c) the structural elements of the tooth are held together."*

*From Willey, Robert E.: The preparation of abutments for veneer retainers, J.A.D.A. 53:141-154, 1956.

The three-quarter crown gives maximum retention with a minimum loss of tooth structure. By preserving the facial enamel surfaces of both anterior and posterior teeth not only is a pleasing esthetic appearance obtained, but also the vulnerable gingival tissues remain healthy.

The mesial and distal slices are made from the lingual approach extending to the labial surface only enough to include areas vulnerable to decay. The full mesiodistal width of the labial surface should be retained, providing casting margins that are practically invisible. The convergence of these walls from the gingival to the incisal surface should be from 2 to 5 degrees from the perpendicular, and the closer to the former the better the end result will be. (See Figs. 6-19 and 6-20.)

In the reduction of the lingual surface of upper anterior teeth (Fig. 6-21) the cut extends from the crest of the cingulum to the incisal edge, leaving the cingulum intact because of its retentive value. Enough tooth structure must be removed to provide clearance in the centric position and the eccentric excursions (allow for a thickness of metal of about 0.75 to 1 mm.).

The incisal area on the lingual surface is beveled to a 45-degree angle to the long axis of the tooth and is hollow ground, for a greater bulk of metal at this vulnerable area so that the

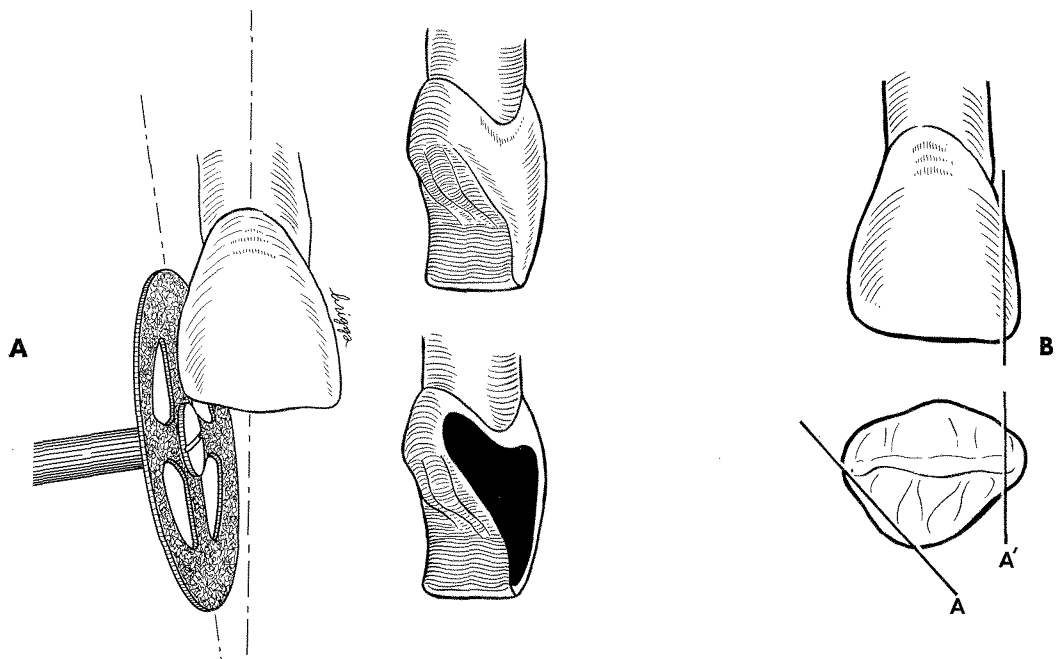


Fig. 6-19. A, Mesial and distal slices are made from lingual approach, allowing for full mesiodistal width of labial surface and thereby almost invisible gold margins. **B,** Correct (*A*) and incorrect (*A′*) methods of preparing mesial and distal slices.

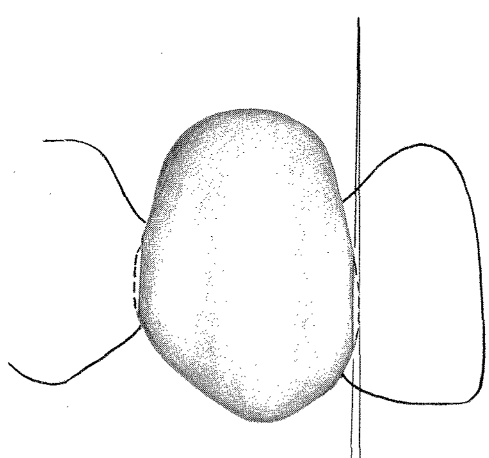


Fig. 6-20. Convergence of mesial and distal walls from gingival to incisal surface should be from 2 to 5 degrees from perpendicular—the closer to 2 degrees the better.

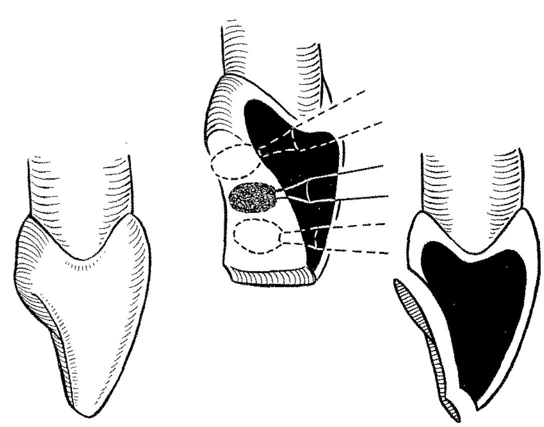


Fig. 6-21. Reduction of lingual surface of upper anterior tooth.

gold is prevented from becoming work hard, brittle, and opening up or lifting away at the margin (Fig. 6-22).

The grooves on the proximal surfaces, running from the incisal bevel to the gingival limit of the preparation, are started with a No. 701 or 701L tapered crosscut fissure bur or its equivalent, and then are followed with a No. 700 or 700L tapered crosscut fissure bur, moving the bur in a labiolingual direction, thereby creating a tapered keyed groove or lock groove. The depth of the groove should extend into the dentin and its diameter in proportion to the size and bulk of the tooth. Round grooves can be used if the tooth is large and the demands are not too great, but the interlocking groove is best because it is effective where the demands are great or not so great and the tooth is small or large. With a groove of this type the tooth is engaged actively in grasping the casting, which practically obviates the possibility of the casting opening up at the cervical margin. The direction of the groove is in a plane closely parallel with the incisal two-thirds of the labial surface (Fig. 6-23). This is the longest distance obtainable, which is a "must," and the grooves should be parallel to each other. If the mesial or distal surface is carious or contains restorations, a shallow box–type preparation with lateral interlocking or tapered keyed grooves and a gingival floor ditch or inclination is indicated. Walls and grooves of proper convergency and adequate length give the needed frictional retention to the casting (See Fig. 6-24.)

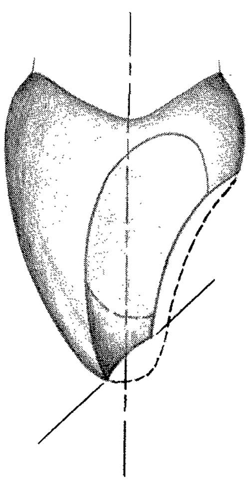


Fig. 6-22. Incisal area on lingual surface beveled to 45-degree angle to long axis of tooth and hollow ground.

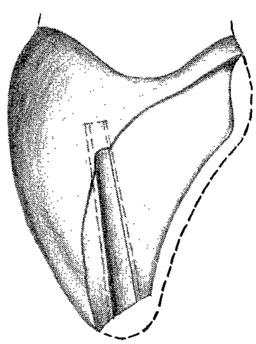


Fig. 6-23. Direction of groove is in plane closely parallel with incisal two-thirds of labial surface. This is longest distance obtainable.

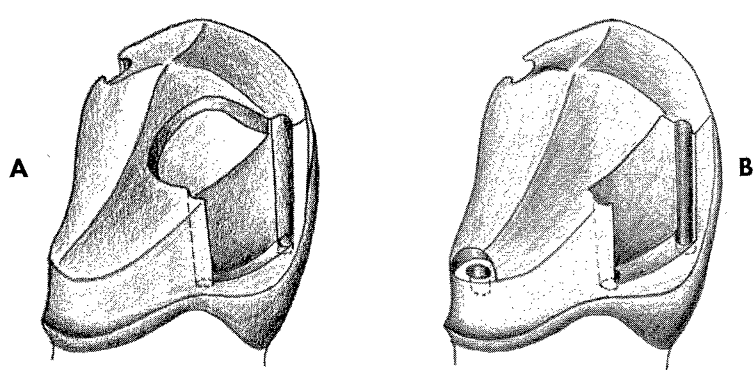


Fig. 6-24. A, Filled or carious mesial or distal surface is prepared with shallow box with lateral interlocking or tapered keyed grooves. **B,** Additional pin retention in region of cingulum also can be used.

The next step in the preparation is to remove a small amount of tooth structure from around the cingulum, keeping this surface as nearly parallel to the mesial and distal walls and grooves as possible for retention (Fig. 6-25).

Willey[7] has shown that the development of properly convergent walls result in various formations of the finishing line region. This principle, as applied to the cingula of anterior teeth, develops a collarlike form, which is a retentive factor (Fig. 6-26). On the lingual surface of the lower molar a knife-edge finish line ensues, whereas on the buccal surface a shoulder or chamfer that is incidental to the paralleling of the walls of the preparation may be developed (Fig. 6-27).

The island of tooth structure in the area of the interproximal slice and the end of the groove is removed using a small diamond flame stone with high speed and very light pressure, thereby establishing a definite finish line.

A pin is used in the cingulum area for added retention. The pinhole, made with a twist drill (.024 or .027) must be made parallel to the retention grooves. The pinhole also can be made with a No. ½ round bur followed with a No. 700 tapered fissure bur, extending to the depth of 1.5 to 2 mm. The pinhole must be made in sound dentin. (See Fig. 6-28.)

A slight reverse bevel is given to the incisal edge. This is done with a xx fine garnet disk coated with petroleum jelly. This procedure bevels the labioincisal enamel rods and protects them against chipping during fabrication of the restoration (Fig. 6-29).

In the preparation of posterior teeth for three-quarter crowns the occlusal surface is a reduced reproduction of the anatomic form instead of a perfectly flat surface, and the mesial and distal slices are made parallel to each other with a convergence toward the occlusal surface of 2 to 5 degrees from the perpendicular (Fig. 6-30).

For bicuspids two grooves are placed on the distal surface and one groove is placed on the mesial surface. The mesial groove is placed as far buccally as possible, permitting at the same time a sliced lap beyond for seal, and the distal grooves are placed at the buccoaxial and linguoaxial line angles (Fig. 6-31). In upper molars, after occlusal, proximal, and lingual reduction, and also a buccal extension or modified reverse bevel, one groove can be placed on the mesial

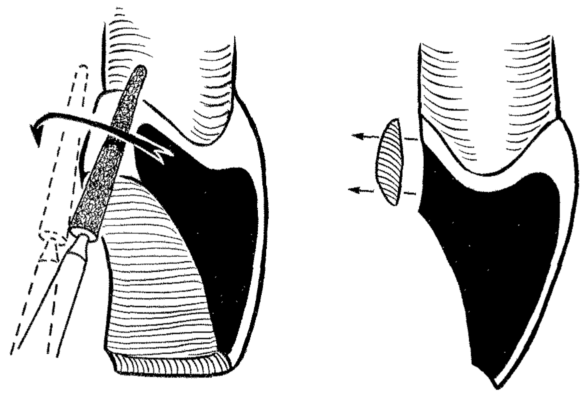


Fig. 6-25. Removal of small amount of tooth structure from around cingulum.

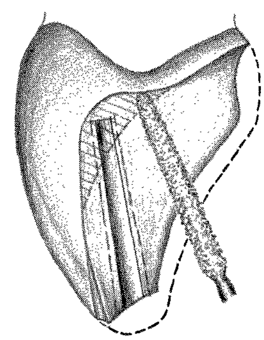


Fig. 6-26. Development of properly convergent walls gives a collarlike form in cingulum area of anterior teeth, which is retentive factor.

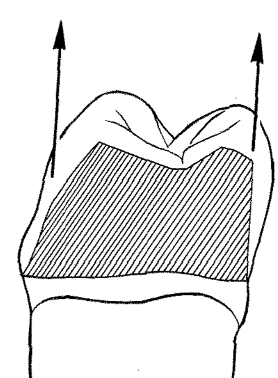


Fig. 6-27. On lingual surface of lower molars a knife-edge finish line usually results and on buccal surface a shoulder or chamfer when paralleling walls of preparation.

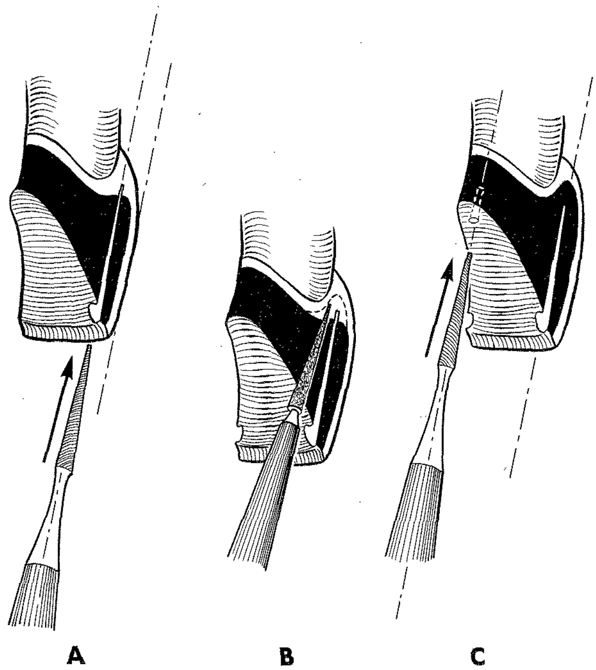


Fig. 6-28. **A,** Development of lock groove. **B,** Removal of island of tooth structure in area of interproximal slice and end of groove. **C,** Added pin retention in cingulum area.

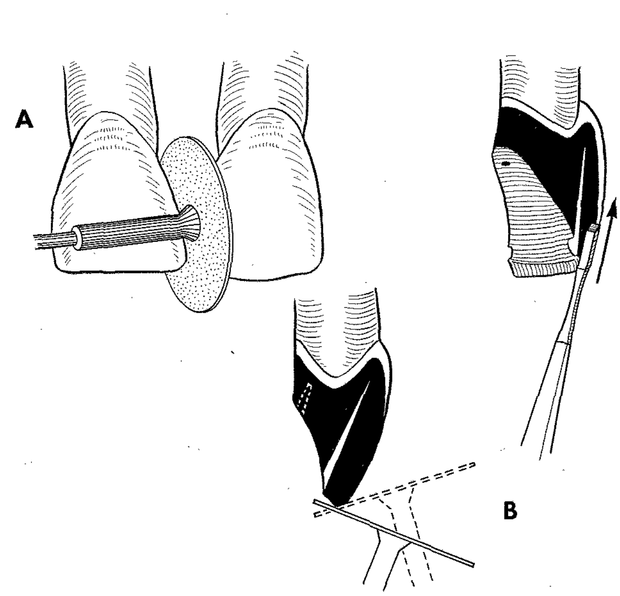


Fig. 6-29. **A,** Use of sandpaper and chisels for finishing and planing of margins. **B,** Slight reverse bevel given to incisal edge to bevel the labioincisal enamel rods and protect it against chipping.

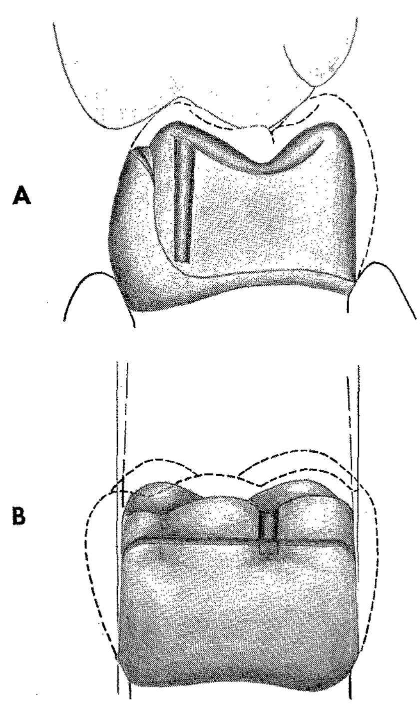


Fig. 6-30. **A,** Occlusal surface is a reduced reproduction of anatomic form. **B,** Mesial and distal slices made parallel to each other with a convergence toward occlusal surface of 2 to 5 degrees from perpendicular.

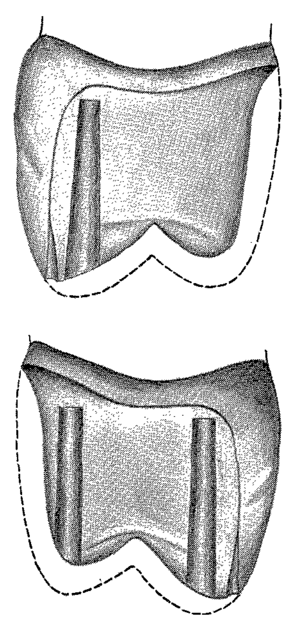


Fig. 6-31. For posterior three-quarter crowns (keeping to principle of tripodism) one groove is placed on mesial surface as far buccally as possible, and two grooves are placed on distal surface.

surface, one groove in the lingual groove, one groove in the buccal groove, and a slight groove on the distal surface to facilitate the handling of the wax pattern. In mandibular posterior teeth, because of their functional relations with the maxillary teeth and their lingual inclinations, a collarlike formation or shoulder is created on the buccal surface, which must be beveled. A groove is placed on the mesial, distal, and buccal surfaces.

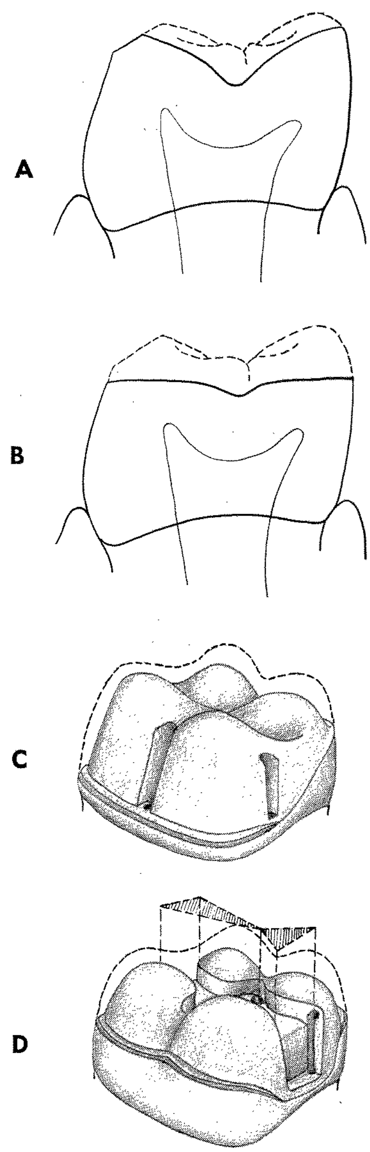


Fig. 6-32. A, Correct occlusal reduction. **B,** Incorrect occlusal reduction. **C** and **D,** Use of grooves, locked grooves, and pins in solid dentin (not cement), fulfilling principle of tripodism for added retention against displacement.

A combination of pins and grooves also are used, and locked grooves must be in solid dentin not less than 2 or 3 mm. in length (Fig. 6-32).

Vale[8] says that the grooves in posterior three-quarter crowns should be parallel in a buccolingual direction and slightly convergent mesiodistally. These grooves should be positioned toward the buccal edge of the slice and directed parallel to the occlusal third of the buccal surface, rather than parallel to the long axis of the tooth, since this enables greater length to be established.

Binocular loupes are used for the final inspection of all preparations. Care must be taken that all margins are smooth, no undercuts exist, all flares are polished, and the axial and gingival margins join in a graceful curve.

If all steps are executed properly, the three-quarter crown, when started to place, should slide in frictional resistance from the time that the gingival ends enter the incisal openings until the crown is seated in position—cement being merely the material used to hermetically seal the joint. Here again the principle of tripodism has been carried out with its resultant stability. (See Fig. 6-33.)

PINLEDGES

Pin retention is one of the strongest retentive forces, mechanically, that can be used in dentistry. Retention is gained primarily by means of the length as well as the judicious placement of the pins. Other advantages of pinledges as individual restorations or retainers are the conservation of tooth structure and good esthetics.

It is now possible to parallel any number of walls and pinholes in any number of teeth, especially in the construction of fixed periodontal splints or extensive fixed partial dentures, by the use of the rules of freehand paralleling or with the aid of the recently developed paralleling devices such as the Parallaid, the Pontostructor, and the Chayes Loma Linda paralleling device. Only true-running handpieces should be used, being careful to run them at comparatively low speeds.

The advent of a new type of drills and sized nylon bristles, as developed by E. D. Shooshan, gives us the tools whereby great accuracy in the preparation of pinholes and their duplication, with extreme fidelity, by the indirect impression technique is possible (Fig. 6-34).

THREE-QUARTER CROWN PREPARATION

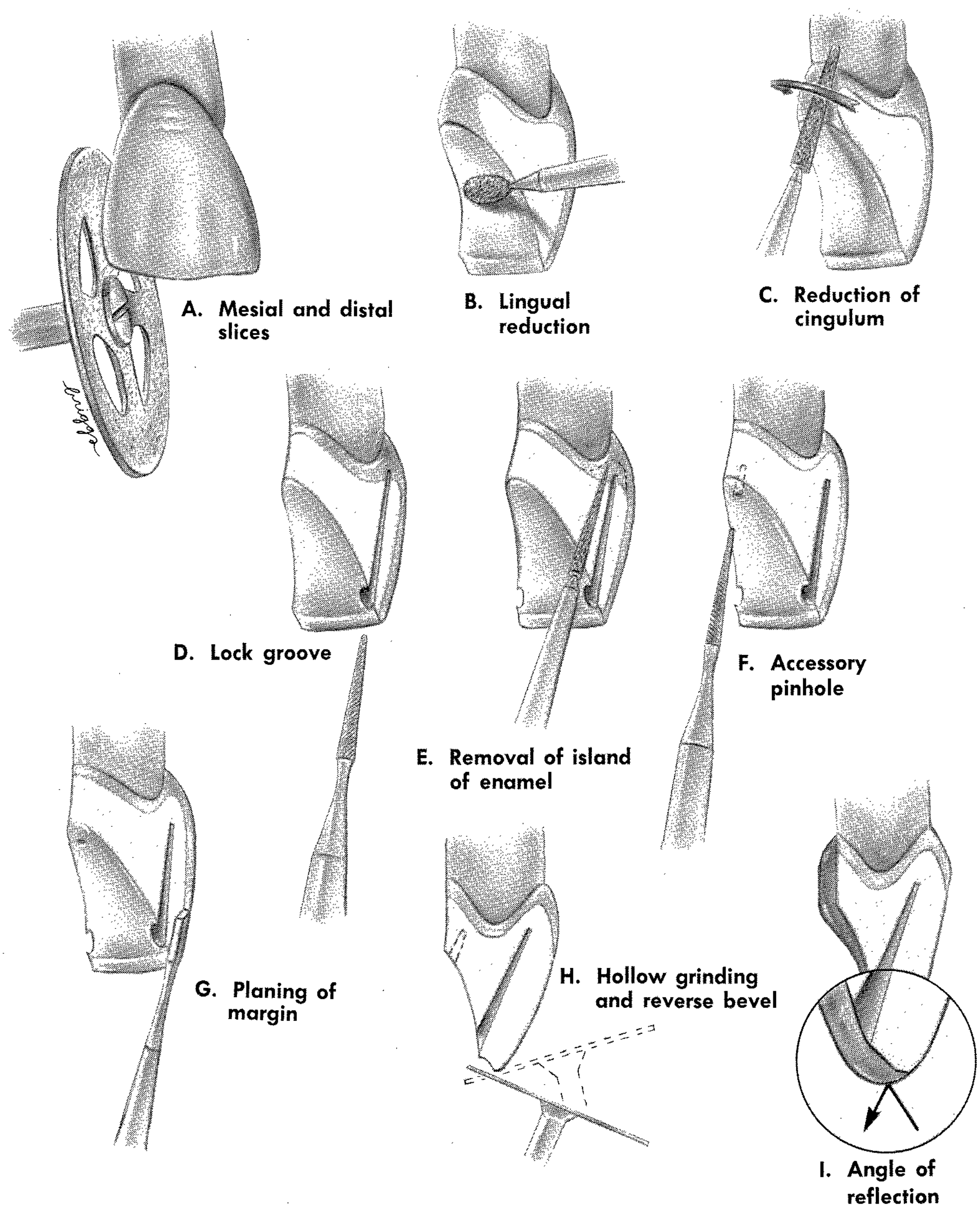


Fig. 6-33. Procedural steps in the preparation of three-quarter crown. **A,** Slicing of mesial and distal surfaces. **B,** Lingual reduction. **C,** Removal of small amount of tooth structure in cingulum area. **D,** Development of lock groove. **E,** Removal of island of enamel. **F,** Added pin retention in area of cingulum. **G,** Planing of margins. **H,** Creation of reverse bevel. **I,** Visible gold of casting rounded so that light will be reflected in downward direction, which will render gold less conspicuous.

Before starting a pinledge preparation a roentgenogram of the tooth should be studied very carefully for the size and position of the pulp. Not only must the pulp be avoided, but also a perforation of a side of the tooth must be prevented.

In cases in which the pinledge is to be used on upper anterior teeth for corrective purposes in occlusal reconstruction, the interproximal surfaces need not be involved. After the proper lingual reduction from the crest of the cingulum and the correct treatment of the cingulum area, a bracing effect and rigidity is given to the casting by grooving the mesial and distal areas in the marginal ridges by means of V-shaped wedge grooves. Then the incisal edge is beveled to a 45 degree angle to the tooth's long axis, or this area can be hollow ground. Small flat ledges or seats are prepared in appropriate positions for starting the pinholes. The pinholes must be drilled parallel to each other to a depth of 2 to 3 mm. I drill the cingulum area hole or holes first because of the pulpal factor and drill the others parallel to this first pinhole. By the use of the twist drill the pinholes can be made small in diameter, permitting adequate frictional resistance and retention without extensive cutting. A very slight incisal reverse bevel then is created to complete the preparation. (See Figs. 6-35 to 6-38.)

The first step in the preparation of a pinledge type of retainer for a fixed splint or bridge is to slice the proximal surface very carefully, using the lingual approach and bringing the labial margin to a self-cleansing area (Figs. 6-39 to 6-41). In many instances one of the proximal surfaces need not be prepared, ending the preparation with a V-shaped wedge groove in the marginal ridge area of this surface (Fig. 6-42).

Fig. 6-34. **A,** Twist drill. **B,** Sized headed pins (Perlon). **C,** Bibeveled carbide center drill.

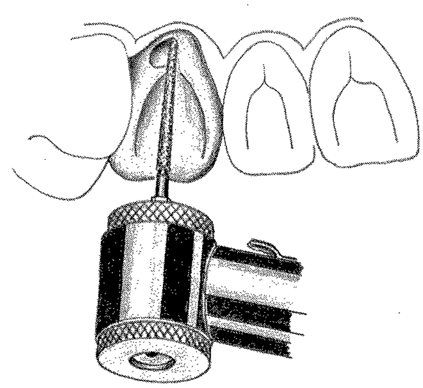


Fig. 6-35. Reduction of cingulum area in pinledge preparation.

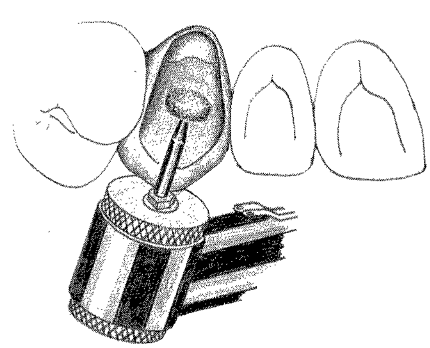


Fig. 6-36. Proper lingual reduction.

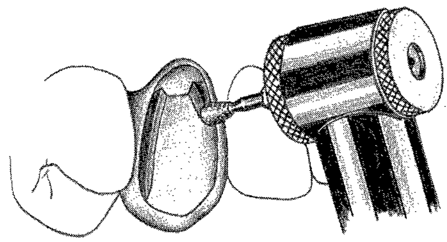


Fig. 6-37. Grooving of mesial and distal areas in marginal ridges creating **V**-shaped wedge grooves for bracing and rigidity.

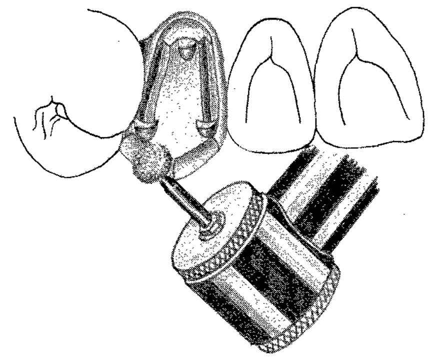


Fig. 6-38. Preparation of small flat ledges to receive pinholes and treatment of incisal edge (bevel to 45-degree angle to long axis of tooth and hollow grind). Follow with slight reverse bevel.

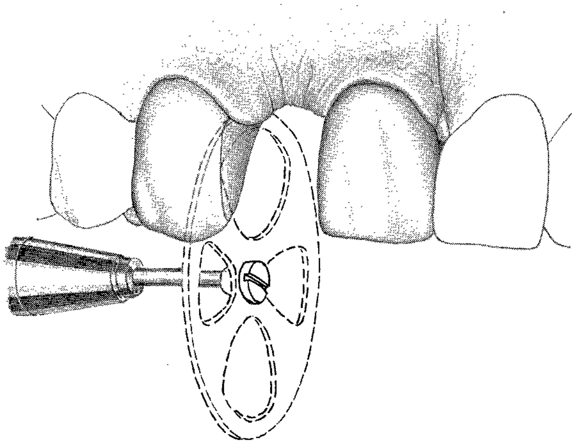


Fig. 6-39. Slicing of proximal surface for preparation of pinledge retainer with disk.

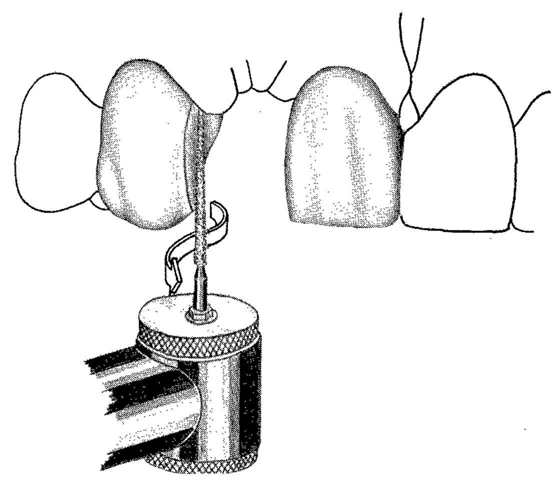


Fig. 6-40. Slicing of proximal surface with small flame-shaped diamond stone (proximal surface must be concave).

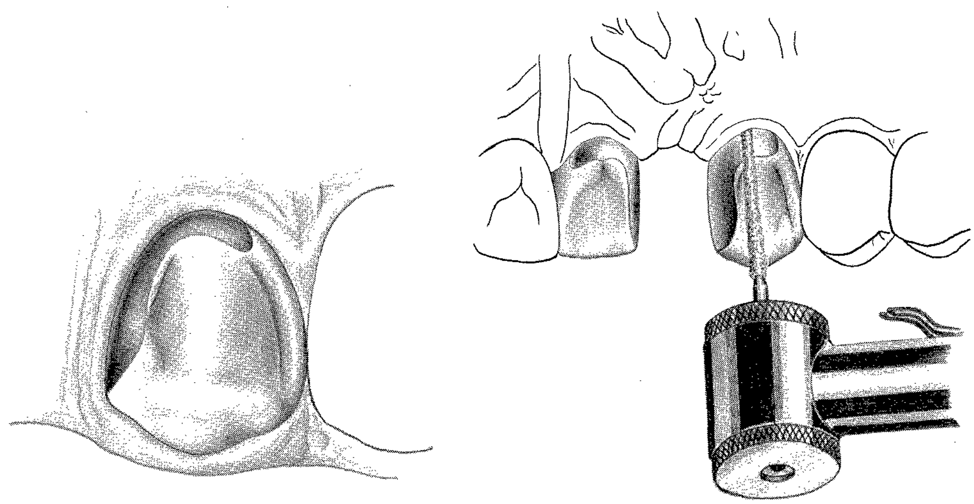


Fig. 6-41. Treatment of cingulum area.

A proximal surface that is adjacent to a pontic area must have a concave surface to allow for more bulk of metal for the avoidance of the warpage of margins during the soldering operation (Fig. 6-43). Where rotational stresses are likely to be great, a tapered keyed groove or locked groove should be used on that side where the pontic is to be soldered, thereby breaking the rotational stress at its inception and keeping it off the pins, which so often results in the loosening of our pinledge retainers. The utilization of a groove in combination with the pins results in a very adequate retainer in short span cases.

The reduction of the lingual surface to the crest of the cingulum is the next step in the procedure, followed by the removal of a small amount of tooth structure from the area around the cingulum producing a definitive gingival margin—a chamfer or modified collarlike formation with very little taper (Fig. 6-44). Because of this vertical surface, the retentive factors of the preparation is enhanced greatly.

The incisal area is then reduced, creating a 45-degree angle to the long axis of the tooth, and it is also slightly hollow ground (Fig. 6-45). In lingual reduction care must be exercised to provide for adequate thickness of metal when the teeth are in centric and eccentric occlusal relations.

Shallow recesses or ledges are cut toward the labial surface with a small cylindrical diamond stone—one at the mesioincisal edge, one at the distoincisal edge, and one in the cingulum area. The ledges for the pinhole openings are made

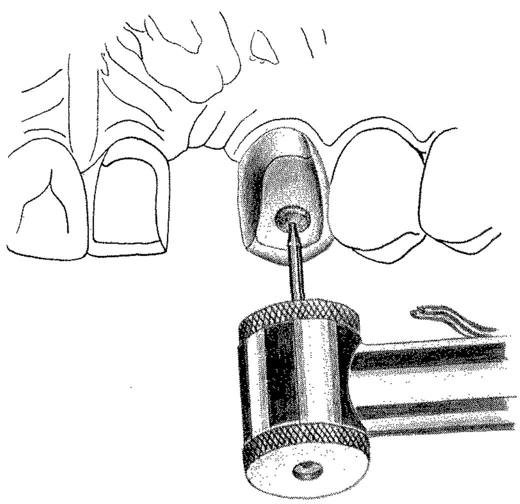


Fig. 6-42. Reduction of lingual surface and ending preparation of this surface with **V**-shaped wedge groove in marginal ridge area of opposite proximal surface.

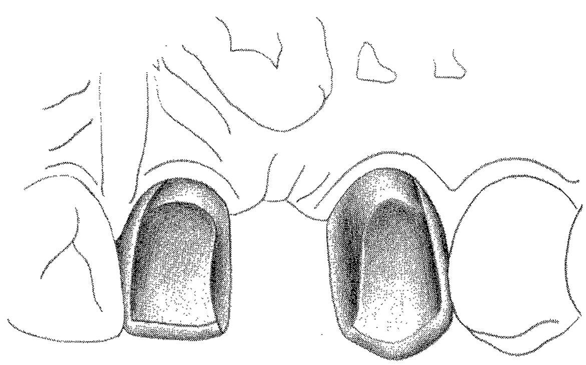


Fig. 6-43. Proximal surface adjacent to pontic area must have concave surface to allow for more bulk of metal to avoid warpage of margins during soldering.

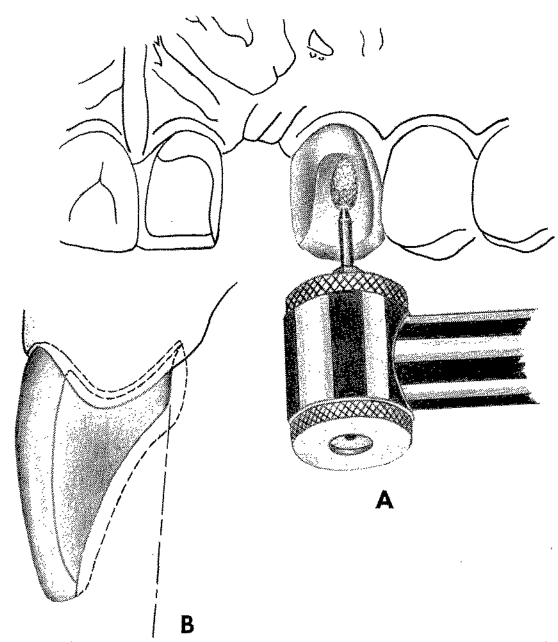


Fig. 6-44. A, Reduction of lingual surface to crest of cingulum followed by removal of small amount of tooth structure in area around cingulum. **B,** Above procedure produces a gingival margin that is chamfered or modified collarlike formation with very little taper.

with sharp angles. The formation of ledges throws the occlusal stress on the tooth rather than on the pins, which merely hold the attachment in position. The shank of the diamond stone should be kept parallel to the face of the tooth viewed labiolingually and parallel to the long axis of the tooth viewed mesiodistally. (See Fig. 6-46.)

The positioning of the pinholes is next in order. Pencil marks can be made at the spots where a small round bur or a special carbide center drill will penetrate any remaining enamel and facilitate the accurate positioning of the holes. This is followed with a Spirec drill or a twist drill or a tapered fissure bur sized to the round bur (if a No. ½ round bur is used, the corresponding sized tapered fissure bur used to finish the pinhole is No. 700) revolving at a slow speed with intermittent withdrawal of the drill for chip clearance. (See Figs. 6-47 and 6-48.)

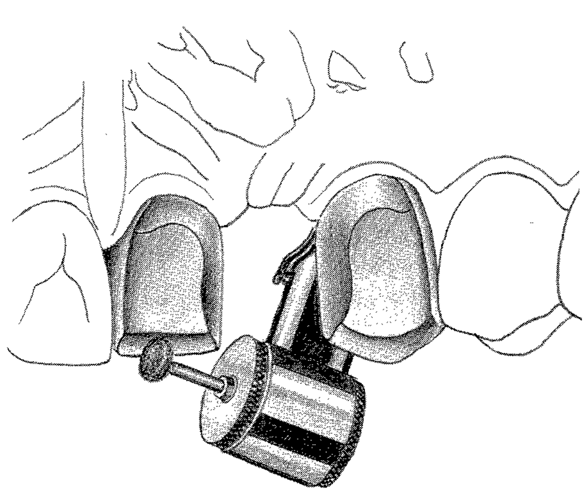


Fig. 6-45. Reduction of incisal area. Hollow-ground incisal area is end result.

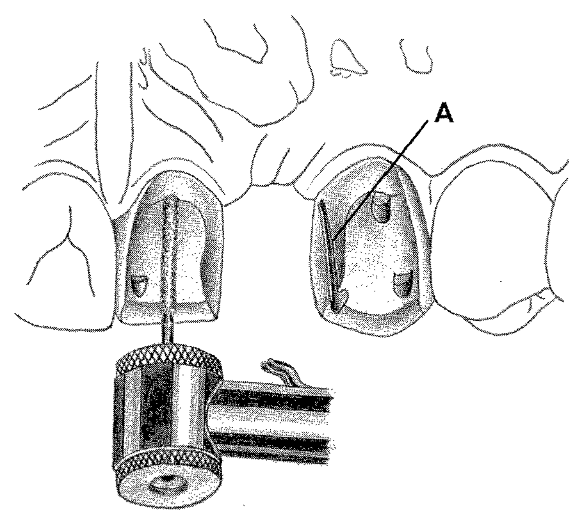


Fig. 6-46. Ledges prepared for pinhole openings. Utilization of lock groove (A) in combination with pins makes for retentive retainer.

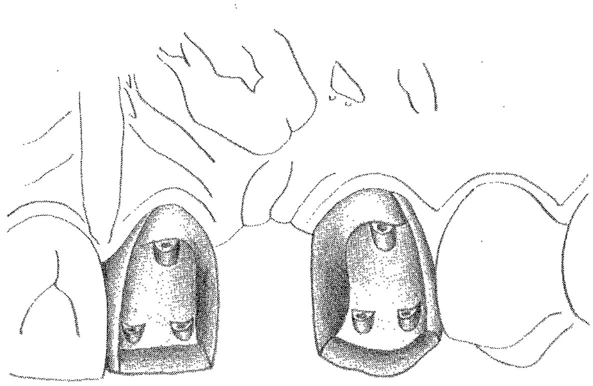


Fig. 6-47. Positioning of pinholes. Make pencil marks at spots to be drilled.

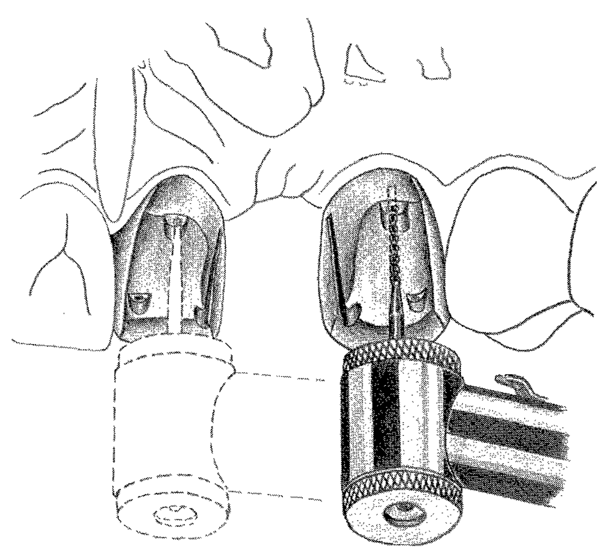


Fig. 6-48. Pinholes made starting with small round bur or special carbide drill, followed by a Spirec drill, twist drill, or tapered fissure bur.

Pinholes may be drilled to the depth of 2 to 3 mm., provided the holes fall mesially, distally, or lingually to the pulp chamber. If a twist drill is used, the depth of penetration, be it 0.024, 0.027, or 0.029 inch, is determined, as a rule, by the collar on these twist drills. Circumstances may make it necessary to decrease this length. If, because of parallelism, one has to be carried directly toward the pulp, 1 mm. will be sufficient. Sometimes one pinhole may be made longer than the average length to compensate for a short pinhole in the preparation. But, by all means, the pinhole should be kept at least 1 mm. away from the pulp. (See Fig. 6-49.)

The gingival pinhole should be drilled first because of the delicate pulpal position, and the other pinholes made parallel to this one. The development of the twist drill allows for pinholes of small diameter, which at the same time permits adequate frictional resistance and retention.

Three or four pinholes are usually adequate, and they must be placed in sound dentin. Pins must be parallel with each other and the walls of the preparation, which gives us the retentive feature of the pins in sound dentin and also internal or external wall retention. Place pinholes inside the dentinoenamel junction and at least 1 mm. from the proximal wall of the preparation.

A proximal cavity or filling may be encountered on one or both sides of the tooth. In such a case a locked groove can be used if little decay or filling material is present and is well confined at the proper place, or it may be necessary to "box out" one or both sides. If one proximal surface is involved, that is the distal surface, a box preparation with a labiodistal and a linguodistal groove is made on the distal surface with the addition of two pinholes, one at the mesioincisal area and one in the region of the cingulum. It also is possible that a locked groove would suffice on the involved distal surface. If both proximal surfaces are involved, the preparation calls for "boxed out" or locked groove preparations, both mesially and distally, with a pinhole in the cingulum area—really a three-quarter crown preparation, or at least a modified three-quarter crown type of cavity design. Pinholes or grooves should never be made in cement since it is not retentive. (See Figs. 6-50 and 6-51.)

The preparation is then smoothed with fine finishing diamond points and sandpaper disks.

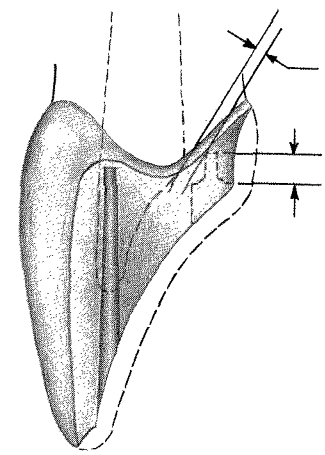


Fig. 6-49. If, because of parallelism, it is necessary to carry pinhole directly toward pulp, a depth of 1 mm. is sufficient.

At this time, with the aid of binocular loupes, the incisal edge is given a slight reverse bevel. The visible gold of the casting in this area can be rounded in such a manner that light will be reflected in a downward direction, which will render the gold practically invisible (Fig. 6-52). We must remember that old law in physics regarding reflection: "The angle of reflection is equal to the angle of incidence, and the two angles lie in the same plane" (Fig. 6-53).

Before the casting is seated, the sharp edges around the top of each pinhole is beveled slightly with a suitably sized round bur. This permits the casting to go to place in its entirety with perfect adaptation and also allows some latitude in aligning the pins with their respective openings.

An effort should be made to fit the pins in the pinholes snugly, but this creates a problem in cementation. Some dentists think that the pins should be beveled slightly on a bias at the bottom of the pins, while others feel that a vent for the cement to escape during cementation should be made with the smallest round bur available inserted into the bottom of the pinholes and withdrawn, a groove resulting which will counteract the plunger effect created by the act of cementation. The twist drill and sized nylon bristle technique compensates for this by giving us a finished pin that is slightly smaller in diameter than the pinhole. This allows for complete seating in cementation by counteracting the plunger effect, and it also gives ample retention and resistance to displacement.

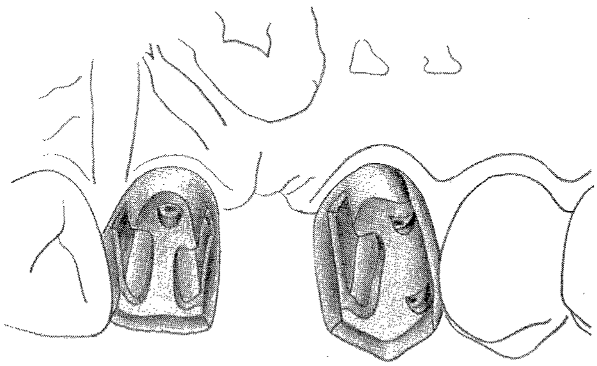


Fig. 6-50. Fillings or extensive caries on a proximal surface necessitates box preparation and two pins.

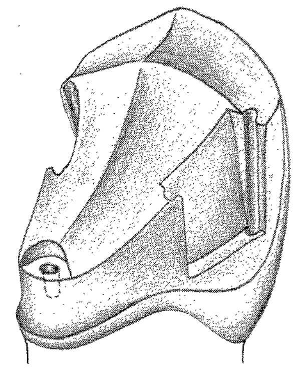


Fig. 6-51. If both proximal surfaces involved, use box preparation with pin retention in cingulum area, a somewhat modified three-quarter crown preparation.

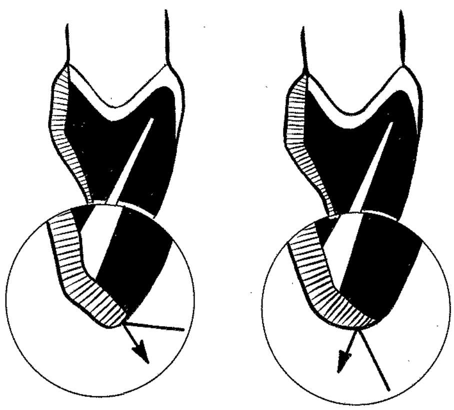


Fig. 6-52. Visible gold of casting rounded so that light will be reflected in downward direction to render gold practically invisible.

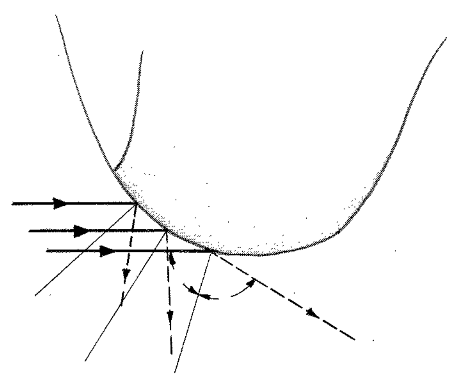


Fig. 6-53. Angle of reflection is equal to angle of incidence, and the two angles lie in same plane.

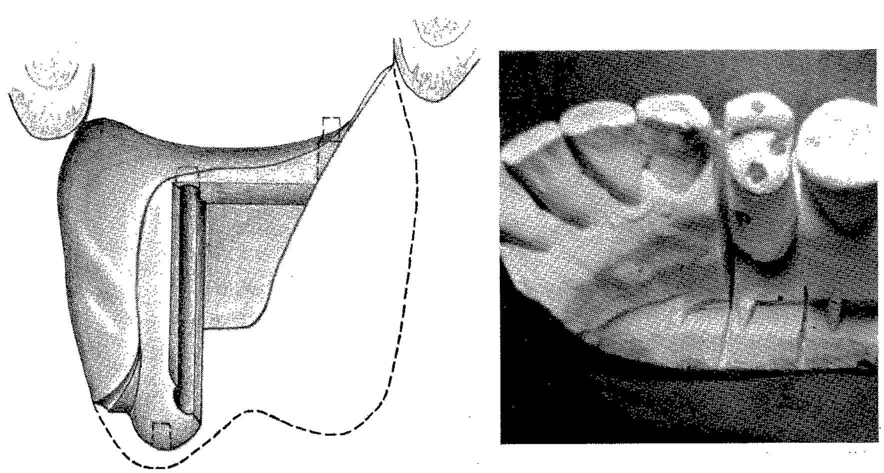


Fig. 6-54. Pins helpful in cases of badly broken down teeth or cases of buccal or lingual wall fracture.

PINLEDGE PREPARATION

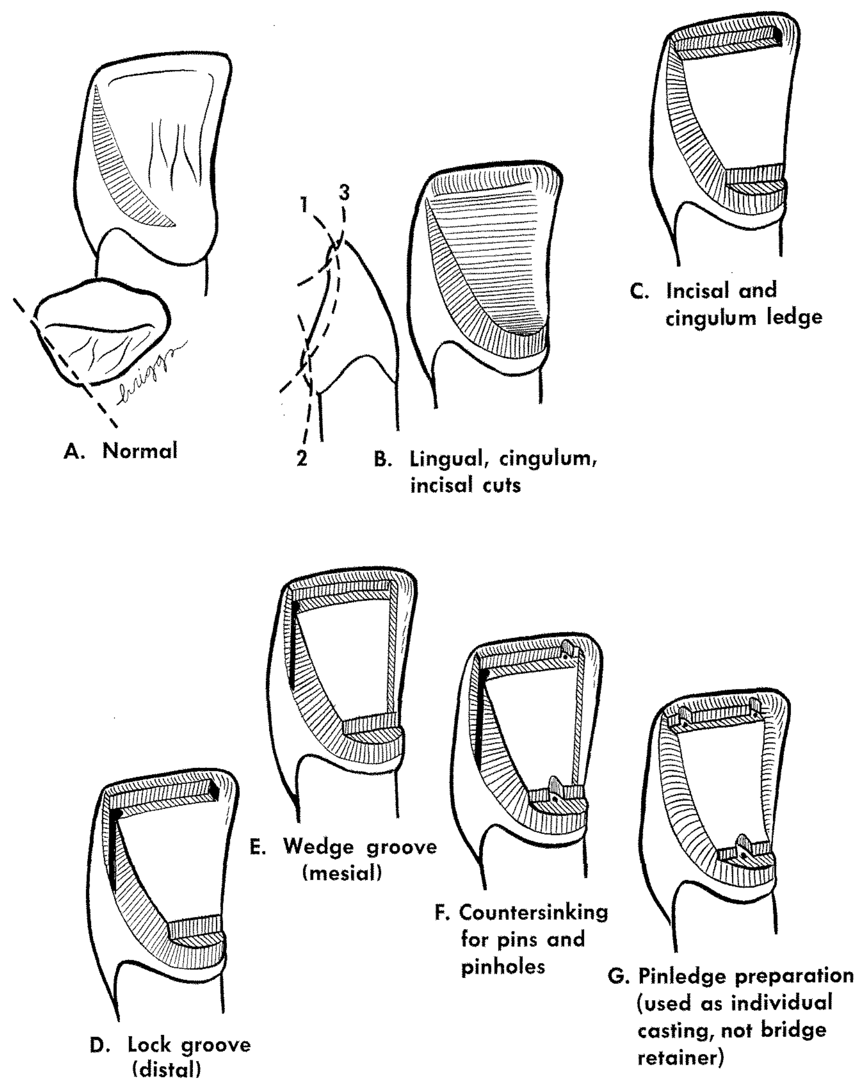


Fig. 6-55. Coordinated steps in preparation of pinledge and pinledge bridge retainer. **A,** Removal of proximal surface (make concave). **B,** Lingual, cingulum, and incisal edge reduction. **C,** Creation of ledges for pinhole openings. **D,** Preparation of lock groove. **E, V**-shaped wedge groove in marginal ridge area made. **F,** Pinholes paralleled to lock groove. **G,** In pinledge preparation, as individual casting, same preparation as above with exception of lock groove. Instead use **V**-shaped wedge grooves in both marginal ridges and three pins for retention and rigidity.

Pins also are useful in the restoration of badly broken down teeth or in cases of fractures of the buccal or lingual plates of posterior teeth (Fig. 6-54).

It has been clearly shown that pins should be distributed as in a tripod, and not bunched together on one side of the tooth (Fig. 6-55).

PULPLESS TEETH

In mouth rehabilitation procedures the endodontist is a very important member of the team. Pathology may result from the necessary extensive tooth preparation, impression taking, temporization, cementation, etc., weeks, months, or even years later. This may call for conservative treatment or surgical procedures such as hemisection and apioectomy. In other words, it will need the expert help of the endodontist.

In diagnosis and treatment planning the conclusions reached may call for the use of elective endodontics to effect parallelism, a better plane of occlusion, a modification of crown-root ratios and tooth contours, and the problems of extruded and tipped teeth, versions, and rotations. Also, successful endodontic treatment sometimes can prevent the complete loss of a case by salvaging strategic abutment teeth or preventing the need for a removable prosthesis where the teeth could not stand the torque and stresses. Many patients cannot adjust themselves psychologically to even the best designed and constructed, removable partial denture.

After endodontic treatment the remaining tooth structure must be given maximum strength and protection. Pulpless teeth are more brittle than vital teeth. Therefore, the complete "shoeing" of the cusps and the use of a post or dowel in one or more canals will give this additional strength and retention. The length of the post or dowel should be at least equal to the length of the coronal portion of the restoration. This may not be possible always because of the length and shape of the roots, periodontal involvements, etc. If this is not possible, then more than one post should be used, or an increase in the width of the walls of the canal is necessary. It has been determined that there is a direct correlation between the lateral area of the dowel and the retention it affords, but the effort to achieve a post length of two-thirds the length of a root or roots is the goal to be achieved (Fig. 6-56).

Even if endodontics is done in a tooth with full coverage, a post in the canal after treatment is a good policy because that can prevent the possibility of a shearing of the tooth at the gingival line. This holds true for all endodontically treated teeth.

The apical portion of the root canal can be sealed with a section of the silver point after the canal or canals have been reamed to enlarge them for the reception of a post or dowel. Many endodontists use the twist off method of the silver point in the canal-filling operation to make it easier for more reaming and enlarging of the canal.

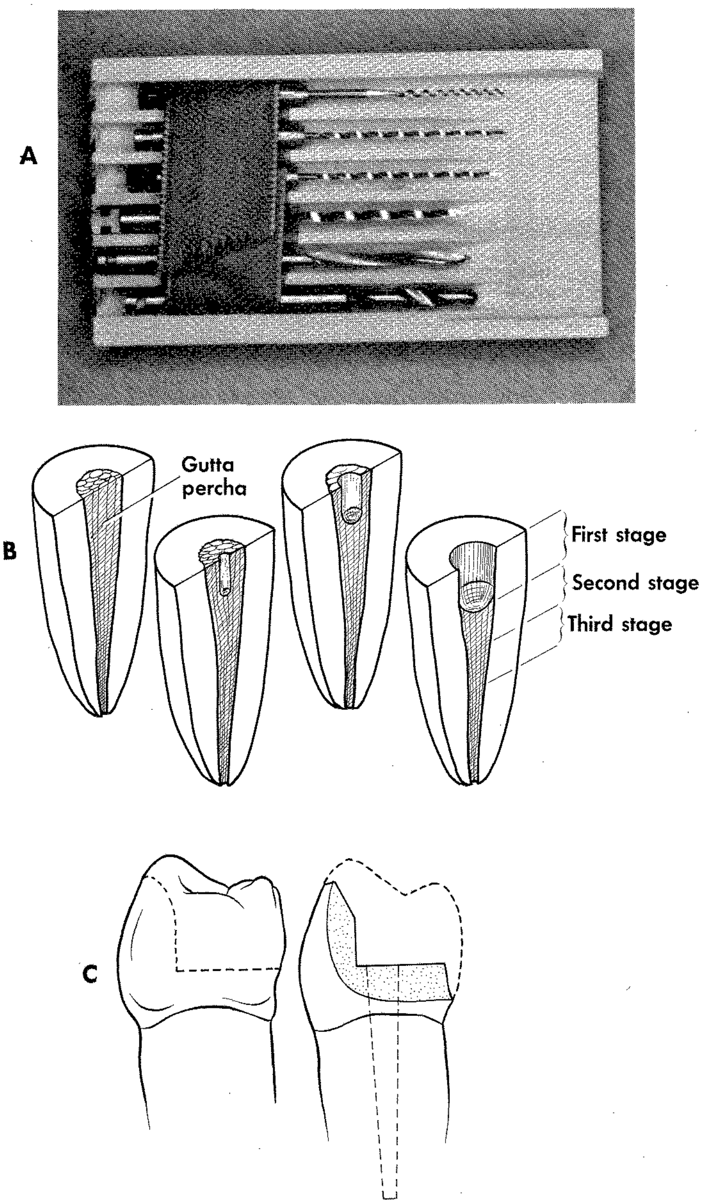


Fig. 6-56. A, Drills and reamers used in reaming and enlarging canals for posts. **B,** Stages of development of canal opening to receive post—round burs of various sizes, drills, and reamers are used. **C,** Length of post should be, if possible, two-thirds the length of the root or equal to the length of the crown.

One must remember that the parallelism of the post or posts to the involved internal and external walls of the preparation must be observed carefully. Also, the enlargement of the canal to a point where a thin shell of dentin remains is contraindicated—it can lead to a lateral perforation.

In cases in which all coronal tooth structure is gone, dependence for survival of the tooth is placed upon the root and the root face. The root face is so prepared as to correspond to the curvature of the gingival tissue establishing two planes, one facially and one lingually (Fig. 6-57).

The post or dowel should be as long as possible, and the gingival portion of the post-anchorage cast gold core must not only contact the two planes of the root face, but also it must encircle the axial surfaces of the preparation. The retention furnished by the post and the additional support afforded by the encirclement of the axial surfaces of the preparation by an accurate fitting casting give longevity to the restoration and preclude the possibility of root fracture.

A small shallow slot or lock also should be cut facially or lingually so that the casting can be seated with ease and accuracy. It prevents the possibility of rotation (Fig. 6-58).

A cast gold or veneered crown is constructed to fit over this primary restoration. The crown has a subgingival apron of gold surrounding the entire circumference of the root, which not only acts as a support or brace, but also gives us the opportunity of removing this crown, if necessary, without taking the chance of fracturing the root or any other remaining tooth structure while trying to remove a post and core (Figs. 6-59 and 6-60).

In cases of "old root canal fillings," in which reentry into the canals is not feasible for one reason or another, "pulp chamber anchorage" with mesial and distal locked grooves or boxes is used (Fig. 6-61). The walls of the pulp chamber are kept parallel to each other and to the grooves or boxes, with little convergence, and go as deep as the particular case allows.

Where there is ample tooth structure to make a full coping unnecessary and at the same time not enough tooth length gingivo-occlusally or incisally, a post and casting extension should be used (Fig. 6-62).

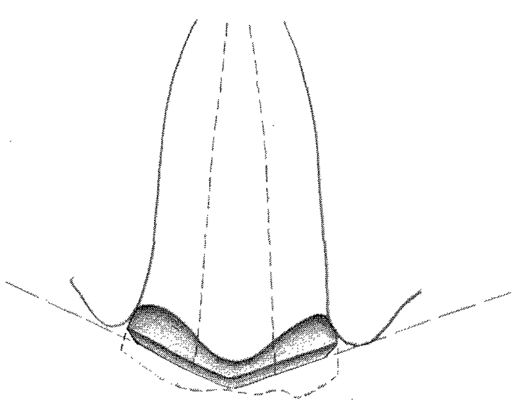


Fig. 6-57. Root face prepared to correspond to curvature of gingival tissue. Two planes established—one facially and one lingually.

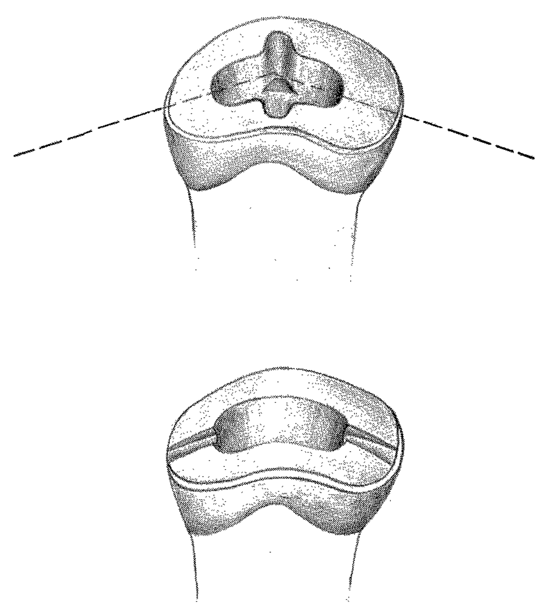


Fig. 6-58. Small shallow slot or lock is cut to facilitate accurate seating of casting. Prevents possibility of rotation.

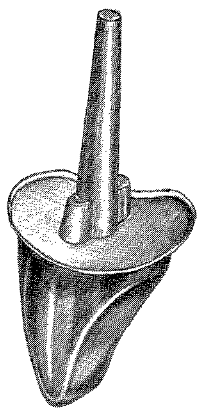


Fig. 6-59. Post-anchorage cast gold core.

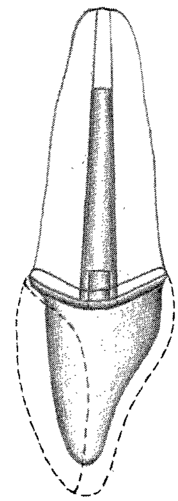


Fig. 6-60. Veneer crown fits over the post-anchorage core restoration. It has subgingival apron of gold surrounding entire circumference of root for support and bracing.

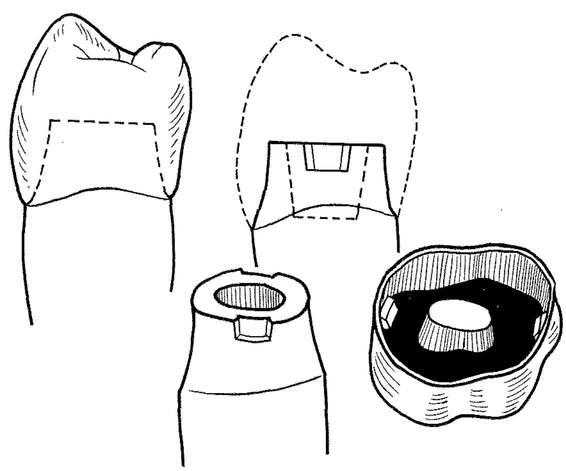


Fig. 6-61. "Pulp chamber" anchorage and wall support in cases in which reentry into canals is not feasible.

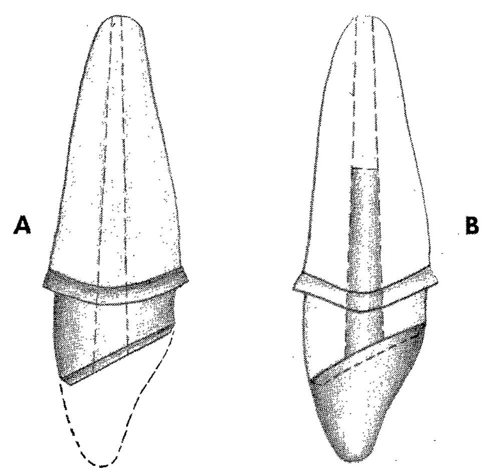


Fig. 6-62. A, Case illustrating insufficient tooth length gingivo-occlusally. **B,** Post and casting extension used in these type of cases.

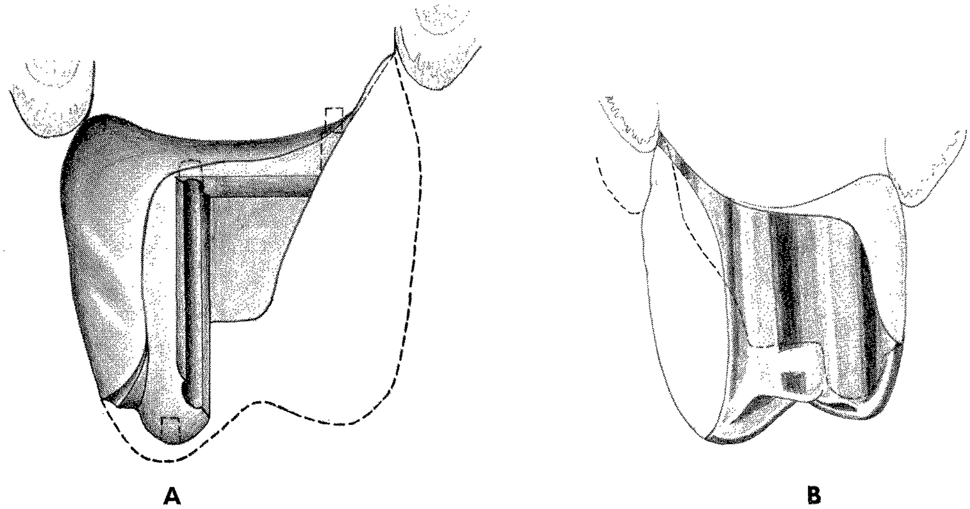


Fig. 6-63. A, Buccal or lingual wall fracture treated by "shoeing" the intact buccal or lingual cusp and making use of accessory pin or post-anchorage retention. B, Double deflecting curvature or contour at cervical third region in cases surgically treated, and "shoeing" of lingual cusp.

We try, however, to encircle the remaining tooth structure and to cause an extension at the same time, whenever tooth preparation allows for a small shoulder to be placed. If this shoulder placement is possible, an oversized crown will not result.

If a fracture of the buccal or lingual wall takes place rather deep subgingivally, surgical interference may be necessary to allow access to the gingival margin. Bone trimming or osteoplasty is performed. A post-anchorage restoration is made, being sure to "shoe" the intact buccal or lingual cusp, using the principle of the "shingle-roof" or reverse bevel. If it is the buccal surface, it can be veneered. (See Fig. 6-63.)

Posts for multirooted teeth need not be as long as for anterior teeth. White[9] and Rosen[10] have shown how posts and cores for teeth with divergent roots are constructed in sections (Fig. 6-64). These are cemented in place independently and can be united with semiprecision locks (in the form of a dowel head) to provide additional strength. The lock in the section to be cemented or seated first must be prepared so that it will be parallel to the canal of the other section.

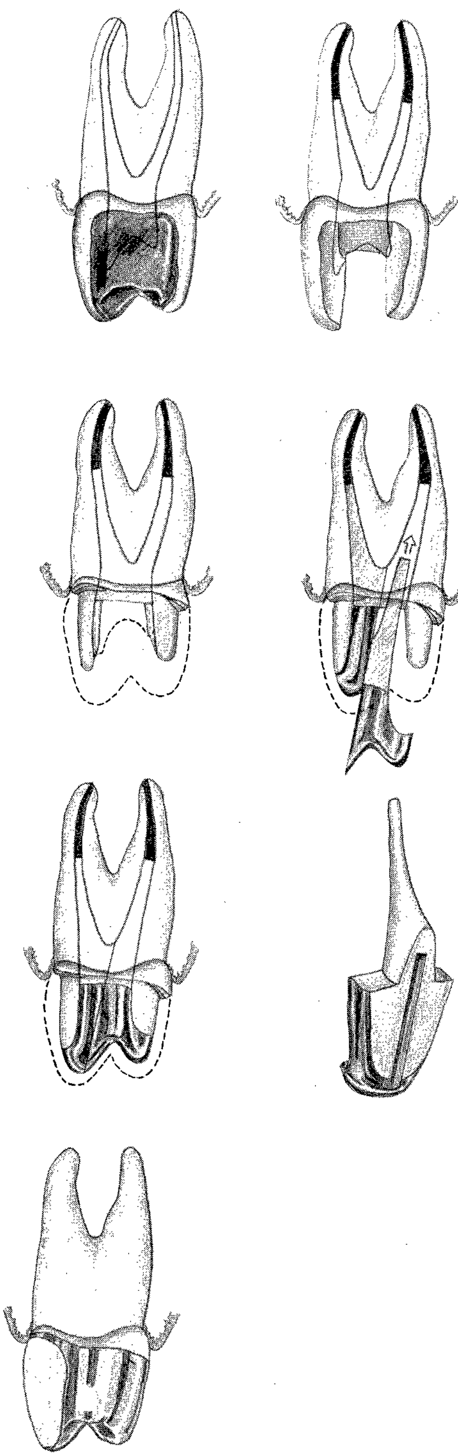
A more recent development in this type of work has been the Kerr endo-post (Fig. 6-65). I have used the Kerr endo-post with much success and feel that it has a very definite place in the restoration of the pulpless tooth.

The endo-post technique works equally well on both anterior and posterior teeth, and narrow-diameter roots cause no problem with this method.

Hand instrumentation, instead of burs or engine reamers, is used to create the canal hole or holes. This obviates the necessity of removing excessive amounts of root structure and minimizes the danger of root splitting or root perforation.

Restorations are safer because two-thirds to four-fifths of the root length, rather than the root diameter, is used for retention and strength. Short tapered cast posts, even with increased lateral areas, will not withstand occlusal stresses as well as a post having at least the length of the coronal surface to be restored.

The endo-post has the same size and taper as the standardized file and/or reamer used to create the hole, and, because of this, the bearing stress and load are distributed uniformly over the entire length and diameter of the post. It has a high tensile strength, and it is said that it is two to four times that of a cast post.



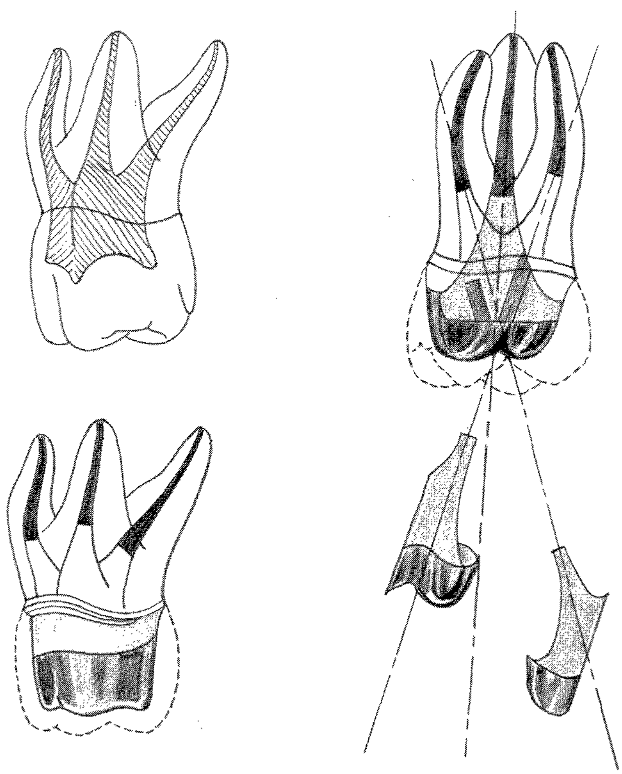


Fig. 6-64. Construction of posts for multirooted teeth with divergent roots.

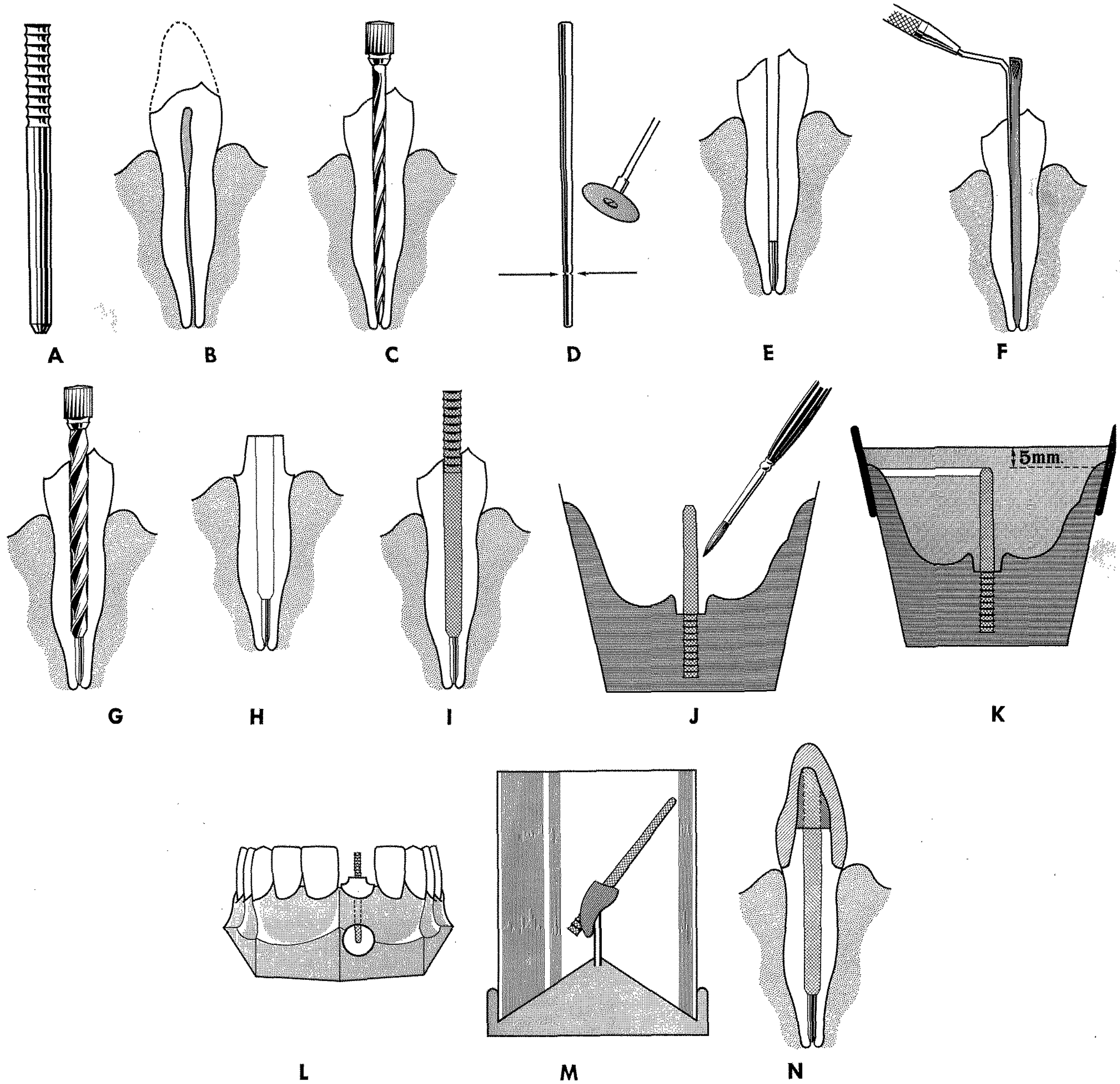


Fig. 6-65. Endo-post technique. **A,** Endo-post. **B,** Tooth to be treated and restored. **C,** Clearing and enlarging root canal. **D,** Notch silver point with a disk around its circumference at its apical third or less. Tip of silver point cemented into place. **E,** Point twisted gently until it breaks where notched. **F,** Gutta-percha points may be used to seal apical third. Standardized files and reamers used to remove gutta-percha from mid-portion and coronal portion of canal. **G,** Remainder of canal enlarged with files and reamers. As little tooth structure as possible removed. **H,** Tooth prepared, leaving as much of the crown portion as possible. **I,** Endo-post inserted and impression taken. Can use Permlastic, Elasticon, or copper tube–modeling compound. **J,** Root end of the endo-post lubricated with Kerr microfilm. **K,** Plastic toothpick or banker's pin luted to periphery of impression and to side of endo-post at its root end extremity. Stone model poured to level of 5 mm. above end of post. **L,** After removal of model from impression, plastic toothpick or pin removed and hole enlarged to form window that enables one to check seat of post after it has been removed and reinserted into model. Any stone that forms seat at end of endo-post should not be cut away. **M,** Wax coronal part of core, sprue and invest in luster cast investment (type of investment that must be used in casting metal to metal to avoid contamination and oxidation of embedded metal). **N,** Casting trimmed and seated in model. Veneer crown constructed and cemented over post-anchorage cast core, which had been previously cemented. (Courtesy Kerr Dental Mfg. Co., Detroit, Mich.)

FULL COVERAGE

The full crown is unquestionably the strongest and most retentive retainer we have in our repertoire of cavity designs. However, full-crown retainers should be used only when the circumstances demand it, after careful diagnosis and prognosis point to its requirement.

In health, the exposed part of the tooth in the mouth is surrounded by a peripereal seal (epithelial attachment) regardless of the gingival level or contour. Our operative and restorative procedures must try to preserve this protective feature.

It has been said many times that subgingival extensions of full-coverage margins produce an environment that is unfavorable to the health of the marginal gingiva, giving tissues that are more rolled, more thickened, and more inflammatory in character.

This accusation cannot be denied, but does the fault lie with full coverage or the dentist? Can an understanding of tooth form and function, crown preparation, and the skillful and careful use of the necessary tools and materials prevent this catastrophe? I think it can.

The marginal finish lines used in the preparation of teeth for full coverage are (1) shoulder, (2) beveled-shoulder, (3) chamfer, (4) knife-edge or featheredge, and (5) McEwen's "chamferette"—a finish line between a chamfer and a featheredge (Fig. 6-66).

The full shoulder preparation is used only in the preparation of teeth for porcelain jacket crowns. This type of crown preparation with its definitive shoulder, makes use of a butt joint, which cannot be used in the construction of cast crowns—all metal or veneer.

It is impossible to cast precisely to a butt joint, and it is difficult to seat a casting adequately to this kind of joint. The process of cementation will verify this statement, and the end result is a cement line that eventually leads to a "wash-out" and subsequent plaque formation and its sequelae—decay and gingival irritation. Therefore a short bevel is needed on the shoulder whenever a cast veneer crown is to be constructed.

In the preparation of average length or short teeth for full coverage, when a veneering material is to be used for esthetics, a facial, mesial,

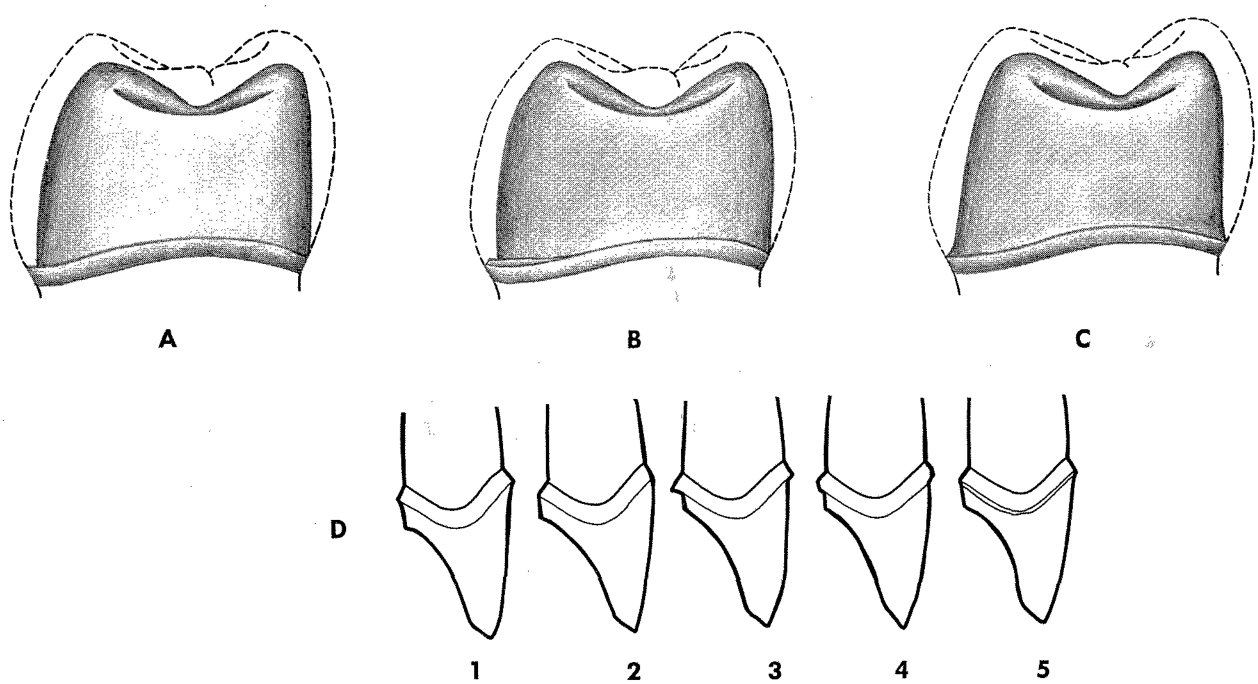


Fig. 6-66. Marginal finish lines. **A,** Shoulder. **B,** Beveled shoulder. **C,** Chamfer. **D,** Chamfer, featheredge, shoulder, beveled shoulder. **D,** *1* to *5* are different views of what one sees in **A** to **C** with the addition of featheredge (*2*) and another view of the beveled shoulder (*4*).

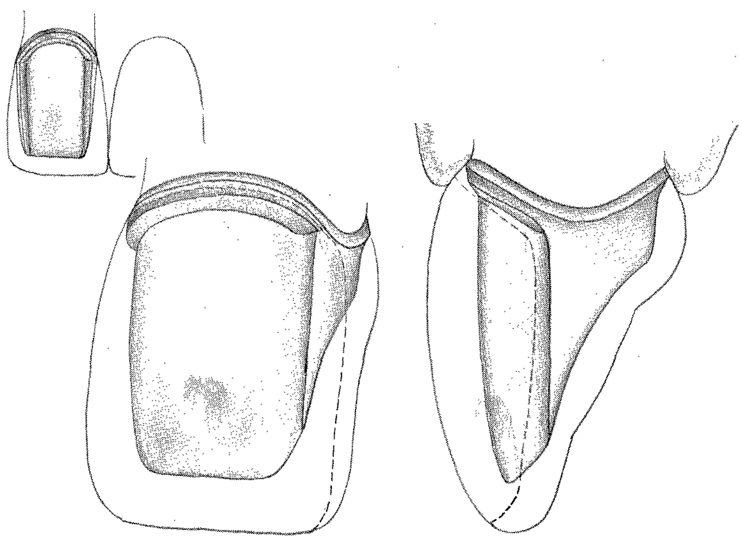
and distal "beveled-shoulder" finishing line is indicated so that room is allowed for the porcelain or acrylic facing, and for better periodontal health such as the avoidance of impingement or strangulation of the interseptal tissue. The shoulder width in these cases should be 1 to 1.5 mm., which also allows for the proper contouring of the crown at the cervical third.

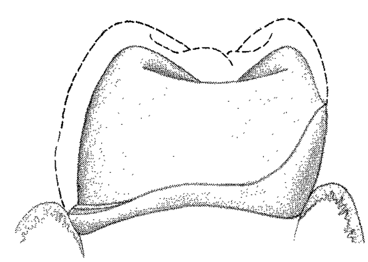
This beveled-shoulder marginal finish line gradually will fade into a chamfer finish line as it approaches the lingual surface, which has a finish line in the form of a chamfer from the mesial and distal aspects (Fig. 6-67).

The taper of this type of preparation should be 2 degrees from the perpendicular, which allows for a tighter frictional grip of the casting to the tooth, and the axial line angles should be reduced sufficiently, which allows more room for the veneering material. If teeth with short or average sized coronal lengths are to be splinted, the preparations should be tapered 2 to 5 degrees from the perpendicular for ease of positioning and correct marginal fit of the restorations.

For teeth with lengthened clinical crowns and large open interdental embrasures, the aftermath of bone loss and periodontal treatment, the "chamferette" finish line is indicated (Fig. 6-68). In these cases, where a number of teeth have to be splinted to reduce mobility patterns, etc., the taper is at least 5 degrees from the perpendicular. This allows for ease of seating of the finished restoration, less chance of pulp involvement, and excellent marginal fit of castings, thereby avoiding the dreaded subgingival cement line.

The technique and instrumentation that are used in the preparation of teeth for full coverage will be considered now (Fig. 6-69).





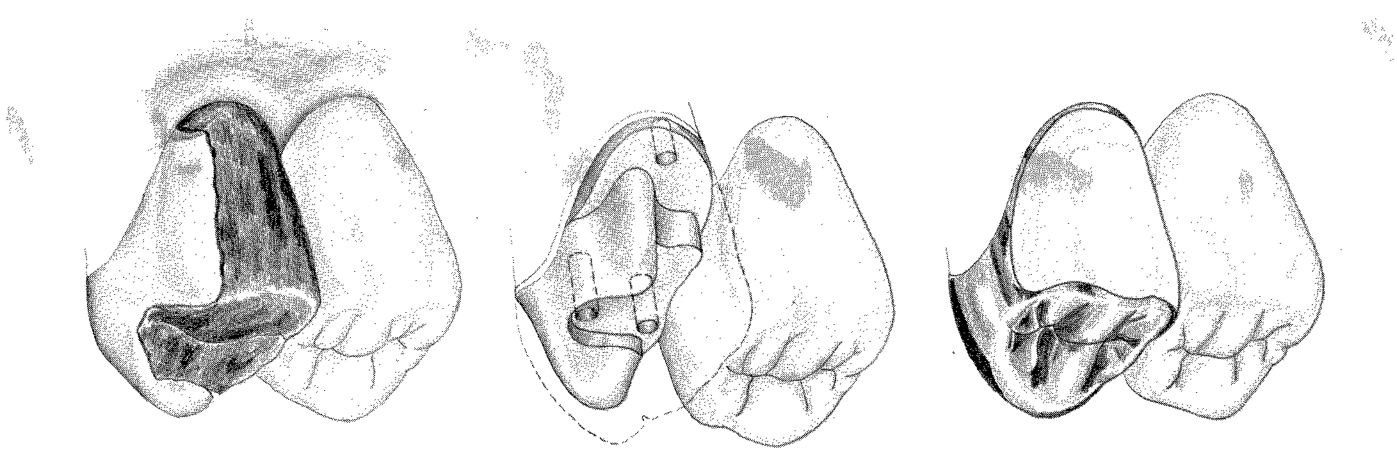


Fig. 6-67. Beveled-shoulder marginal finish line gradually fades into chamfer finish line as it approaches lingual surface.

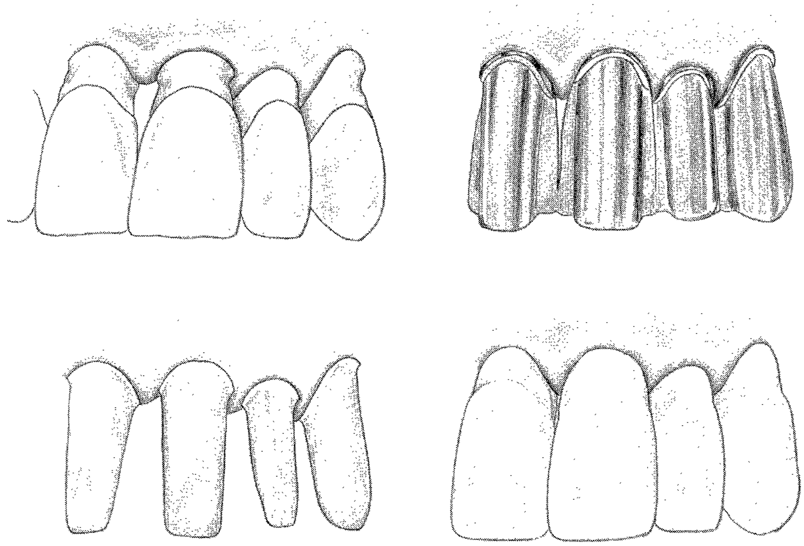


Fig. 6-68. "Chamferette" finish line indicated with lengthened clinical crowns and large open interdental embrasures. (Suggested by Dr. R. A. McEwen, Atlanta, Ga.)

Fig. 6-69. Types of diamond points that I use.

The incisal area is reduced, as a rule, about 2 mm. following the lingual plane at a 45-degree angle to the long axis of the tooth. In the lower anterior teeth the incisal plane is inclined toward the labial surface (Fig. 6-70).

The general fundamentals of occlusal reduction are similar for both mandibular and maxillary posterior teeth. The occlusal architecture should be followed, making the occlusal cut in two planes, sloping from the height of the buccal and lingual cusps toward the central groove and following the inclines and slopes of the cusps, at the same time comparing with the opposing occlusion as we go along to gain a uniform reduction of the surfaces involved. We try for a replica of the original occlusal surface at a reduced level, creating sufficient clearance from articulating contacts in every direction, and thereby allowing for an adequate thickness of gold. (See Fig. 6-71.)

The proximal surfaces are reduced next, tapering slightly toward the occlusal surface.

The facial and lingual surfaces are then reduced with the cutting tool in a rapid, brushlike movement, starting at the distal surface and working gently and carefully in a mesial direction. This is done with an instrument running axially with the tooth, being sure to emphasize its action around the axial line angles to reduce them sufficiently and to round them off.

In average length or short teeth, when veneering material is to be used either in the form

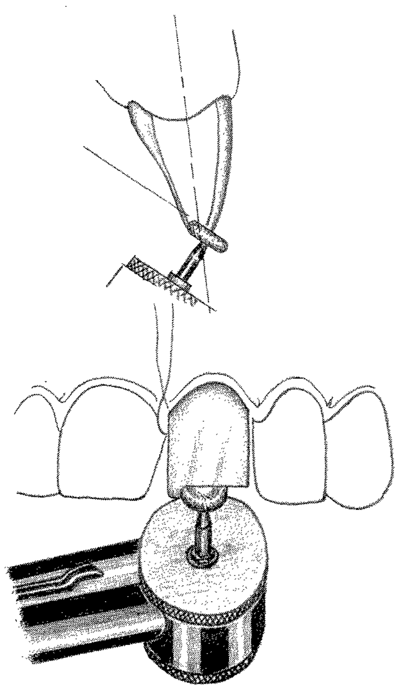


Fig. 6-70. Reduction of incisal area in full-coverage preparation.

A

B

C

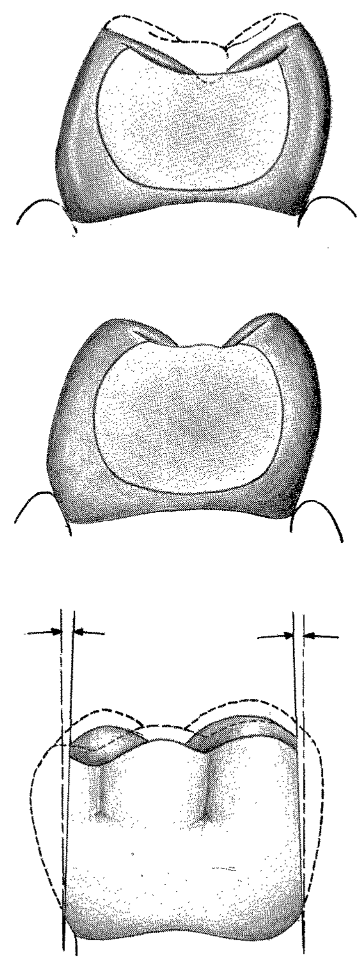


Fig. 6-71. A, Occlusal reduction of posterior teeth for full-coverage preparation. Occlusal architecture followed. **B,** Proximal surfaces reduced tapering slightly toward occlusal surface. **C,** Amount of taper in preparation for full coverage should be within the range of 2 to 5 degrees from the perpendicular. **D,** Procedural steps in preparation of a posterior tooth for full coverage.

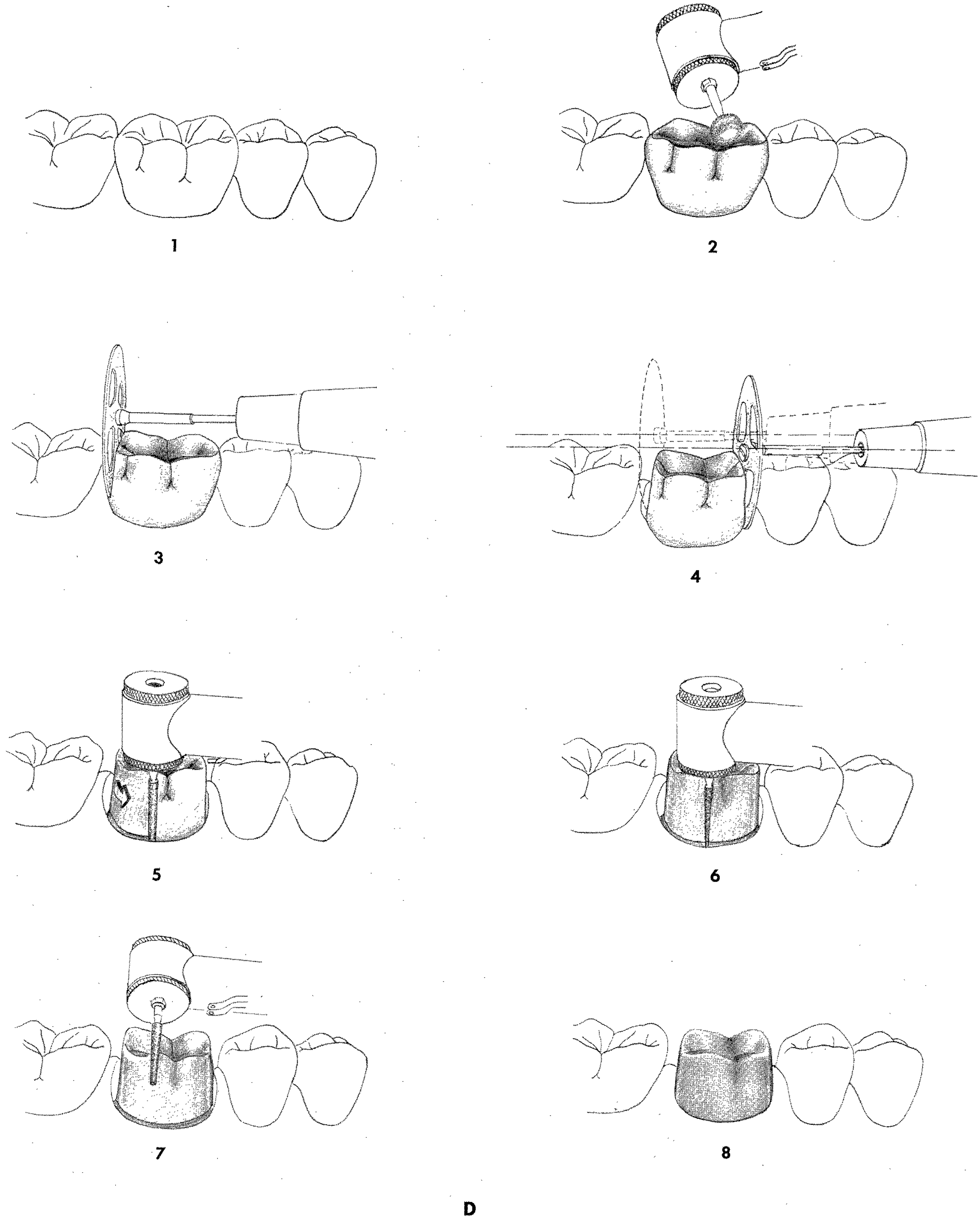


Fig. 6-71, cont'd. For legend see opposite page.

of a porcelain jacket crown or a cast veneer crown, a slight taper has not only been given to the tooth, but also a shoulder has been developed. Then the shoulder outline should be extended below the free margin of the gum and its definition and smoothness improved. If the cast veneer crown is the one being prepared, then the shoulder is beveled with a very fine flame-shaped diamond stone.

For teeth with lengthened clinical crowns, showing a bone loss, the facial and lingual surfaces are reduced with a diamond instrument, starting at the distal surface and working with rapid brushlike movements, in an axial direction, to the mesial surface, at the same time emphasizing its action around the axial line angles for sufficient reduction. A taper is given to the tooth, at the same time creating a chamfer finish line, which is extended under the free margin of the gum with a flame-shaped diamond point. The point of this instrument, when carried below the free gum margin, will produce a minimal cut, giving the "chamferette" finish line, whereas the wider portion of the instrument will engage that part of the tooth where maximal removal for correct taper and parallelism is required.

PREPARATION OF AN ANTERIOR TOOTH FOR A PORCELAIN JACKET CROWN

1. Break the contact areas with a very small flame-shaped diamond stone, No. 265-8P, making sure to avoid abrading the proximal surfaces of the adjacent teeth (Fig.6-72). A flat diamond disk, running at conventional lower speeds, can be used if desired. The mesial and distal slices, extending from the incisal surface to the gingiva, will establish slight interproximal shoulders (Fig. 6-73).

2. Reduce the incisal surface about 2 mm., following the lingual plane at a 45-degree angle to the long axis of the tooth (Fig. 6-74). In lower anterior teeth the incisal plane is inclined toward the labial surface (Fig. 6-75). All three cutting surfaces of Starlite No. 34P or 110SP are employed to undercut as well as reduce the incisal edge to a proper depth and to establish incisal bevel.

3. Reduce labial surface and area around the cingulum with a No. 556-7P or 558-7P, running the instrument axially with the tooth with rapid, light strokes in a brushlike manner (the labial and lingual enamel bulk also can be removed by using the rounded edge of No. 110SP) (Fig. 6-76). With a No. WM-1 or WM-2,

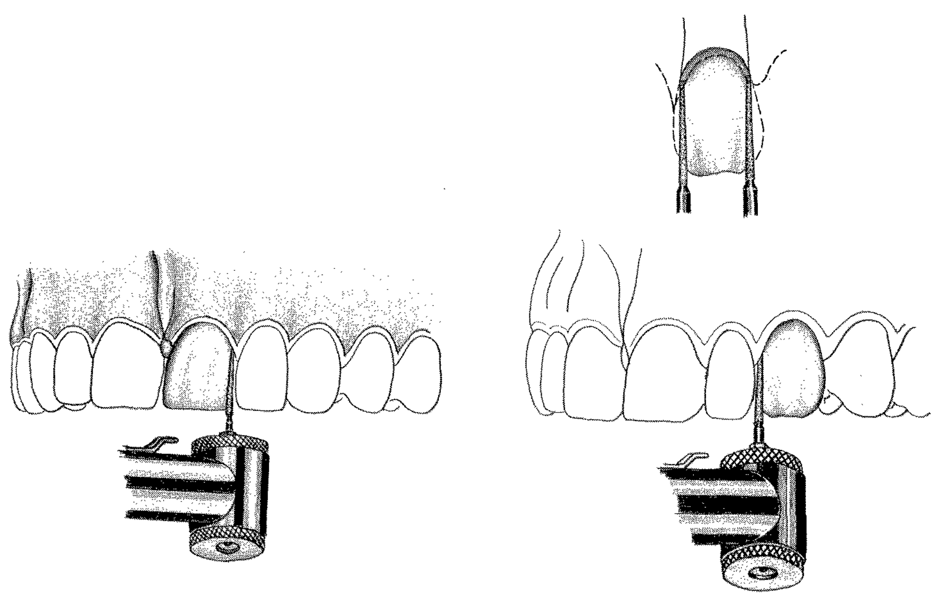


Fig. 6-72. Breaking contact area with small flame-shaped diamond stone in preparation of anterior tooth for porcelain jacket crown.

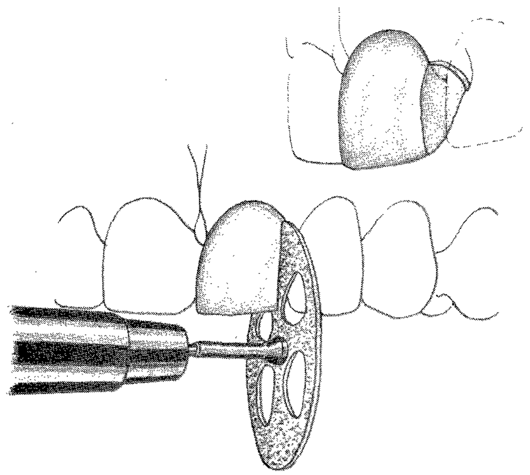


Fig. 6-73. Breaking the contact area with a disk (alternate method).

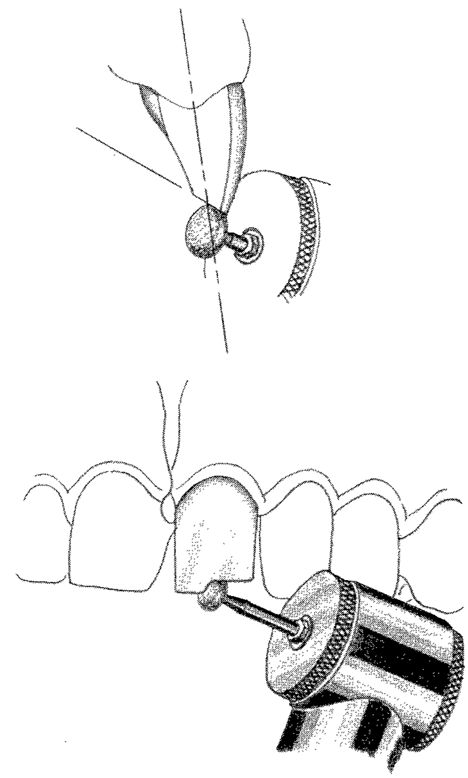


Fig. 6-74. Reduction of incisal surface following lingual plane at 45-degree angle to long axis of tooth.

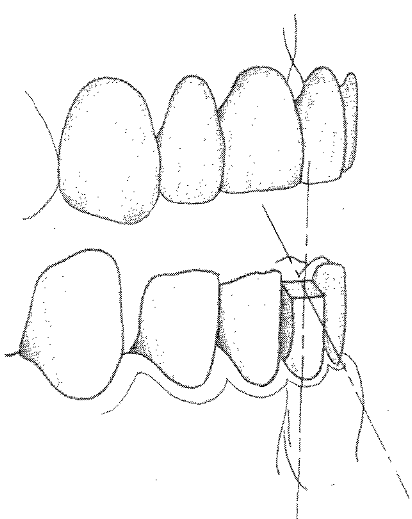


Fig. 6-75. In lower anterior teeth incisal plane is inclined toward labial surface.

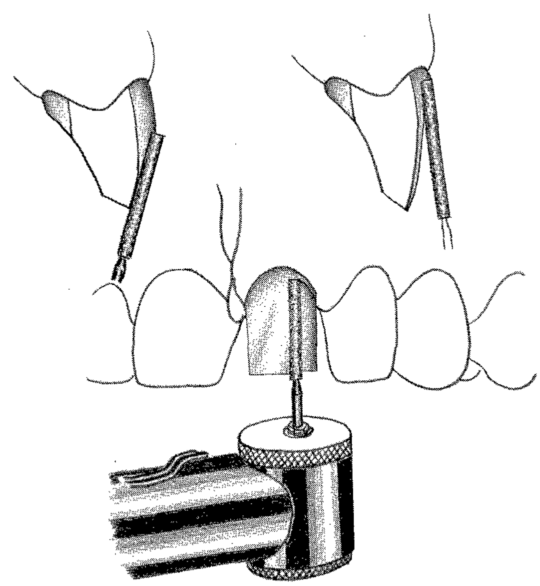


Fig. 6-76. Reduction of labial surface with No. 556-7P or 558-7P diamond stone. Labial and lingual enamel bulk also can be removed by using rounded edge of No. 110SP.

which is a special functionally shaped instrument, remove lingual tooth structure from the crest of the cingulum to the incisal edge by planing from proximal to proximal. This instrument will preserve the lingual concavity, assuring uniform removal of bulk, and it also assures an even thickness of porcelain in the finished crown (Fig. 6-77).

4. Follow with a No. 700-7P or 700-8P, which is a tapered diamond stone that is 0.8 mm. wide at its tip. This point establishes uniform depth, and the curvature of the cut is oriented to the curvature of the tissue. (At no time should we traumatize tissue.) Make the cut away from tissue, the diamond point first being tipped away to establish a shoulder and then angled parallel to the long axis of the tooth (Fig. 6-78). This imparts proper taper and establishes a shoulder of desired depth or thickness. (If a wider shoulder is desired, use No. 701-8P, which is 1.1 mm. wide at its tip.)

This instrument follows around from the labial surface to the mesial surface and then around the linguocingulum area to the distal proximal surface, creating an even width of shoulder automatically, which is required especially for a porcelain jacket crown.

5. The shoulder should be extended carefully below the free gum margin and developed fully with cutting tools used at conventional lower speeds (Fig. 6-79). This may be done with a No. 900 or 901 end-cutting bur, which can be used without danger of undercutting the axial walls of the preparation because its axial surface is smooth. The plane of the shoulder is squared and placed at right angles to the axial surfaces of the preparation, and the shoulder can be planed smooth by using a hoe (S.S.W.

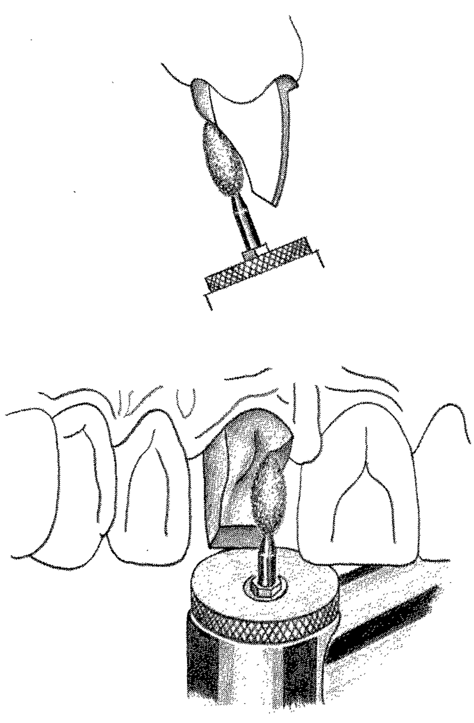


Fig. 6-77. Removal of lingual tooth structure from incisal edge to upper border of cingulum area with a special functionally shaped diamond instrument—No. WM-1 or WM-2.

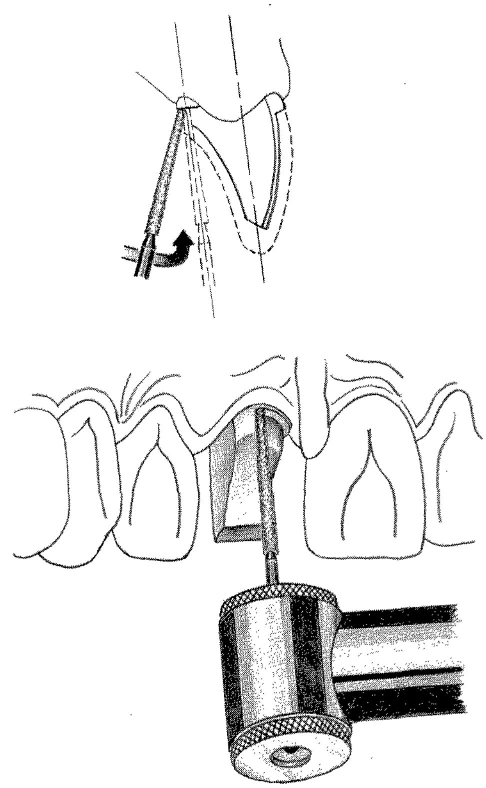


Fig. 6-78. Removal of tooth structure in cingulum area and creation of shoulder.

No. 6-2-6 or 8-3-6) and special Bastian or Krause files.

A shoulder that forms a slightly acute angle with the axial surface, thus transmitting the induced forces toward the interior of the tooth, gives us a most favorable condition. A shoulder that forms a right angle with the axial surface absorbs all the transmitted force, but a shoulder that forms an obtuse angle with the axial surface gives rise to a horizontal component of force, which is likely to cause fracture of the crown (Fig. 6-80).

The preparation is then treated with superfinishing diamond stones—No. 700-8F and No. WM-1F or WM-2F—after which it is carefully examined, using binocular loupes and a light stream of warm air, for undercuts or roughness (Figs. 6-81 and 6-82).

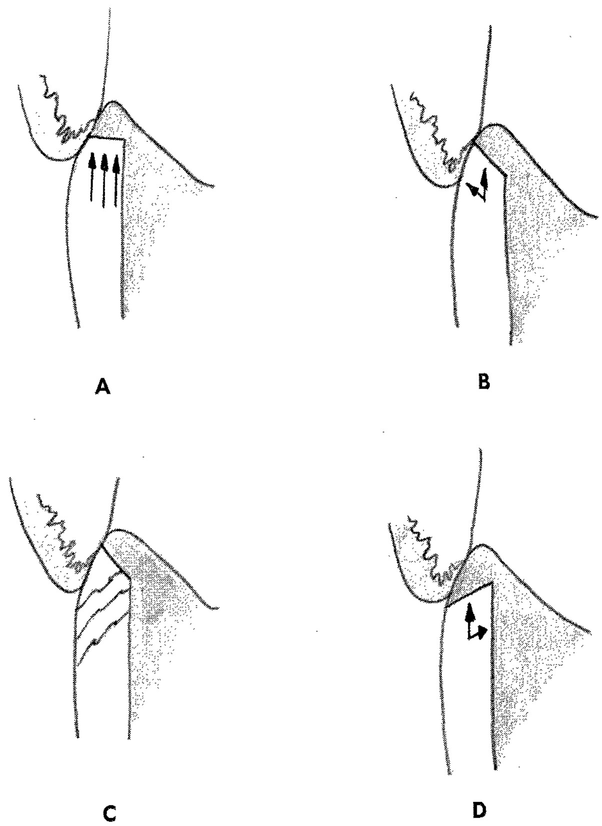


Fig. 6-80. **A,** Shoulder that forms right angle with axial surface absorbs all the transmitted force. **B,** Shoulder forming an obtuse angle gives rise to horizontal component of force, which is likely to cause fracture of crown, as in **C.** **D,** Most favorable condition exists when shoulder forms slightly acute angle with axial surface, thus transmitting induced forces toward interior of tooth. (Redrawn from Conod, H. In Grubb, H. D.: Basic procedures essential for successful porcelain restorations, Proceedings of the Dental Centenary Celebration, 1940.)

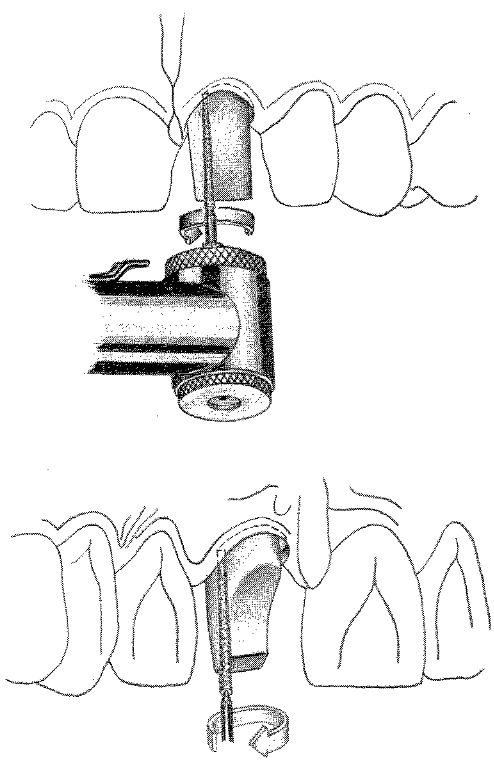


Fig. 6-79. Extending shoulder below free gum margin—developed with cutting tools used at conventional lower speeds (stones, end-cutting burs, etc.).

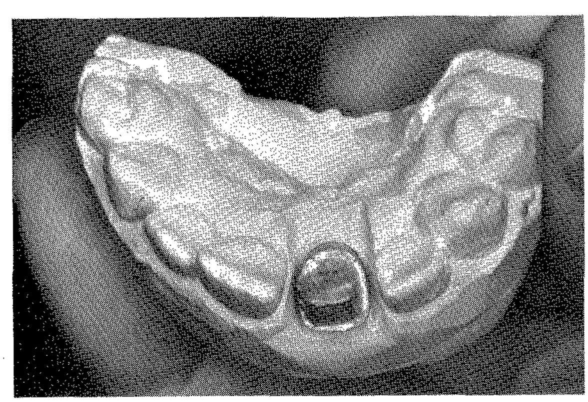


Fig. 6-81. Die of completed preparation from practice.

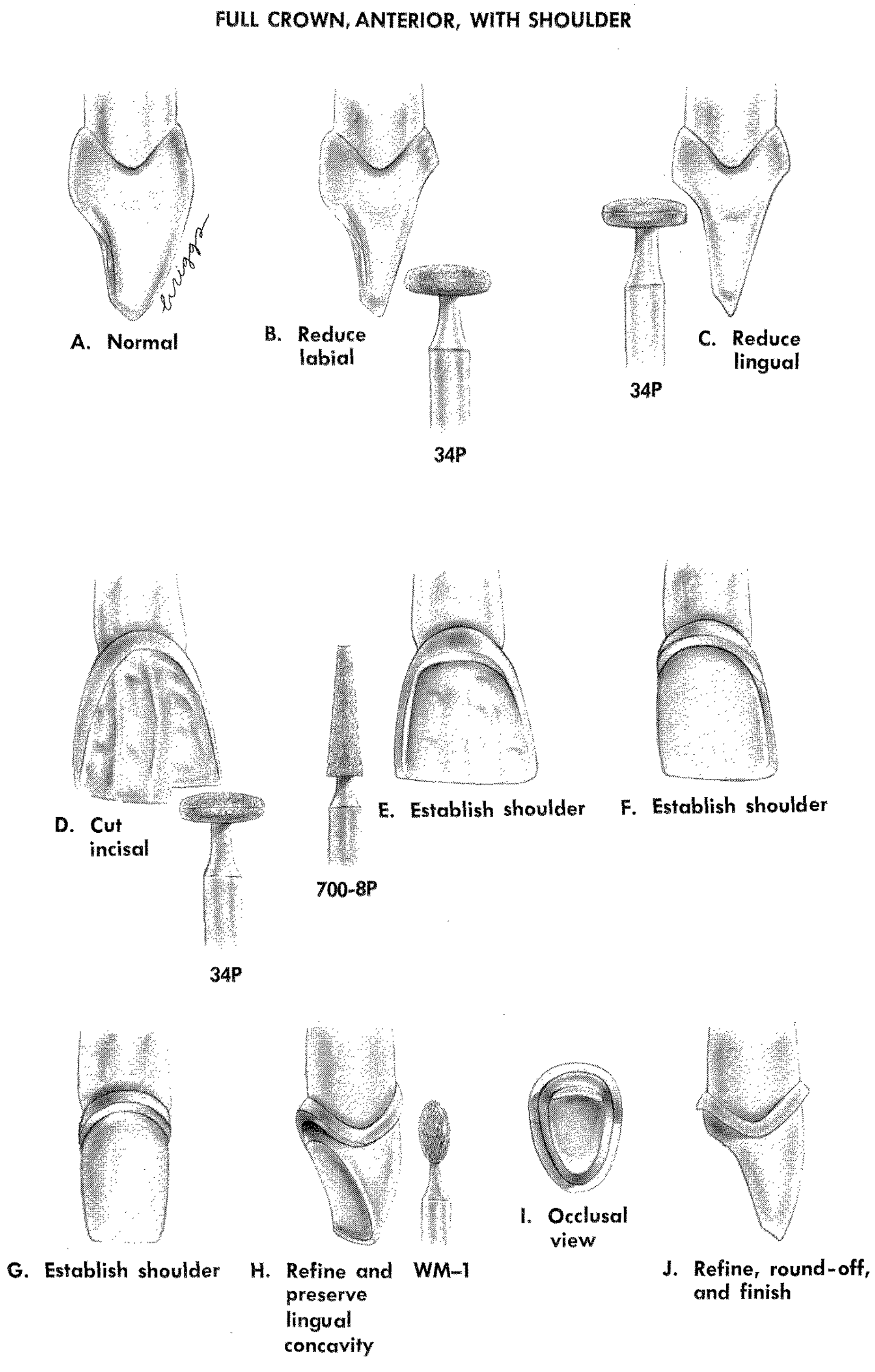


Fig. 6-82. Procedural steps in preparation of anterior tooth for porcelain jacket crown.

PREPARATION OF AN ANTERIOR OR POSTERIOR TOOTH FOR A CAST VENEER CROWN

1. Break the contact areas with a very small flame-shaped stone No. 265-8P, making sure to avoid abrading the proximal surfaces of the adjacent teeth. McEwen[11] accomplishes this by following the contour of the proximal surface of the adjacent tooth, creating a concavity and then establishing the proper taper to the preparation. A flat diamond disk, running at conventional lower speeds, can be used if desired. The mesial and distal slices, extending from the incisal edge to the gingiva, will establish slight interproximal shoulders.

For posterior teeth the mesial surface is reduced, using a straight safeside diamond disk from the occlusal surface to the gingiva, and a cup-shaped diamond disk is used for the distal surface reduction.

2. All three cutting surfaces of No. 110SP are employed to undercut as well as reduce incisal edge to proper depth and to establish incisal bevel.

For posterior teeth reduce occlusal surface with No. 110SP, removing enamel into dentin, following the occlusal architecture. Make the occlusal cut in two planes—sloping from the height of the buccal and lingual cusps toward the central groove and following the inclines and slopes of the cusps.

3. Facial gross enamel reduction just into the dentin is accomplished with No. 556-7P or 558-7P or with the rounded edge of No. 110SP, moving the stone in an axial relation to the tooth with rapid, light strokes in a brushlike manner.

Gross lingual enamel reduction of posterior teeth and the cingulum area of anterior teeth is reduced with No. 556-7P or 558-7P or with the rounded edge of No. 110SP.

With a No. WM-1 or WM-2, which is a special, functionally shaped stone, remove lingual tooth structure of anterior teeth from the crest of the cingulum to the incisal edge by planing from proximal to proximal surface. This instrument will preserve lingual concavity, assuring uniform removal of bulk.

4. Follow this planing with a No. 700-7P or 700-8P, which is a tapered diamond stone 0.8 mm. wide at its tip. This point establishes uniform depth, and the curvature of the cut is oriented to the curvature of the tissue (instrument must not contact soft tissue).

Make the cut away from the soft tissue, the diamond point first being tipped away to establish shoulder and then being angled parallel to the long axis of the tooth. This imparts proper taper and establishes shoulder of desired depth or thickness. (If a wider shoulder is desired, use No. 701-8P, which is 1.1 mm. wide at the tip.)

This diamond stone is used on the facial surface and then is followed around from the facial surface to the mesial surface and from the facial surface to the distal surface, the shoulder preparation gradually fading out proximally to the shoulderless lingual surface.

The linguocingulum area of anterior teeth and the lingual surface of posterior teeth are then tapered with No. 770-7P or 770-8P. The lingual finish line in these cases can be featheredge or a slight chamfer.

5. Refine shoulders and axial line angles

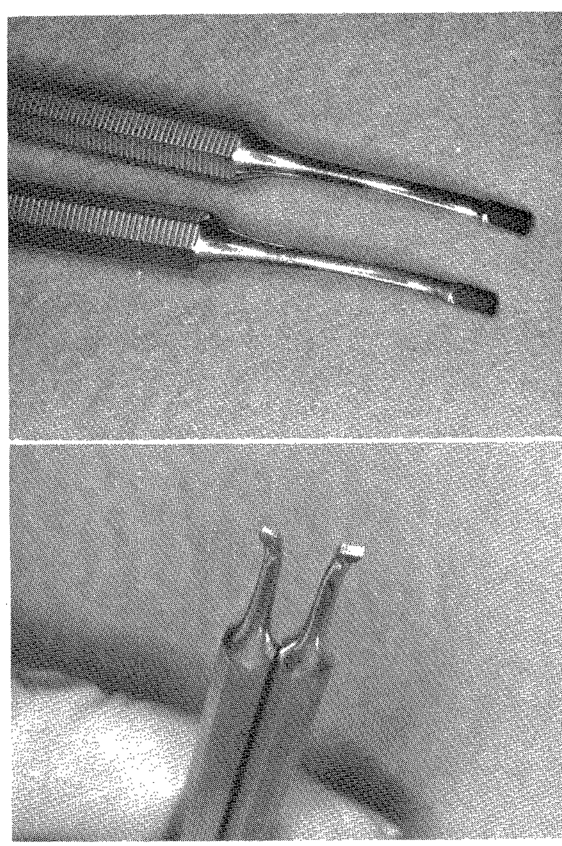


Fig. 6-83. Bastian files used to plane shoulder smooth.

using No. 700-8F, a superfinishing diamond stone. Use No. WM-1F or WM-2F to finish or smooth lingual concavity above crest of cingulum of anterior teeth, and use No. 103SP to round or bevel occlusal line angles of posterior teeth and to establish buccal and lingual grooves.

6. The facial, mesial, and distal shoulder should be extended carefully below the free gum margin and developed fully with cutting tools used at conventional lower speeds. This may be done with a No. 957 or 958 end-cutting bur, which can be used without danger of undercutting the axial walls of the preparation because its axial surface is smooth. The plane of the shoulder is squared and placed at right angles to the axial surfaces of the preparation, and the shoulder can be planed smooth by using a hoe (S.S.W. No. 6-2-6 or 8-3-6) and special Bastian or Krause files (Fig. 6-83).

7. The preparation is completed with a beveling of the shoulder, using the tip of a small flame-shaped diamond point.

In cases in which short clinical crowns are present, increased retention may be obtained by introducing accessory anchorage, grooves and pits, in accordance with the principles of tripodism.

For the all-metal posterior crown use a chamfer marginal finish line.

PREPARATION OF ANTERIOR OR POSTERIOR TEETH WITH LENGTHENED CLINICAL CROWNS FOR CAST VENEER CROWNS

The following procedural steps are used in the preparation of teeth that have lost a great deal of supporting bone for cast veneer crowns:

1. Break the contact areas with a very small flame-shaped stone, No. 265-8P (Fig. 6-84). (See also Fig. 6-85.)

2. All three cutting surfaces of No. 110SP are employed to undercut as well as reduce incisal edge to proper depth and to establish incisal bevel (Fig. 6-85, *D*.)

For posterior teeth reduce occlusal surface with No. 110SP, removing enamel into dentin, following the occlusal architecture. Make the occlusal cut in two planes—sloping from the height of the buccal and lingual cusps toward the central groove and following the inclines and slopes of the cusps (Fig. 6-91, *D*).

3. Facial gross enamel reduction just into dentin is accomplished with the rounded edge of Starlite No. 110SP (Fig. 6-86). Move the handpiece from the incisal or occlusal edge to the gingival edge with short, rapid, light strokes. Continue the use of No. 110SP for bulk lingual reduction of posterior teeth and the cingulum area of anterior teeth (Fig. 6-85, *C*). With a No. WM-1 or WM-2 (Fig. 6-87), which is a special, functionally shaped stone, remove lingual tooth structure of anterior teeth from the crest of the cingulum to the incisal edge by planing from proximal to proximal surface. This instrument will preserve lingual concavity, assuring uniform removal of bulk.

4. Beginning at facial gingival line with a No. 770-7P stone, penetrate to width of instrument (0.8 mm. wide at tip, and tip is rounded), creating chamfer at gingiva. Then begin to establish taper of preparation by holding diamond stone parallel to long axis of tooth. Carry stone around interproximally and lingually. Continue to refine taper of tooth and chamfer and to contour it into bifurcation and trifurcation areas where indicated.

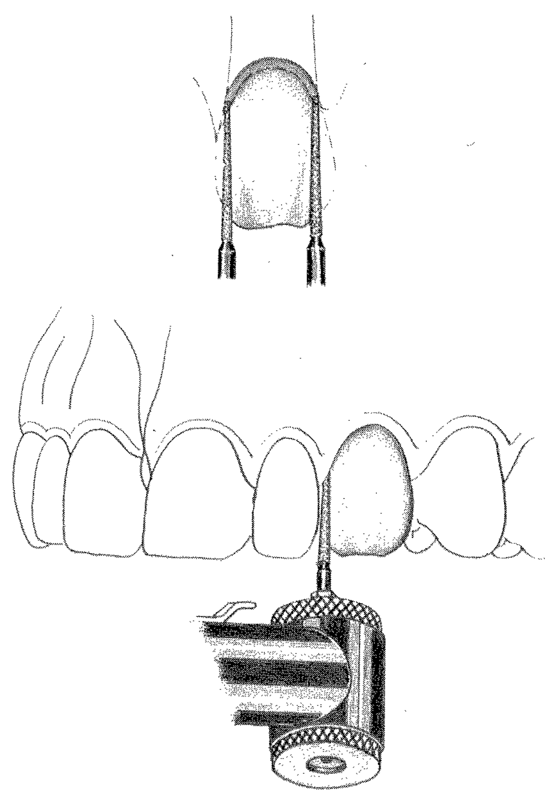


Fig. 6-84. Break contact areas with flame-shaped diamond stone.

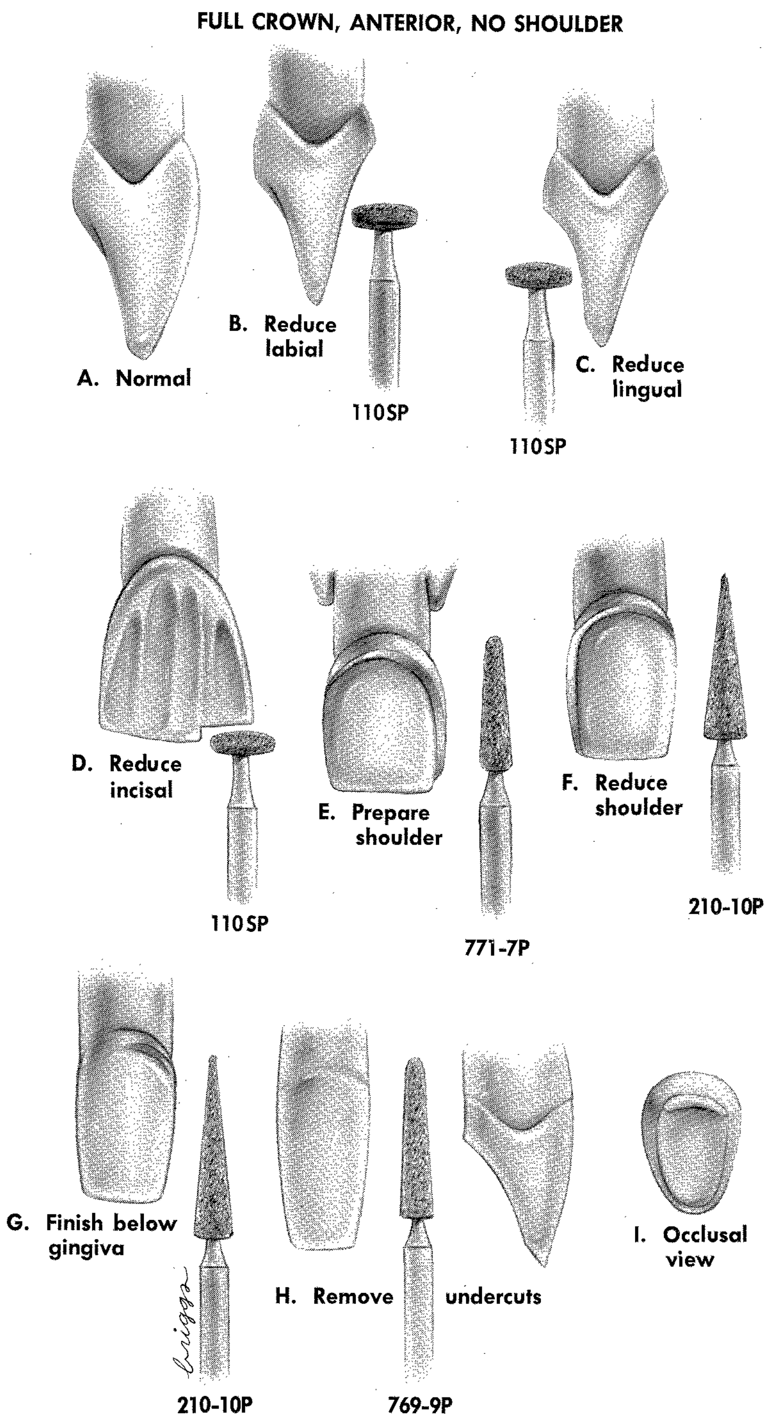


Fig. 6-85. Procedural steps in preparation of anterior tooth with lengthened clinical crown for cast veneer restoration.

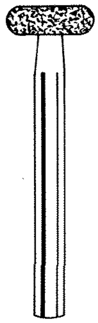


Fig. 6-86. Diamond point No. 110SP.

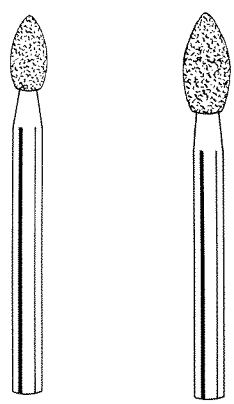


Fig. 6-87. Starlite No. WM-1 or WM-2—special, functionally shaped stone for removal of lingual tooth structure.

Fig. 6-89. Cutting instrument (No. 210-10P) used for subgingival extension—narrows chamfer slightly and carries preparation onto root surface. Functional taper of this diamond stone imparts proper taper to preparation and removes undercuts.

For a tooth with a longer clinical crown, select a diamond stone with a longer cutting head, No. 770-8P or 10P (No. 771-7P will inscribe more deeply than No. 770-7P). In other words, choose the cutting length of this instrument to agree with the length and accessibility of the tooth (Fig. 6-88).

5. With a No. 210-10P stone, placing the tip of this instrument carefully under the tissue, begin subgingival extension, narrowing chamfer slightly and carrying preparation onto the root surface. Only the tissue adjacent to the tooth is touched at this time (Fig. 6-85, *F*).

6. Continue subgingival extension, using same No. 210-10P stone (Fig. 6-89). The functional taper of this diamond stone imparts proper

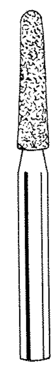


Fig. 6-88. Diamond instrument (Nos. 770-8P and 771-8P or 770-10P and 771-10P) used to create chamfer at gingiva and taper to preparation both facially and lingually.

Fig. 6-90. Diamond point No. 769-9P for final finishing of preparation. Rounds axial line angles, establishes finishing line, and refines occlusal contours. Follow this procedure with stone No. 769-9F (superfinishing diamond stone) to remove striations, rough areas, and smooth all surfaces.

taper to the preparation. Also, this instrument will remove undercuts at this time (Fig. 6-85, *G*).

7. Use diamond point No. 769-9P (Fig. 6-90), which does the most delicate and least amount of reduction, for the final finishing. It establishes the finishing line subgingivally, the "chamferette", rounds the axial line angles, and refines occlusal contours. Follow with No. 769-9F, which is a superfinishing diamond stone, to remove striations, rough areas, and smooth all surfaces (Fig. 6-85, *H*). (See also Fig. 6-91.)

Upon completion of crown preparation a careful rotary curettage of existing pockets is executed. Minker[12] uses the diamond point No. 769-9P for soft tissue curettage when needed. Using an abundant stream of water, the dentist slightly tilts the instrument against the tissue and moves it around the tooth, removing the epithelial lining of the pocket.

FULL CROWN, LOWER MOLAR, NO SHOULDER

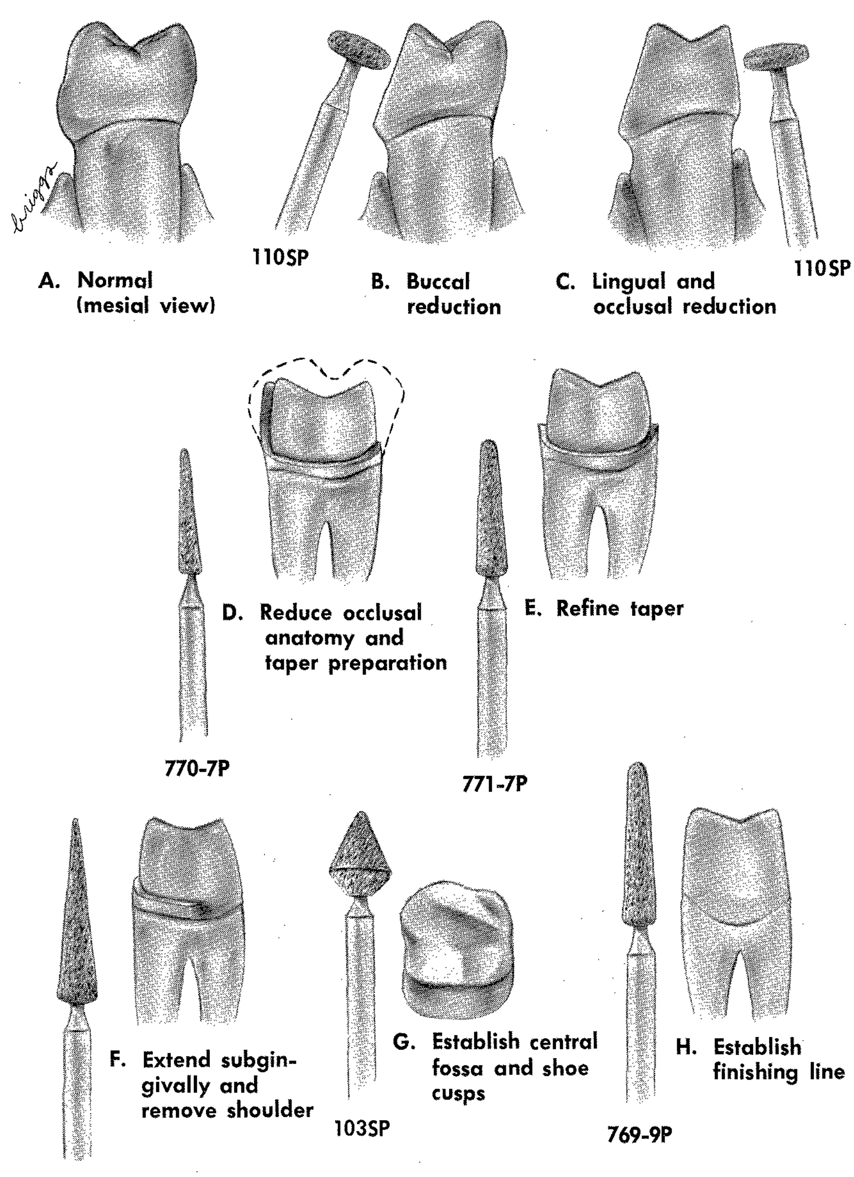


Fig. 6-91. Various steps in preparation of posterior tooth with lengthened clinical crown for cast veneer restoration.

Salient facts

For expediency the teeth should be prepared in quadrants, using the necessary instruments in sequence for efficiency in tooth structure reduction, finishing completely with one cutting tool before changing to another.

Remember how the finished preparations should appear when coupled with any necessary, modified relationship to the plane of occlusion, curve of Spee, etc.

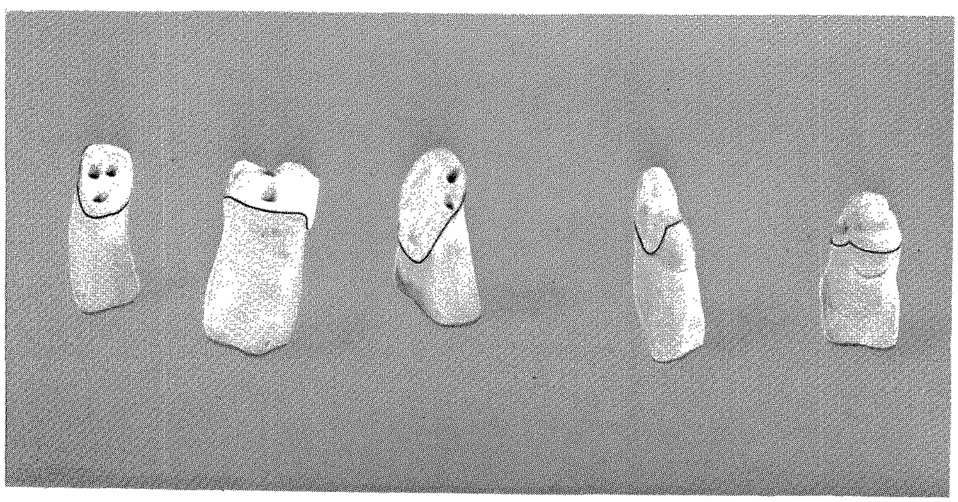
When it is judged that the teeth have been adequately prepared, dry each area with a warm-air syringe, which will also reflect the gingival tissue, and subject it to a critical inspection for (1) length and parallelism of walls, pins, and grooves, (2) absence of undercuts, (3) smoothness of walls and margins, and (4) delineation of marginal finish lines. Also recheck clearance in centric position and eccentric excursions. Binocular loupes should be used during this inspection.

Avoid the use of strong drugs, and make use of liners or bases to protect the pulp from irritating restorative materials.

Cover the teeth immediately following preparation: this allows the pulps to recuperate from the trauma and irritation of the preparation.

Preparations must be made so as to accept a completed restoration and meet the requirements of good form and function. (See Figs. 6-92 to 6-100.)

Fig. 6-92. Use of half-crown on an upper second molar.



A B C D E

Fig. 6-93. A group of preparations made from previously prepared and badly decayed and broken-down teeth. **A,** Pinledge with concavity on distal surface for establishment of contact area. **B,** Short coronal surface necessitating accessory anchorage. **C,** Treatment of distal-incisal preparation of cuspid with badly broken-down distal surface. **D** and **E,** M.O.D. onlay on upper and lower bicuspids (note treatment of buccal surfaces by pencil outlines).

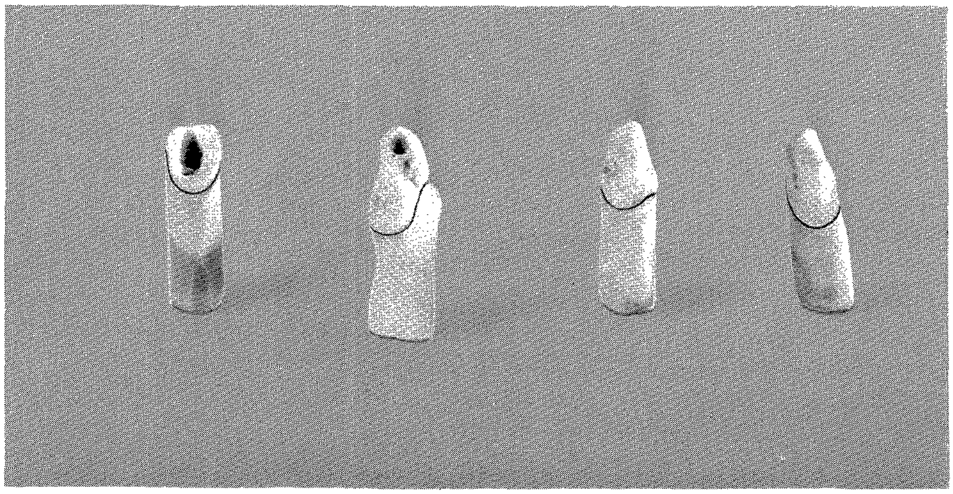


Fig. 6-94. Preparations showing treatment of previously prepared and decayed teeth. **A,** Treatment of tooth for post-anchorage support. **B,** Use of auxillary pin in full coverage with fractured lingual wall. **C** and **D,** Treatment of carious and previously prepared teeth for full coverage.

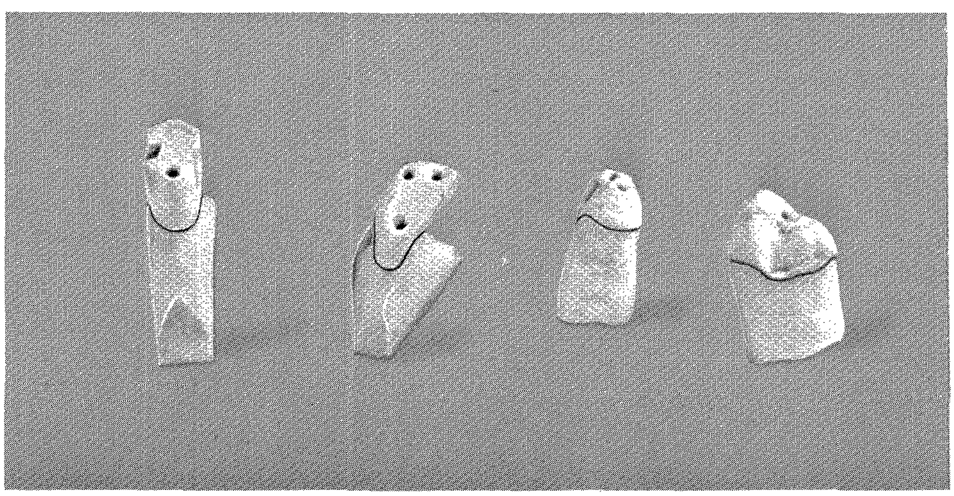
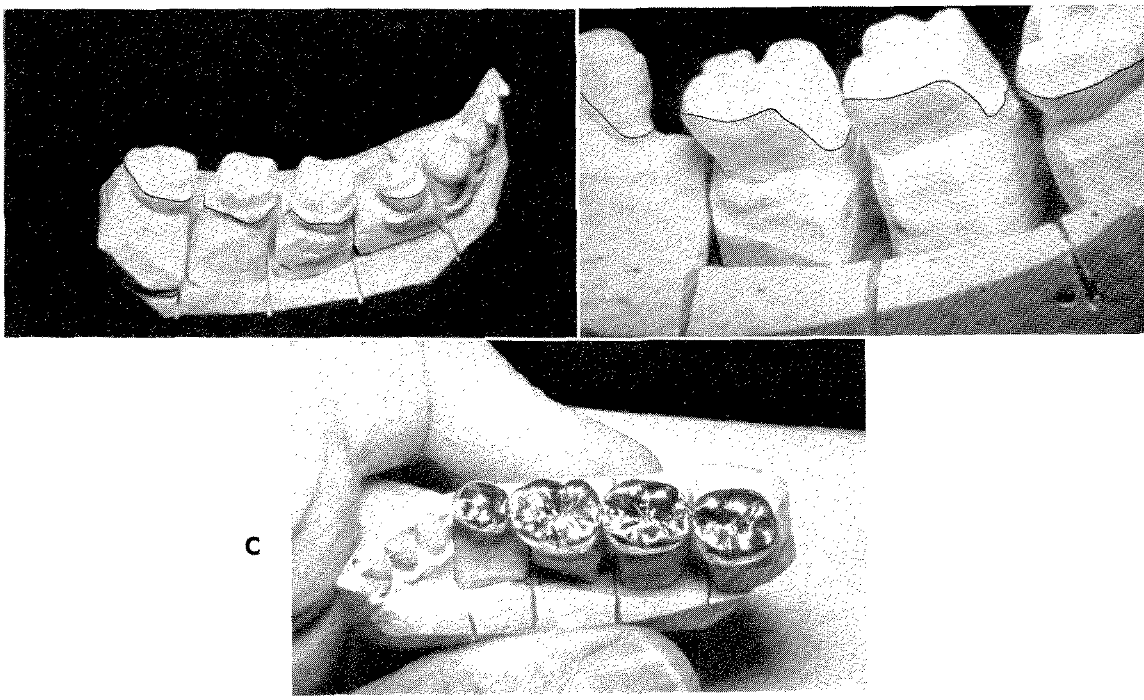
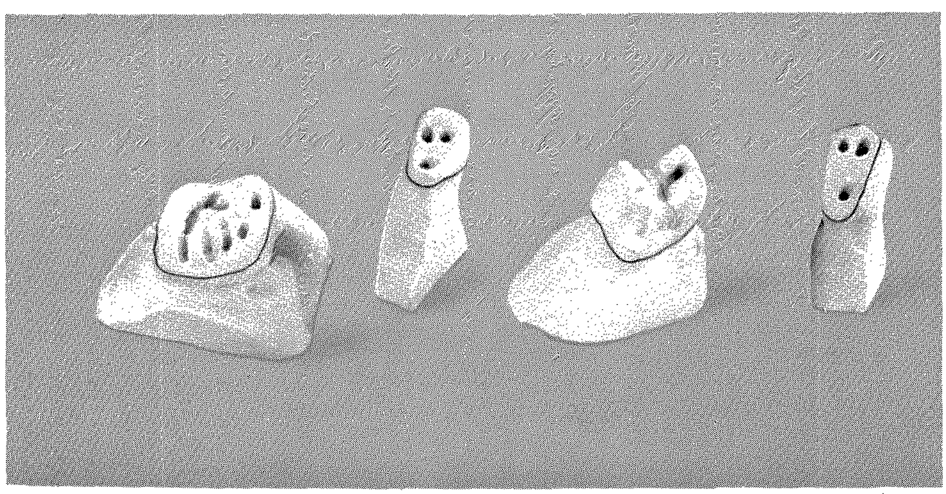


Fig. 6-95. Preparations made from previously filled teeth. **A,** Use of lock groove and auxillary pin in three-quarter crown preparation. **B,** Shallow groove (distal) and pinholes for modified pinledge preparation for restoration of correct contact area. **C** and **D,** Use of groove-pin accessory anchorage in short and broken-down teeth for full coverage.



A B C

Fig. 6-96. Modified onlay preparations. **A,** Buccal view. **B,** Lingual view. **C,** Occlusal view of castings.



A B C D

Fig. 6-97. Some atypical preparations. **A,** Use of pin and groove retention for modified onlay. Carious areas sometimes lend themselves to placement of these grooves and pins for added retention without encroachment on pulp. **B** and **D,** Pinledge preparations for establishment of correct contact area and for corrective purposes in occlusal reconstruction. **C,** Three-quarter crown preparation with accessory anchorage.

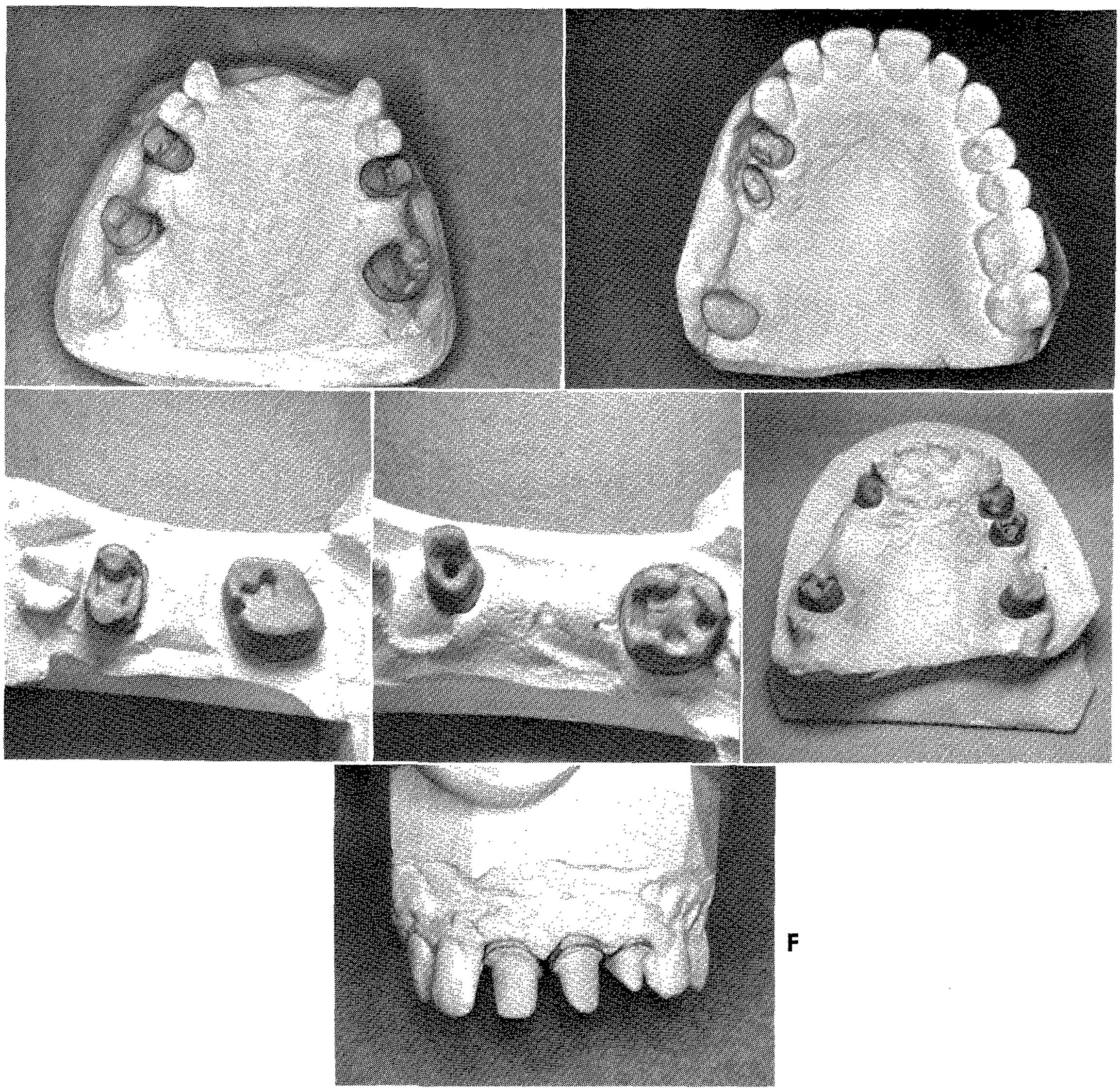


Fig. 6-98. **A,** Caries and "old" fillings necessitate various modifications in preparation of teeth for three-quarter crown retainer. **B,** Rotated teeth require establishment of enough shoulder for proper coronal form and solder joint to avoid impinging upon interdental papilla. **C** to **E,** Showing treatment of teeth (preparations) requiring onlay, post-anchorage, and full coverage. **F,** In preparation of teeth for veneer crowns create ample shoulder facially and interproximally to midline.

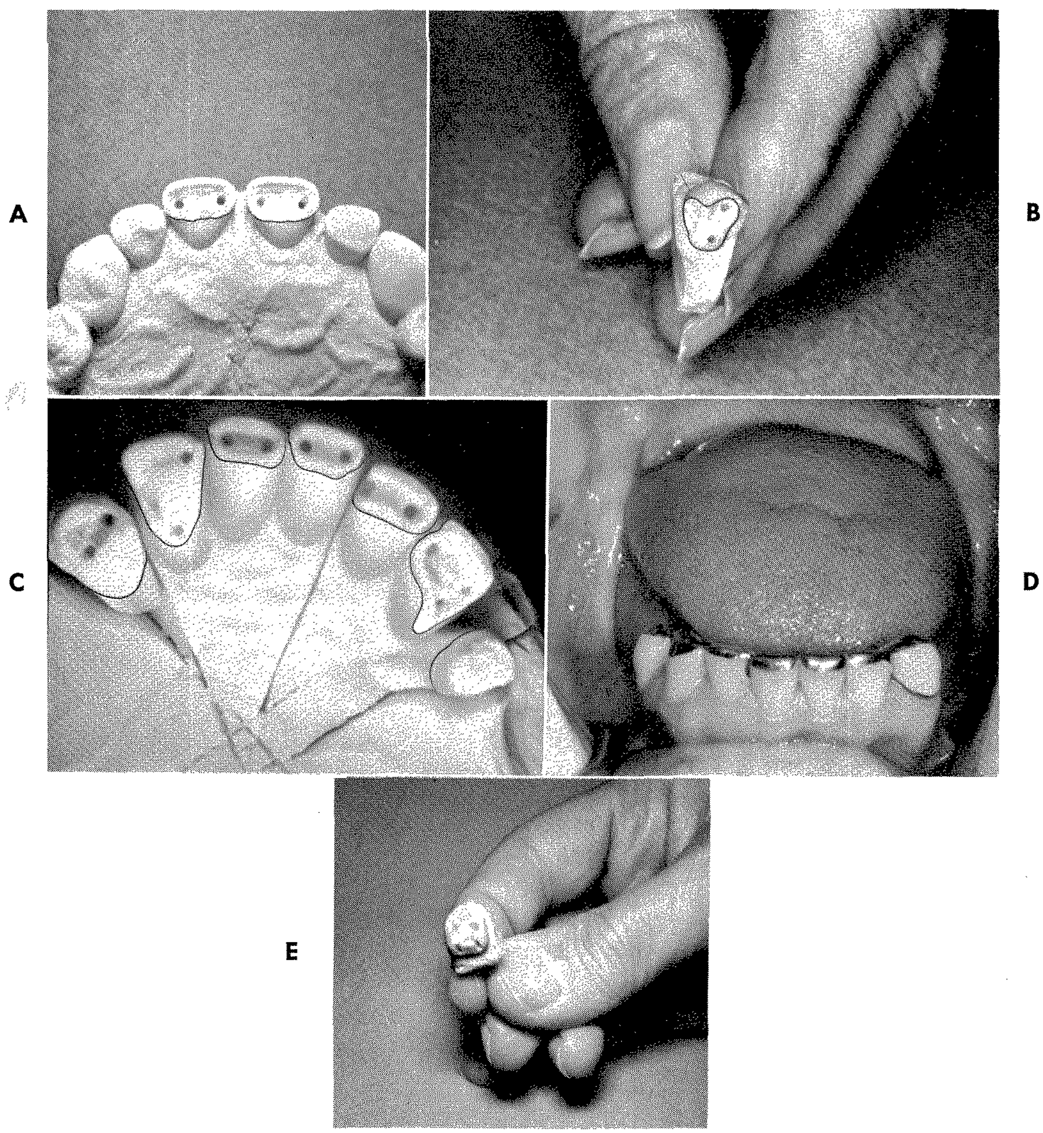


Fig. 6-99. A and B, Use of pin retention to gain resistance to displacement and avoid excessive tooth destruction. C, Pinlay preparations in lower anterior teeth and full coverage on bicuspids. D, Note double deflecting curvature on buccal veneer surfaces of bicuspids for maintenance of gingival health. E, Use of mesial lock grooves and occlusal pin anchorage for onlay on lower third molar.

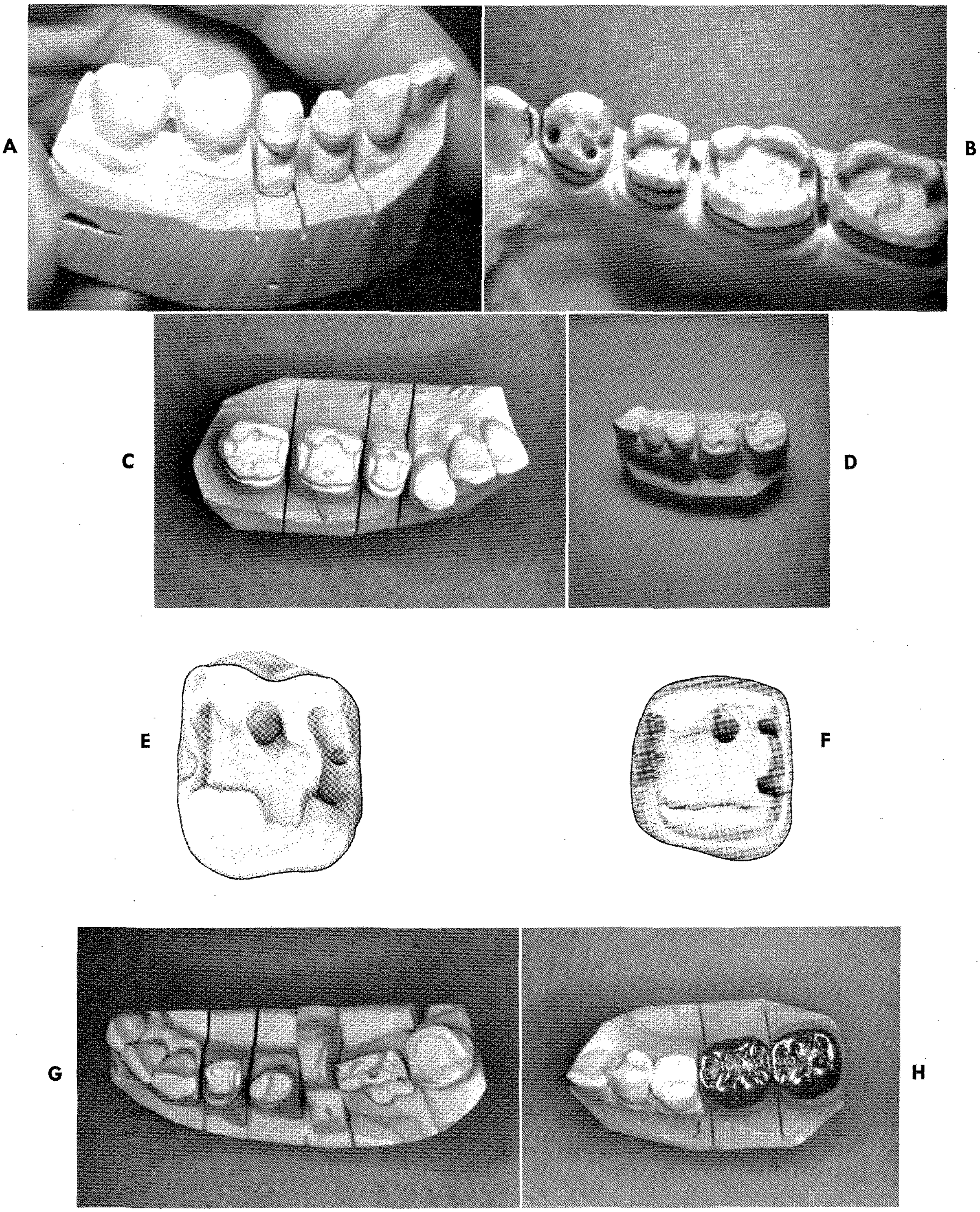


Fig. 6-100. **A** to **G,** Modified onlay preparations—every effort should be made to avoid need of restoring the cervical third. **H,** Occlusal view of castings for preparations, **D.**

REFERENCES

1. Keys, Donald A.: Effect of cavity and pattern design on structure, stress, strain and density of castings, J.A.D.A. **30**:1432-1437, 1943.
2. Fox, Lewis: Letters to the editor, Dent. Times **3**:6, 1961.
3. Weiss, Marvin B., Massler, Maury, and Spence, John M.: Operative effects on adult dental pulp, Dent. Progr. **4**:10-19, 1963.
4. Stein, R. Sheldon: Periodontal-prosthetic interrelationships. In Glickman, Irving: Clinical periodontology, Philadelphia, 1964, W. B. Saunders Co., p. 756.
5. Kilpatrick, Harold C.: Work simplification in dental practice, Philadelphia, 1964, W. B. Saunders Co.
6. Anderson, John A.: The selection and use of operator's stools and contour chairs, D. Clin N. Amer., pp. 303-318, July, 1965.
7. Willey, Robert E.: The preparation of abutments for veneer retainers, J.A.D.A. **53**:141-154, 1956.
8. Vale, W. A.: Abutment preparations for fixed bridgework, Dig. Dent. Sci. **2**:360-363, June, 1953.
9. White, Jesse D.: Personal communication.
10. Rosen, Harry: Operative procedures on mutilated endodontically treated teeth, J. Prosth. Dent. **11**:973-986, 1961.
11. McEwen, R. A.: Efficient restorative procedures, D. Clin. N. Amer., pp. 343-354, July, 1965.
12. Minker, Jules S.: Simplified full coverage preparations, D. Clin. N. Amer., pp. 355-372, July, 1965.

Chapter 7

Impressions; casts and dies

Impression materials

Several types of impressions are involved in the process of mouth rehabilitation. In this chapter impressions for the dentulous and the semidentulous as well as prepared teeth for the construction of microscopically accurate dies will be discussed.

A consideration of both the irreversible (alginate) and reversible (hydrocolloid) impression materials will be undertaken.

ALGINATES

Preparation of material for a full cast

The alginate gels used in the dental alginate impression materials change from the liquid, or sol, phase to the solid, or gel, phase as the result of a chemical reaction. Once gelation is completed the material cannot be reliquefied.

The alginate impression products have good elastic properties and compare well with the agar materials. Preparation for use requires only the mixing of measured quantities of water and powder (Fig. 7-1). Careful attention must be paid to the details of handling this type of material. The manufacturer's instructions should always be followed. The water-powder ratio and the temperature of the water must be observed. If this is done, the resulting mix will flow well and register fine surface detail accurately. Some manufacturers have this material available in small sealed packets containing a quantity suitable for one impression and ready for mixing with a measured quantity of water. In most instances this is the best method for greater accuracy.

The proper proportioning of the powder and water before mixing is critical if consistent results are to be obtained. Changes in the water-powder ratio will alter the consistency and setting times of the mixed material and also the strength and quality of the impression. The manufacturers usually provide suitable containers for proportioning the powder and water by volume, which are sufficiently accurate for clinical use.

The mix usually is made in a rubber bowl using a spatula having a broad and stiff blade (Fig. 7-2). The mixing time for the alginate materials is one minute, and it is most important that this should be timed since undermixing and overmixing are both detrimental to the strength of the set impression. The mix also can be made under vacuum.

The setting time of the alginate products is determined and established by the manufacturer. Variation in the temperature of the mixing water will give some modification and control of setting time. High temperatures speed the set, and low temperatures prolong the setting time. It is not advisable to use water that is cooler than 65° F., nor warmer than 75° F. *The temperature of the water is important. Do not attempt to modify the setting time of a given product to individual needs. Follow the manufacturer's instructions.*

The strength of the alginate type of materials is adequate if they are manipulated correctly. This requires spatulation for the correct time, correct water-powder ratio, and retention in the mouth for the recommended time after loss of

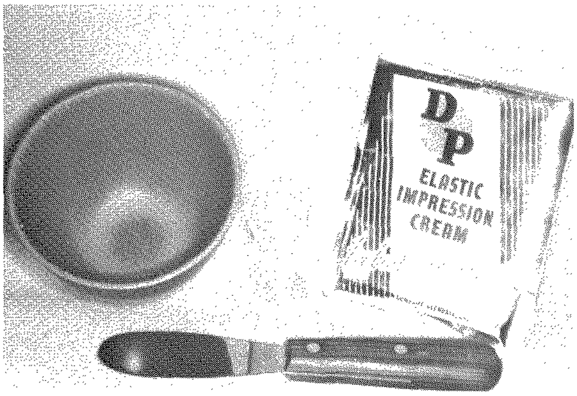


Fig. 7-1. Armamentarium and materials necessary for making an alginate impression.

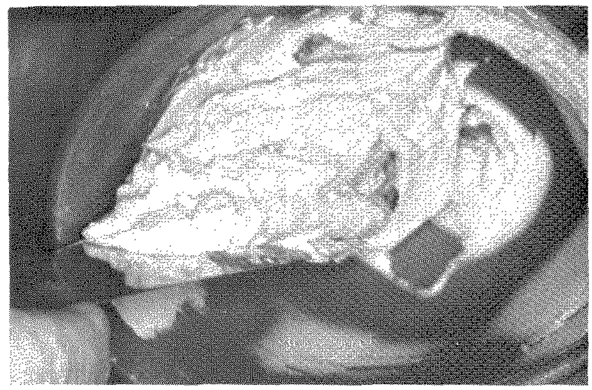


Fig. 7-2. Mix of alginate is made in rubber bowl using spatula with broad and stiff blade. Mixing time is exactly one minute.

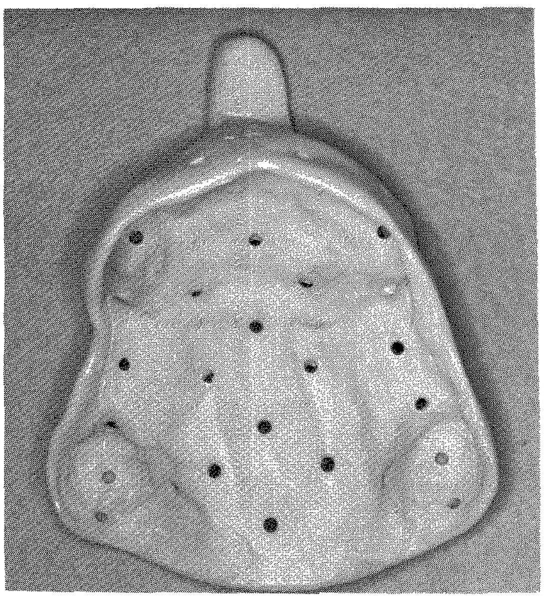


Fig. 7-3. Custom-made acrylic tray to accommodate arch size.

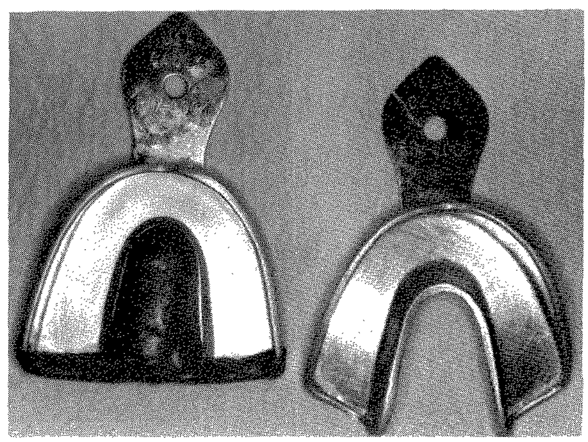


Fig. 7-4. Preparation of tray to confine material and create less bulk of material in vault area.

surface tackiness. Although the alginate materials have higher compressive strength values than does the agar type and are sufficiently elastic or flexible for all clinical purposes, they tear more readily in thin sections than do the agar hydrocolloids. The alginates recover well following compression or bending.

The impression tray should never be removed prematurely nor left in the mouth too long. It has been shown that if the impression is left in the mouth too long after gelation, a definite distortion results.

Preparation of impression tray for a full cast

In the taking of an accurate alginate impression one of the important problems encountered is the distortion that is caused by excessive deformation of the material in removing the jelled impression over deep undercuts. The greater the bulk of material and the smaller the percentage of deformation, that is required for removal, the less danger of distortion there will be in the finished impression. Therefore, a tray large enough to hold an adequate bulk of material and one that is rim-locked is necessary. In some instances impression trays have to be custom-made because of arch size, tooth positions, etc. (Fig. 7-3). These can be constructed of acrylic or cast aluminum.

It is important also to prevent the overseating of the impression tray and to prevent the tray from showing through the material. A palatal stop is made of wax or modeling compound in the vault of the upper tray to create less bulk of material in this area, and a post dam is placed across the posterior boundary to confine the material (Fig. 7-4).

The rim-locked lower tray, provided it is carefully positioned and as much room lingually as buccally is provided between the teeth and the tray, works well for the fully dentulous mouth. In the semidentulous mouth it usually is necessary to rim the periphery of the tray with a low-heat compound. The compound should not be carried down into the tray to fill the area between the tray and the teeth, or the compound placed in any area where there is a possibility of becoming locked into an undercut.

All these precautions prevent the overseating of the tray and the showing of the tray through the material and make proper confinement of the impression compound possible.

Technique for a full cast

The trays, having now been prepared for impression taking, are again tested by fitting them in the mouth. The impression material and other necessary equipment are checked for completeness and readiness.

The proper proportions of water and powder are placed in the bowl, and the material is mixed well for one minute. Then the tray is loaded carefully, avoiding the trapping of air (Fig. 7-5). The occlusal surfaces of the teeth are dried with a gentle blast of air, and a small amount of the alginate material is picked up with the finger and wiped over the occlusal surfaces of the teeth to prevent air from being trapped in the sulci and grooves (Fig. 7-6). Then the loaded tray is carried carefully to position and held passively and steadily for three minutes until gelation has taken place.

In removing the impression do not take hold of the handle and pull, but grasp the periphery of the tray on each side in the region of the premolars and remove with a quick, straight, vertical pull (Fig. 7-7). Never twist, rock, or

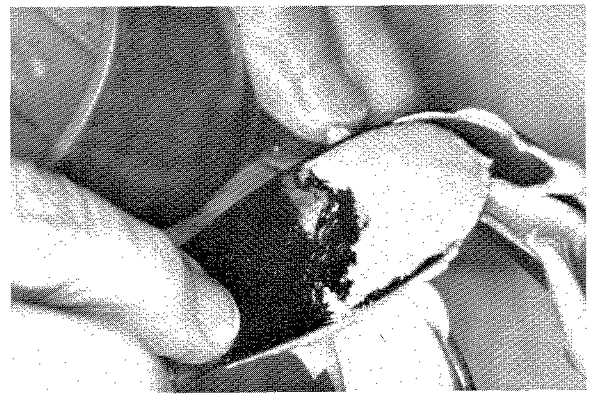


Fig. 7-5. Load tray carefully, avoiding trapping of air.

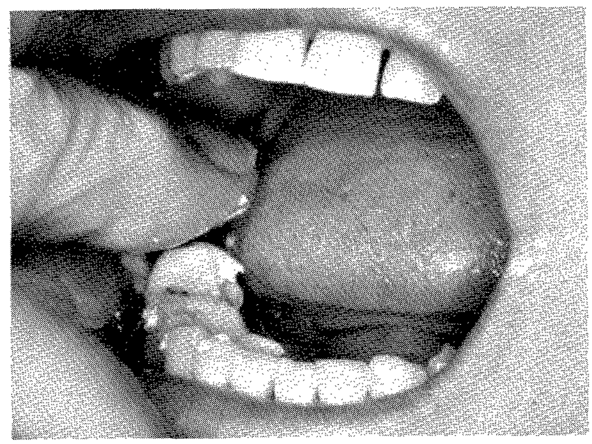


Fig. 7-6. After drying occlusal surfaces of teeth with gentle blast of air, wipe small amount of the alginate material over these surfaces, thereby preventing air from being trapped in sulci and grooves.

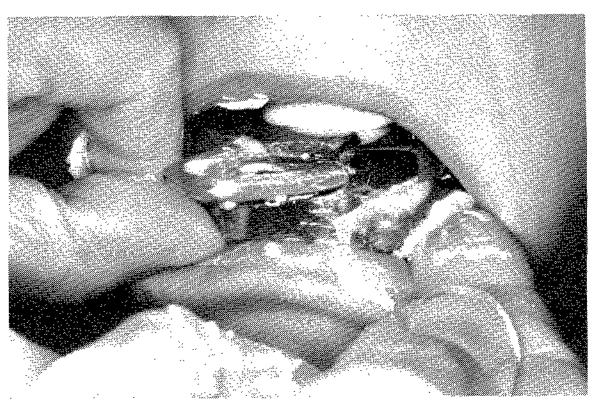


Fig. 7-7. In tray removal never grasp handle of tray and pull. Place finger on the periphery of the tray on each side in region of premolars and remove with rapid, vertical pull.

slowly remove an impression tray—it will cause distortion. (See Figs. 7-8 and 7-9.)

With the modern alginates control solutions are not necessary. The impression should be poured immediately, and, if for some reason it must be left for five to ten minutes before pouring, it is best stored in a humidor or wrapped in a wet towel.

Since the alginates lose water to the air on standing, they shrink, and impressions left on the bench for as short a time as thirty minutes may become inaccurate. If the impression is then placed in water, it will absorb moisture, but it does not return to its previous contours exactly—a smiliar phenomenon to that observed with the agar hydrocolloids.

Also, if the impression is left uncovered on the bench for a period of time, the alginate will lose moisture to the air and subsequently may absorb moisture from the surface of the stone during setting, with a detrimental effect on the surface quality of the cast.

The impression is rinsed well in cold water to remove saliva, and then all free water is eliminated before pouring the cast. If free water is left on the surface, it tends to accumulate in the deeper parts of the impression and to dilute the stone. Such areas on the cast are chalky and friable.

If ropy saliva is encountered, then a thin wash of plaster or stone is used for removal of this debris. A small amount of powdered stone,

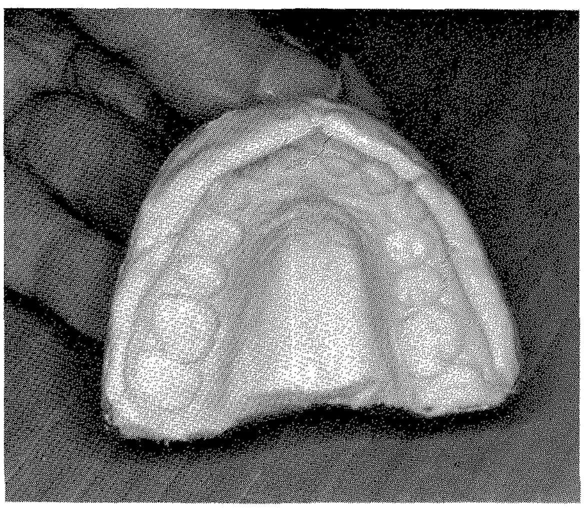


Fig. 7-8. Completed upper impression.

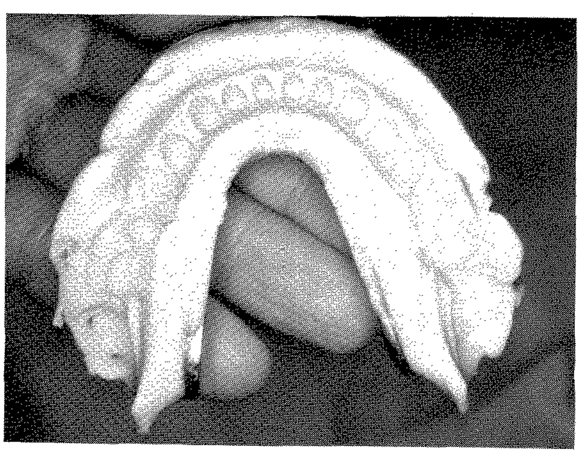


Fig. 7-9. Completed lower impression.

Figs. 7-10 to 7-14. Correct method of pouring stone into impression to make good cast.

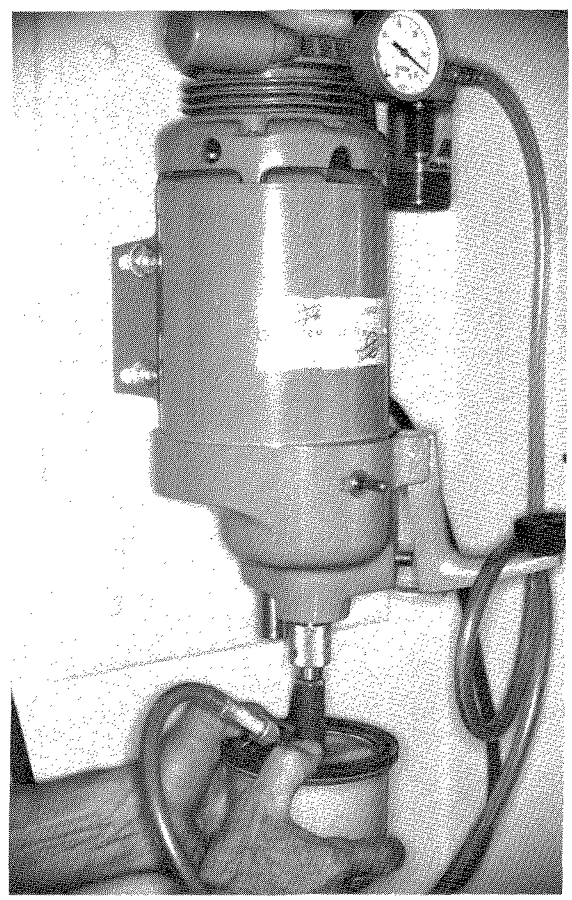
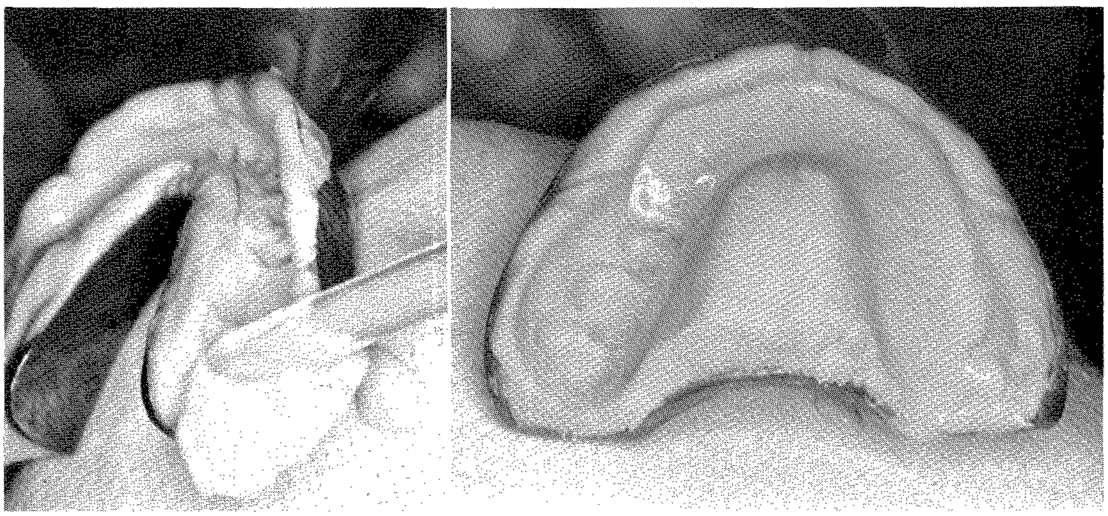


Fig. 7-10. Proper water-powder ratio and mechanical mixing.

the same as will be used for the cast, is placed in the impression, and the inside is scrubbed gently with a soft, wet brush to cut the saliva and debris and to produce a better cast. The impression then is washed out very carefully.

After the free moisture is removed with a gentle blast of air, the mixed stone, using the correct water-powder ratio, is poured into the impression and vibrated gently to eliminate air bubbles (Figs. 7-10 and 7-11). Never invert the poured impression onto a glass or plastic slab because the weight of the stone will pull it away from the impression (Fig. 7-12). (See also Figs. 7-13 and 7-14.)

A



B

Fig. 7-11. A, Gently vibrate impression material into impression to eliminate air bubbles, pouring stone at one end of impression and flowing it around to the other end. Pouring lower impression. **B,** Pouring upper impression.

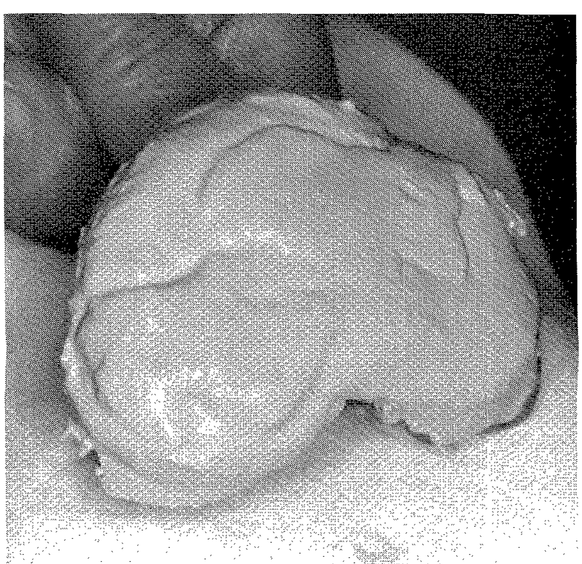


Fig. 7-12. Never invert poured impression onto a slab—weight of stone will pull it away from impression.

Fig. 7-13. A harder stone cast results if, after pouring mix into imprints proper, the remaining stone in bowl is partially dried by compressing in towel.

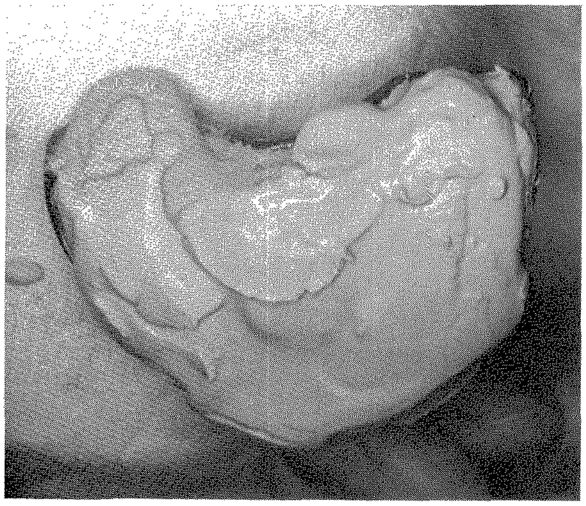


Fig. 7-14. Place compressed material on top of softer material in impression and lightly vibrate for few seconds to create union of the two parts.

Fig. 7-15. Poured impression in humidor (atmosphere of high relative humidity).

The poured impression should be placed in an atmosphere of high relative humidity. This is best achieved by the use of a humidor, but, when one is not available, the impression can be wrapped in a wet towel (Fig. 7-15).

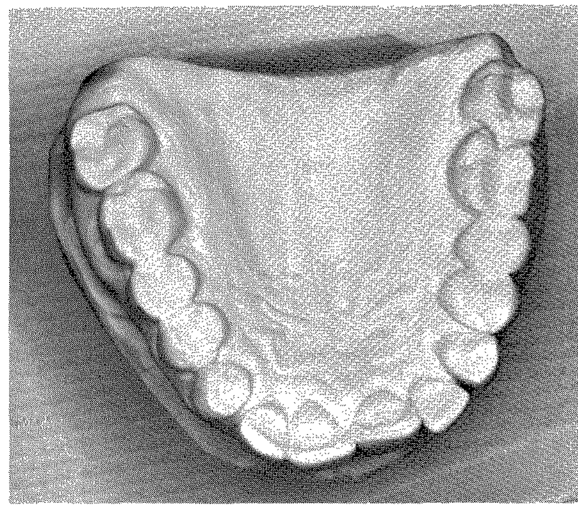


Fig. 7-16. Cast properly trimmed and debubblized.

After forty-five to sixty minutes the cast may be separated from the impression and trimmed to the desired shape (Fig. 7-16).

If the removal of gross undercuts in the first impression is feasible without any chance of distorting it or losing some important details, then it is possible to pour a second cast with fairly accurate results. This second cast can be used for preoperative wax-ups, construction of clutches, etc.

AGAR HYDROCOLLOIDS

When a standardized and sound procedure is followed, reversible hydrocolloid is unexcelled as an impression material. This material produces accurate results with a minimum of effort.

The problem involved in taking accurate hydrocolloid impressions is distortion that is caused by excessive deformation of the material in removing the jelled impression over deep undercuts. The danger of impression distortion upon removal can be minimized by using ample bulk of material and creating conditions that lessen the possibility of deformation.

Tray selection

A water-jacketed tray with no perforations should be used. A large enough impression tray should be selected so that an adequate bulk of material can be used, eliminating the possibility of deformation, especially in the molar areas.

The tray must be centered accurately so that the impression material on the buccal and lingual surfaces will be equal in amount, thereby avoiding distortion caused by the larger mass of material on one side shrinking more than the small mass on its opposite side. This particular problem sometimes necessitates the construction of custom-built acrylic or cast aluminum trays, allowing for the use of a minimal amount of impression material, equal in amount both buccally and lingually, thereby giving maximum accuracy.

The trays should be rim-locked to retain the material mechanically. It also is important to prevent the overseating of the tray and to prevent the tray from showing through the material.

In full upper mouth impressions with agar hydrocolloid a post dam should be used across the posterior boundary to prevent the material from flowing out of the back end of the tray, and the tray built up in the palatal area with modeling compound to ensure a uniform thickness of material. These procedures not only confine the material to the tray, but also prevent movement and distortion during the gelation period (Fig. 7-17). It prevents overseating of the tray and the possibility of the tray showing through the material.

In a fully dentulous mouth the lower tray, which is rim-locked, must have an equal amount of space both buccally and lingually between the tray and the teeth, and it must be seated carefully when taking the impression. The labial, buccal, and lingual flanges of the tray assist in holding it in position.

A requirement in taking an impression of a semidentulous mouth is the rimming of the periphery of the tray in the edentulous area with a low-heat modeling compound. Care must be exercised not to carry the compound beyond the peripheral seal area, and definitely not into an area where there is a possibility of becoming locked into an undercut, such as in wide embrasure spaces, under pontics, or overcontoured restorations. Also, remember the need to prevent the overseating of the tray and the showing of the impression tray through the material.

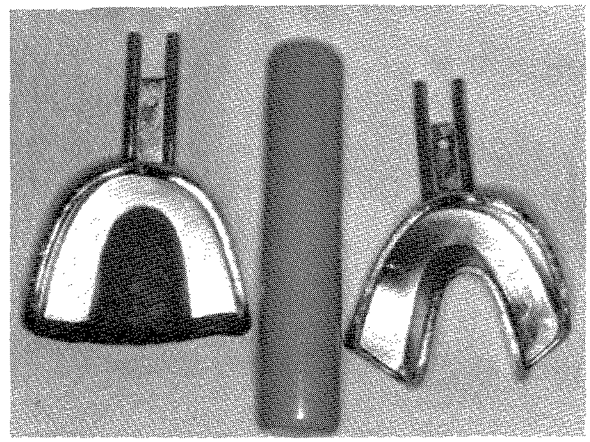


Fig. 7-17. Upper tray properly prepared for agar hydrocolloid impression to confine material, to prevent it from flowing out of the back of tray, and to create less bulk in vault area.

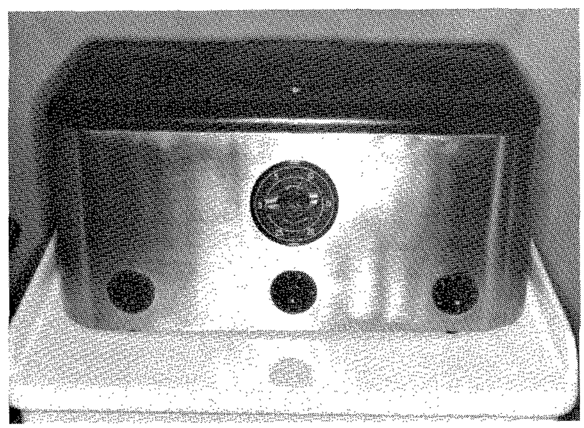


Fig. 7-18. Thompson agar hydrocolloid conditioner —thermostatically controlled.

Preparation of materials

The trays, having now been prepared for impression taking, are again tested by fitting them in the mouth. The impression material and other necessary equipment are checked for completeness and readiness.

The agar hydrocolloid impression material should be prepared each morning by boiling it for eight to ten minutes in a thermostatically controlled water bath and then by transferring the material to the storage compartment (Fig. 7-18). This bath or conditioner contains three compartments—one for boiling of the material, one for storage of the melted material at 150° to 155° F., and one for tempering of the material at 115° F.

The boiled material in the small syringes and large jacketed tubes is stored in chamber 3 of

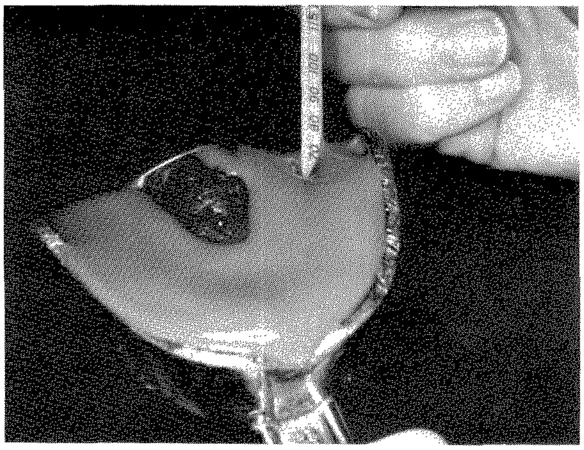


Fig. 7-19. Checking temperature of material in tray before insertion into mouth to prevent tissue burns.

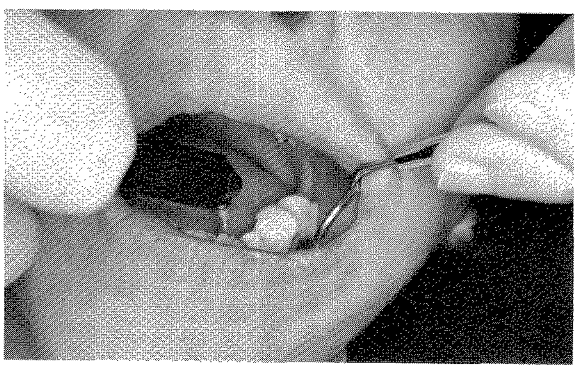


Fig. 7-20. Injection of fluid hydrocolloid onto incisal and occlusal surfaces using a small syringe. This procedure prevents trapping of air in sulci and grooves.

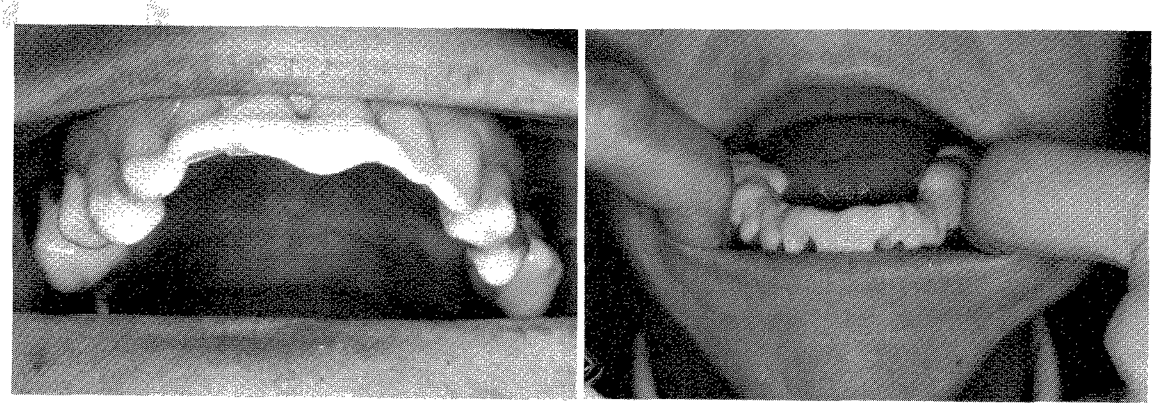
the hydrocolloid conditioner at a temperature of 150° to 155° F. until ready for use. The minimum cooling period before use is five minutes.

After the hydrocolloid material has been ejected into the rim-locked water-jacketed tray, it is put into tempering chamber 2 of the hydrocolloid conditioner at a temperature of 115° F. to lower the temperature of the tray material and to condition it. The material should be held at that temperature between ten and fifteen minutes to obtain the most desirable consistency and body. The temperature also should be checked by insertion of a small thermometer into the impression material in the tray—a precaution that can prevent serious and aggravating mouth tissue burns (Fig. 7-19).

The cheeks are retracted and the excess saliva blown from the teeth with a gentle blast of air. The fluid hydrocolloid is injected onto the occlusual surface of the teeth by means of a small syringe. This procedure prevents air from being trapped in the sulci and grooves. (See Figs. 7-20 and 7-21.)

The tray is removed from the tempering bath, the temperature checked, the hoses to the tray and water line connected, the contaminated, water-covered surface material scraped away, thereby exposing fresh hydrocolloid, and the tray centered gently and accurately into place, holding passively and steadily for a full five minutes of continuous chilling until gelation has taken place (Fig. 7-22). If the tray moves or jiggles in the mouth during this period, distortion will occur.

A



B

Fig. 7-21. Incisal and occlusal surfaces of entire arch is so treated. **A,** Upper arch. **B,** Lower arch.

The chilling of the agar hydrocolloid material is important and critical. As aforementioned, the material must be chilled for five full minutes (Fig. 7-23), with water running through the jacketed tray, changing the sol into the gel by circulating water at 50° to 60° F. Too cold or too rapid a chilling will produce distortion, and inadequate chilling will leave the material in a somewhat softened condition with incorrect registrations of the desired areas.

After proper and adequate cooling the impression is removed by placing a finger on the

A

B

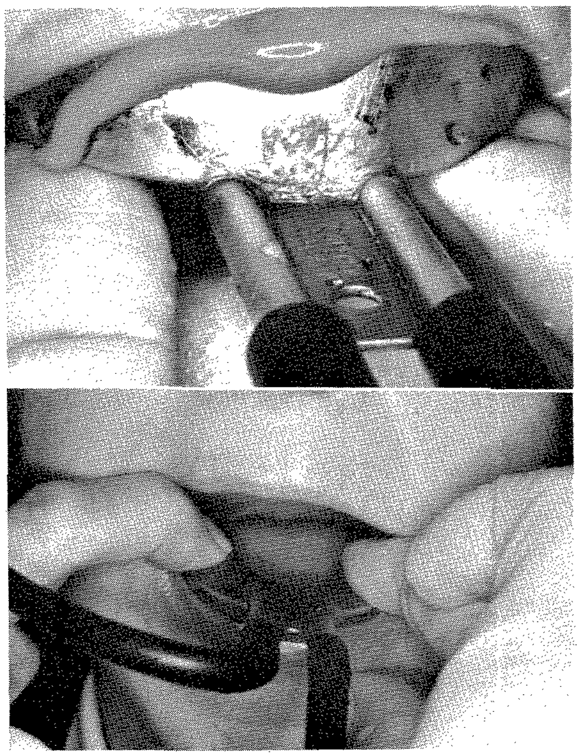


Fig. 7-22. Tray properly centered and passively held during chilling process. **A,** Upper tray. **B,** Lower tray.

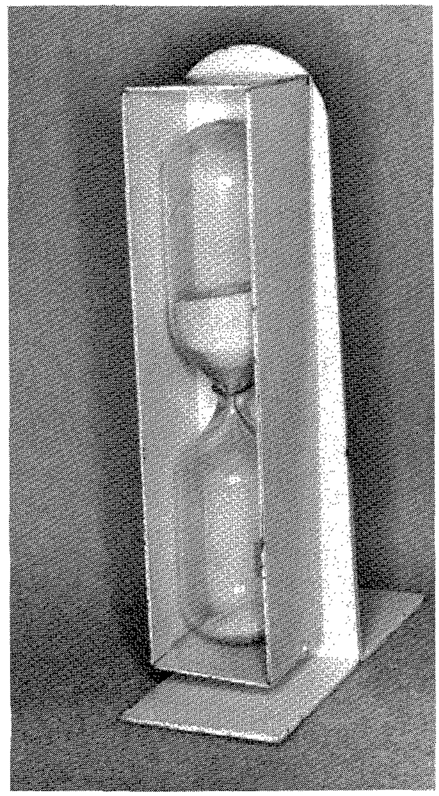
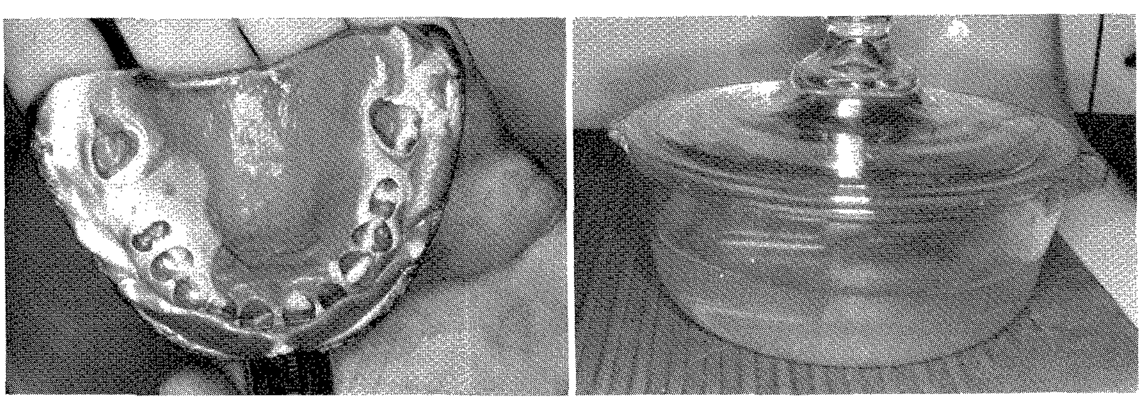


Fig. 7-23. Apparatus for exact timing for proper gelation of hydrocolloid material—five minutes.

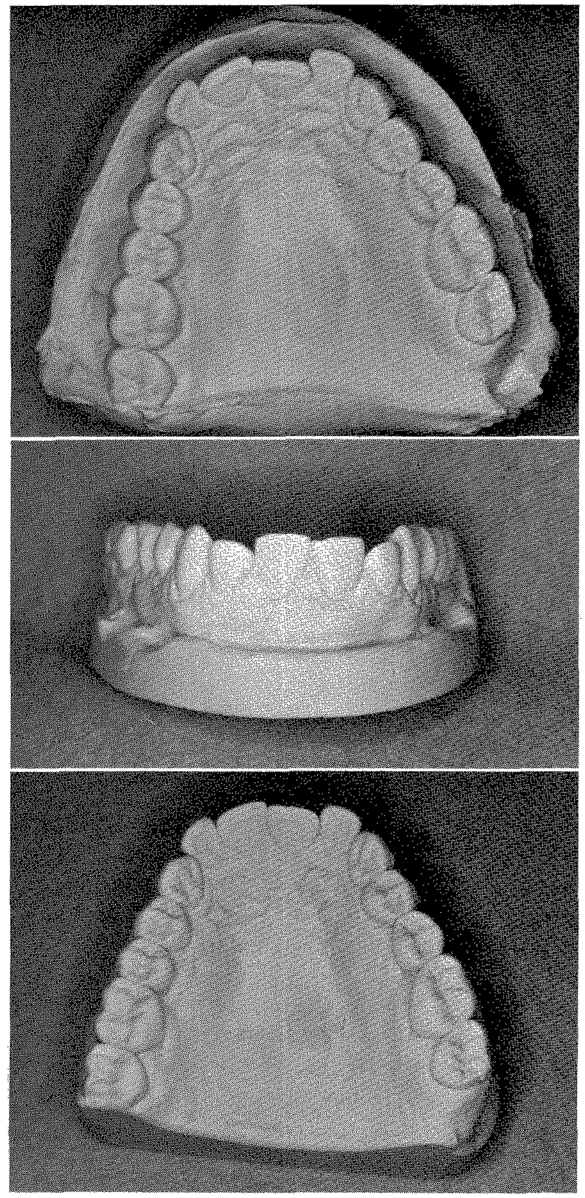
A



B

Fig. 7-24. A, Impression is examined for sharpness of outline and definitiveness. **B,** Impression is placed in container of 2% aqueous solution of potassium sulfate to accelerate setting of stone and to give smooth and dense surface to stone.

Fig. 7-25. Pouring full hydrocolloid impression.



A

B

C

Fig. 7-26. A, Cast separated from impression. **B** and **C,** Trimmed to desired shape.

periphery of the material on each side of the tray and then quickly pulling the tray vertically away from the teeth without hesitation.

After the tray has been removed from the mouth it must be examined carefully for sharpness of outline or distorted and ruptured areas. If satisfactory, the impression is washed gently in water at room temperature to remove the salvia and any small particles of material and then is placed immediately in a 2% aqueous solution of potassium sulfate (Fig. 7-24).

If a thick or ropy saliva is encountered, the impression should be washed thoroughly and carefully with a very thin mix of plaster of Paris or stone before placing it into the potassium sulfate bath. A small amount of powdered stone, the same as that to be used for the cast, or a fine plaster of Paris is placed in the impression, and the inside is scrubbed gently with a soft, wet brush to cut the saliva and debris and thereby produce a better cast. Then the impression is washed out very carefully and placed into the potassium sulfate bath.

All impressions should be poured within ten to fifteen minutes after removal from the mouth. It must be remembered that no hydrocolloid impression should be left exposed in air longer than two or three minutes. If an impression is allowed to dehydrate, subsequent immersion in water before pouring does not produce an accurate cast. The hydrocolloid will imbibe the amount of water lost, but it will be done at the expense of a distorted cast, which is caused by the release of stresses within the impression.

The impression is placed in a 2% aqueous solution of potassium sulfate to accelerate the setting of the stone, which is poured into the impression, and to give a smooth, dense surface to the stone.

Before pouring the impression all excess and droplets of potassium sulfate solution are blown out of the impression carefully. Do not dehydrate the hydrocolloid surface; otherwise the gel will adhere to the surface of the cast upon its removal. The surface of the impression should have a moist appearance.

Following the use of the correct water-powder ratio the mixed stone is poured into the impression and is vibrated gently so that air bubbles are eliminated. The poured impression should never be inverted because the weight of the stone will pull it away from the impression (Fig. 7-25).

The poured impression should be placed in an atmosphere of high relative humidity. This is best achieved by the use of a humidor, but, when one is not available, the impression can be wrapped in a wet towel. After forty-five to sixty minutes the cast may be separated from the impression and trimmed to the desired shape (Fig. 7-26).

Tissue displacement

NECESSITY FOR TISSUE DISPLACEMENT

That the indirect technique has been accepted by the profession as a whole in the reconstructive phases of dentistry is due primarily to the development of materials that can reproduce accurately all areas and types of preparations and retain their dimensional accuracy upon removal from the mouth.

When a standardized and sound procedure is followed, reversible hydrocolloid is unexcelled as the impression material of prepared teeth for the construction of microscopically accurate dies. My clinical and laboratory experiences over a number of years verify this statement.

Impression materials such as Dietrich's or modeling compound, when properly manipulated, are capable physically of pressing away the gingiva and creeping into the crevice, thus reproducing the margin. The hydrocolloid gels, however, do not possess this ability to displace soft tissue adequately; therefore, the margins must be exposed before the impression is attempted. Failure to retract or remove interfering gingival tissue prior to impression taking has led to more failures with hydrocolloid than all other causes combined. It is imperative that the margin of the preparation and about 0.5 mm. beyond it must be visible, or the hydrocolloid cannot reproduce the margin accurately. Tissue displacement should be done very carefully so that the membrane is not detached from the tooth.

It is most important to remember, before preparation of the teeth or tissue displacement for impression taking, that the gingiva must be healthy, not swollen or inflamed, and that its position on the tooth must be established.

Also it must be remembered that a mechanical vehicle always is necessary to carry a medicament into the sulcus area for effective exposure of the cavity margin, to which must be added the factors of time and pressure.

Technique of choice

In the tissue displacement technique that I use, the first step is to spray into the gingival crevice a 3% solution of hydrogen peroxide under pressure with a spray bottle for a period of two or three minutes, at which time the tissue adjacent to the gingival seat turns white or blanched because of the absorption of free oxygen. Bassett and Ingraham, who introduced this method, feel that "it is the most advantageous method of inhibiting hemorrhage and preparing the tissue for retraction by additional methods. And also there ensues an elimination of a large percentage of pathogenic bacteria in the area, and better tissue tone and improved healing post-operatively."*

The area that has been sprayed with the 3% solution of hydrogen peroxide then is isolated from the cheek with cotton rolls or Fiber-Lint.† A chemically impregnated string is used to cause the tissue displacement in the area of the subgingival margins and also to arrest any remaining hemorrhage or seepage that is present (Fig. 7-27).

*From Bassett, R. W., Ingraham, Rex, and Koser, J. R.: An atlas of cast gold procedures, Buena Park, Calif., 1964, Uni-Tro College Press, p. 48.

†S. S. White Dental Mfg. Co., Philadelphia, Pa.

Fig. 7-27. Chemically impregnated string for tissue displacement.

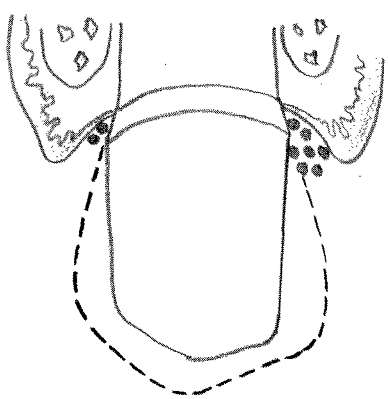


Fig. 7-28. Enlargement of sulcus follows tucking of retraction cord apically from margin. Small blood vessels are constricted.

Fig. 7-29. Enlargement strands are replaced with strands of dried alum string, which absorbs the moisture and keeps sulcus open. This is method advocated by La Forgia that I use in practice.

For interproximal inlays, onlays, pinledges, or crowns a few pieces of tightly twisted strands of Van R retraction cord No. 1[*] (or Racord No. 8[†] or Gingi-Pak retraction cotton[‡]) are tucked into the gingival crevice, stepping it apically from the margin with the aid of a gingival retraction instrument, which has serrated ends and is designed for this purpose. The tissue is forced away from the tooth and is not depressed. The pressure is directed obliquely against the long axis of the tooth rather than toward the apex of the root. The strands mechanically deflect the tissue from the margin and chemically constrict the small blood vessels.

The next step in the procedure, following the method advocated by La Forgia,[1] is the enlargement of the sulcus and the arrest of any slight hemorrhage and seepage (Fig. 7-28). This is accomplished by using a number of tightly twisted strands of Van R retraction cord No. 3 stepped into the sulcus to and not below the margin. This step allows for greater accuracy and convenience in registering marginal detail during the impression taking.

The Van R retraction strands No. 3 are removed after five to ten minutes, but the Van R retraction strands No. 1, positioned apically from the margin, are allowed to remain.

The enlargement or Van R No. 3 strands are replaced with three to six strands of dried alum string, which absorbs all moisture and keeps the sulcus open until all is in readiness for impression taking (Fig. 7-29). At this time the Van R retraction cord No. 1 below the gingival margin and the alum string in the enlarged sulcus are removed. The area is flushed and dried with a gentle stream of warm air, allowing for a quick inspection of the margins and surrounding field just before the impression is taken.

A word of warning must be given at this time. The use of a string for tissue displacement containing an 8% solution of epinephrine calls for some careful consideration. In many instances, patients with cardiac involvements, hypertension, hyperthyroidism, etc. cannot tolerate this procedure very well. In cases in which the tissues are abraded and two, three, or more

[*]Van R. Dental Products, Inc., Los Angeles, Calif.
[†]Pascal Co., Inc., Seattle, Wash.
[‡]Surgident, Ltd., Los Angeles, Calif.

subgingivally prepared teeth need tissue displacement, the absorption into the general circulation can cause a severe reaction. It is advisable to consult with their physician and, if necessary, use a string containing a decreased concentration of epinephrine or one without this particular medicament.

DISPLACEMENT USING ALUMINUM SHELLS

Another good procedure for tissue displacement for full and three-quarter crowns is one that utilizes aluminum shells.

The aluminum shells are selected slightly larger than the prepared teeth and are contoured gingivally with crown and bridge shears and left long enough to allow the edge of the shell to enter the gingival crevice. The shells are checked then for length under biting stress. They now are filled with soft, warm, temporary stopping and forced into place, first with finger pressure and then under biting stress, to clear the occlusion. Then the filled shells are removed with a curved serrated hemostatic forceps, and the excess stopping is trimmed away.

Two lengths of Van R retraction cord No. 1 or Gingi-Pak that are long enough to loop around the tooth are cut. One length is looped around the tooth and twisted tightly with curved serrated forceps; then the gingival retraction instrument is used to gently tuck it down into the gingival crevice. The second length of cord is looped over the crevice that was created by the first length and packed into position. The prepared aluminum shell or shells now are placed on the teeth and forced to place under biting stress for four or five minutes. Thus the cord is held snugly in the crevice while the medicament is at work relaxing the tissue. Tissue displacement occurs while bleeding is controlled simultaneously (Fig. 7-30). When ready to take the impression, remove the aluminum shell, carefully remove the cord or pack, and flush, isolate, and dry the area with a gentle stream of warm air.

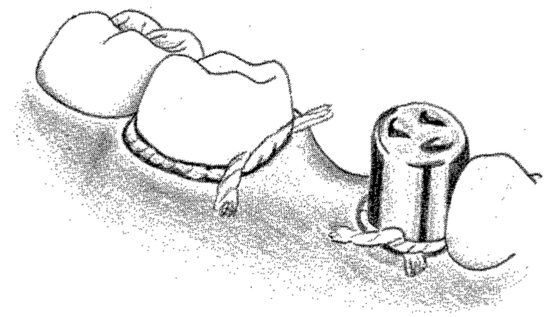
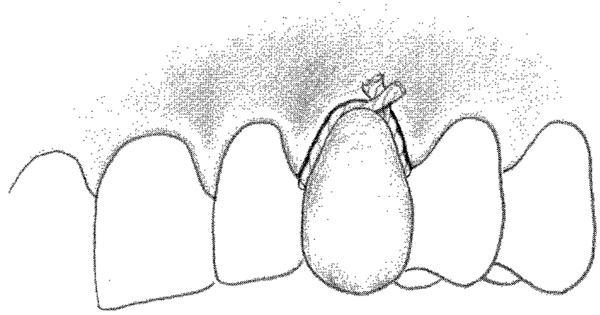


Fig. 7-30. Tissue displacement by means of impregnated string and filled aluminum shells.



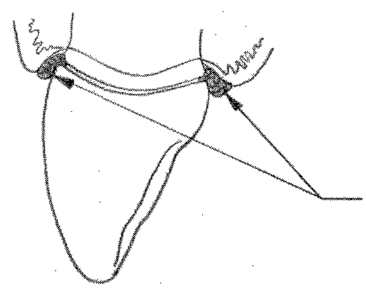


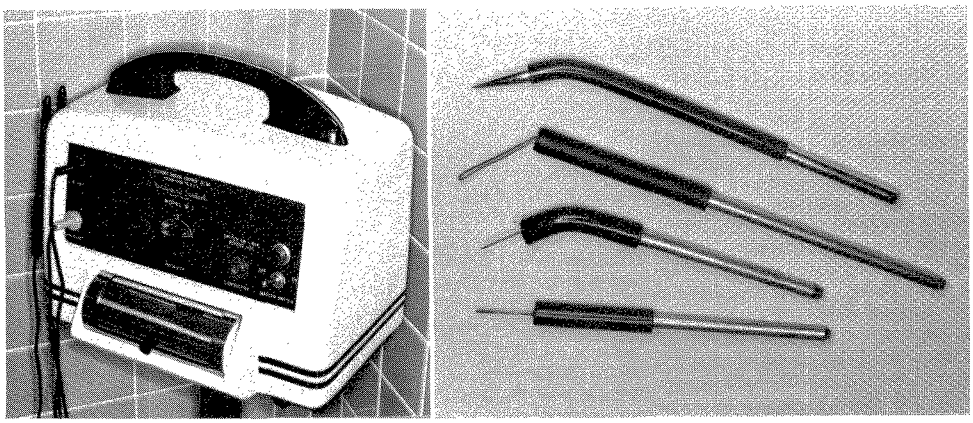
Fig. 7-31. A slightly overextended temporary acrylic crown can be used to force retraction cord against tissue for further displacement.

A slightly overextended temporary acrylic crown, bridge, or splint also can be used to force the retraction cord against the tissue for further displacement (Fig. 7-31).

Displacement using a radio knife

In a certain percentage of cases the tissue displacement problem cannot be handled by the methods already discussed. These are usually the cases in which a large bulk of inflammatory edematous tissue interferes with making a good preparation and/or taking a good hydrocolloid impression. When confronted with this problem, we must resort to the least desirable way of attaining access to the margins of the preparations, that is, with surgery or the radio knife. The electrodental scalpel or radio knife must

A



B

C

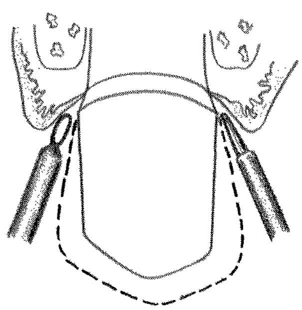


Fig. 7-32. A, Radiosurg scalpel used when confronted with a large bulk of inflammatory edematous tissue. If used with skill and great care, it can be used routinely with great success. **B** and **C,** Various electrosurg tips.

be used with skill and great care because, if it touches the interproximal septa of bone, a sequestrum can result (Fig. 7-32).

Tissue displacement, by whatever means, should be carried out with care and understanding of principles so that irreparable damage to the gingival tissues is avoided.

Impressions of tooth preparations

CHOICE OF MATERIAL

After the retraction of the gingival tissue has been accomplished, the next procedure is the taking of the impression. The material of choice for the construction of the small type casting is a reversible dental hydrocolloid, which allows for accuracy, simplicity, speed, and versatility.

Reversible hydrocolloids

Armamentarium in small type castings

The armamentarium necessary for the reversible hydrocolloid method of impression taking is a conditioner that is thermostatically controlled and contains water baths for the liquefaction, storage, and tempering of the impression material, small and large syringes, individual jacketed hydrocolloid, rim-locked water-cooled trays, and tubing for the cooling water supply (Figs. 7-33 to 7-35). With such equipment it is possible to liquefy the hydrocolloid impression material to the proper temperatures and to place it into the mouth without injuring the tissues.

Technique

Before taking the impression make sure that the prepared teeth are clean and dry, free of blood and saliva.

The impression is taken in a tray of sufficient size to provide a bulk of material so that, if undercuts are present, there will be sufficient bulk of impression material to allow for passing these areas without permanent distortion. The hydrocolloid should be able to be stretched or

Figs. 7-33 to 7-35. Armamentarium necessary for agar hydrocolloid impressions in crown and bridge procedures.

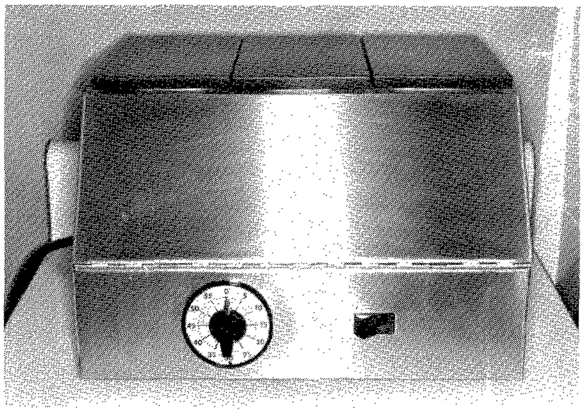


Fig. 7-33. Van R hydrocolloid conditioner.

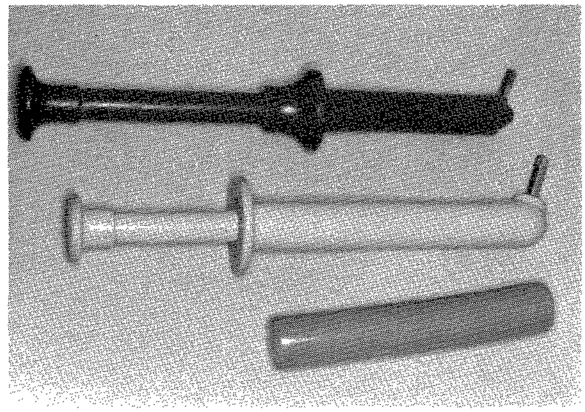


Fig. 7-34. Small syringes (different gauge needles) and small jacketed tubes of hydrocolloid.

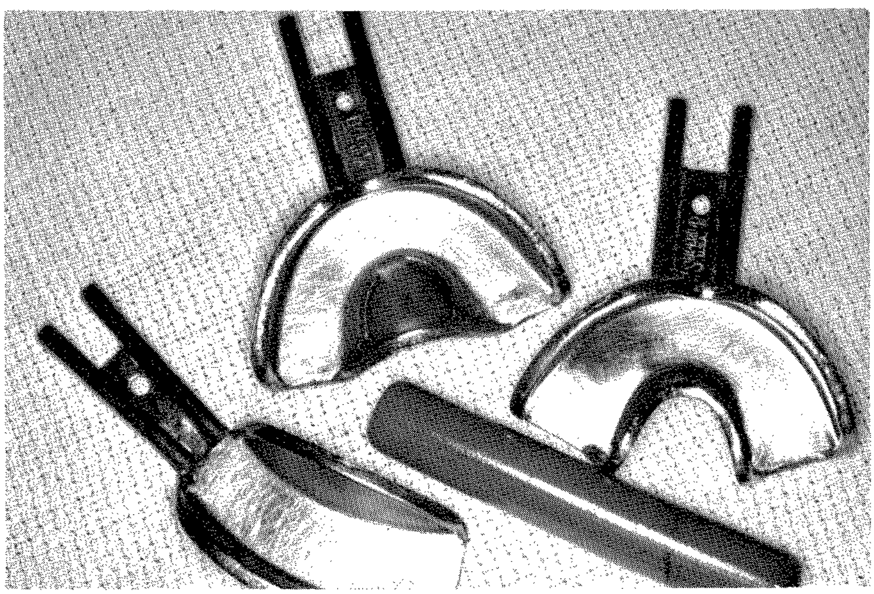


Fig. 7-35. Small water-cooled trays for different quadrants of mouth.

compressed without crushing or fracturing the material. Stops, either of wax or modeling compound, should be placed at each end of the tray beyond the prepared teeth to allow for sufficient thickness of the impression material over the occlusal area of the prepared teeth and to restrict and confine the material in the tray when the impression is taken. These steps also aid in maintaining stability during the critical period of gelation.

The procedure of using reversible hyrocolloid can be divided into the following steps:

1. Liquefaction of the material by boiling for eight to ten minutes (four to five minutes for junior jacketed tubes).
2. Storage of the boiled material in the small syringes and jacketed tubes in chamber three at a temperature of 150° to 155° F. until ready for use. This maintains the material in a colloidal state.

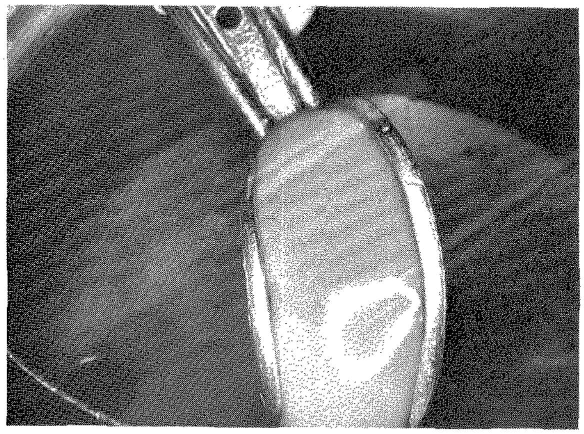


Fig. 7-36. Tray filled with agar hydrocolloid and placed immediately in tempering bath at 115° F. for about ten minutes.

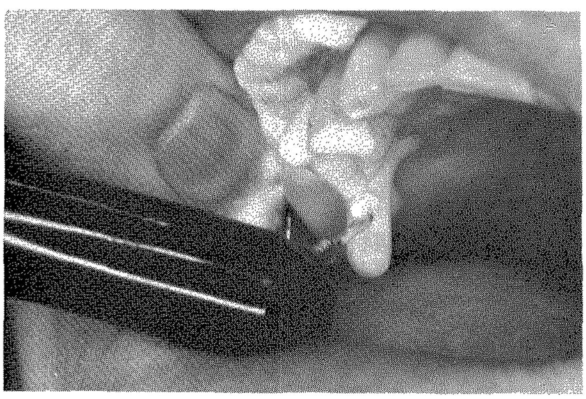


Fig. 7-37. Injecting fluid hydrocolloid from small syringe into preparations.

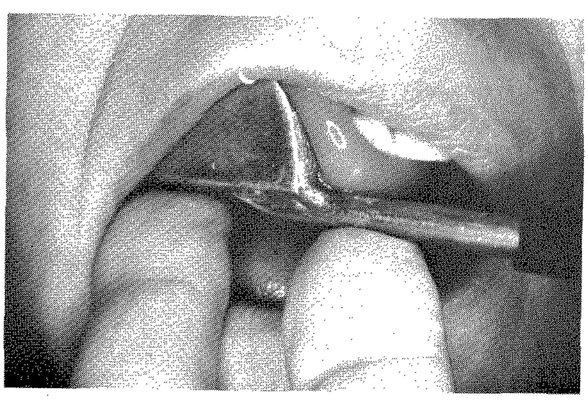


Fig. 7-38. After water-soaked outer layer of hydrocolloid is removed, tray properly positioned and held with passive pressure.

3. Placement of the tray material in chamber 2, or the tempering bath, at a temperature of 115° F. and holding that temperature between five and fifteen minutes. The temperature of the tray material is lowered so that it is not too hot when introduced into the mouth and it has the desired degree of stiffness or body.

4. Filling of the prepared teeth with the fluid hydrocolloid (reproduces the cavity details more accurately) in the small syringe taken from chamber 3.

5. Removal of the tray with its tempered material from the tempering bath (chamber 2) and carrying it to the mouth, after scraping off the top layer, which was exposed to the water.

6. Careful location of the tray, followed by changing the sol into the gel by circulating water at 50° to 60° F. through it. The tray must be held immovable until gelation is completed.

7. Rapid removal of the impression from the mouth, which prevents distortion, and pouring of the dies or casts in artifical stone.

Boiling water is a convenient means of liquefying the material. A minimum boiling time of eight minutes is essential, and longer periods of boiling is not harmful. Phillips[2] calls attention to the fact that "whenever the material is reliquefied after a previous use it is more difficult to break down the agar lattice-work, so approximately three minutes should be added each time the material is reboiled."*

After the liquefaction process the syringes and tubes of material in the sol condition are stored in the water bath at a temperature of 150° to 155° F. until ready for use.

After the preparations are completed and before the displacement of the gingival tissue is started, the tray is filled and placed immediately in the tempering bath at 115° F. for about ten minutes (Fig. 7-36). The purpose of tempering is to increase the viscosity of the impression material so that it will not flow out of the tray and also to reduce the temperature to prevent discomfort to the patient.

By the time the hydrocolloid material has been conditioned properly, the toilet of the

*From Phillips, R. W.: Hydrocolloid impression materials; technical consideration. In Skinner, E. W., and Phillips, R. W.: The science of dental materials, Philadelphia, 1960, W. B. Saunders Co.

cavity preparation and displacement of the gingival tissue have been completed, and all is in readiness for taking the impression of the prepared teeth. The small syringe is removed from the storage bath, and the portion of the colloid within the needle is expelled in an area outside of the cavity before the sol is first ejected at the gingival portion of the preparation and then carried distomesially over the cavity (Fig. 7-37). The needle must be held close to the tooth, beneath the surface of the ejected material, to prevent a trapping of air bubbles.

After the preparations and adjoining teeth have been covered with a bulk of hydrocolloid to prevent premature chilling, the tray material, which has been tempering, is removed, and the water-soaked outer layer of hydrocolloid is scraped off. Failure to remove that layer may prevent a firm union between the tray material and the hydrocolloid, which has been injected previously into the cavity preparation.

The tray is brought immediately into position and completely seated with passive pressure (Fig. 7-38). The tray, with the water circulating very slowly, must not be allowed to move in any direction during the gelation period. Gelation is accomplished by circulating water at a temperature of approximately 50° to 60° F. for not less than five minutes (Fig. 7-39). It is not advisable to use ice water.

The impression must not be removed before complete gelation has taken place because, if the hydrocolloid material is incompletely gelled, there will be a distortion of the impression, and an inaccurate die or cast will result. Gelation depends on coordinating the factors of time and temperature—time is as important a factor as the temperature of the water used.

After the gelation process the impression is withdrawn by placing a finger on the periphery of the material on each side of the tray and then by quickly pulling the tray vertically away from the teeth (Fig. 7-40). Removing the tray with a rocking motion will result in distortion; also, fracture is more likely to occur.

"The brush-heap structure of the gel is of such a nature that a sudden force is always resisted without distortion or fracture more successfully than a force which is applied slowly. Consequently, when the impression is removed, it is necessary to remove it suddenly, with a jerk rather than to tease it out. The re-

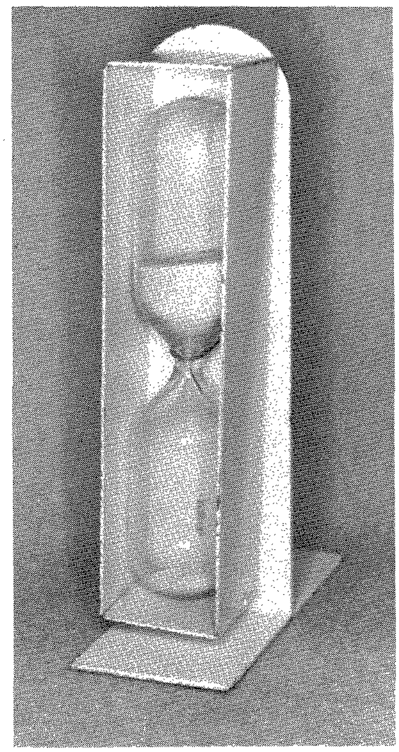


Fig. 7-39. Complete gelation requires five minutes of chilling.

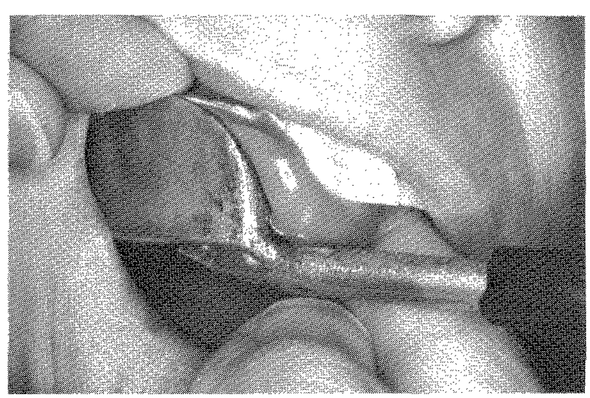


Fig. 7-40. Correct removal of impression—placing finger on periphery of tray on each side and quickly pulling tray vertically away from teeth.

Fig. 7-41. Examine impression for definitiveness of detail—sharpness of cavity outline and absence of distorted or ruptured areas.

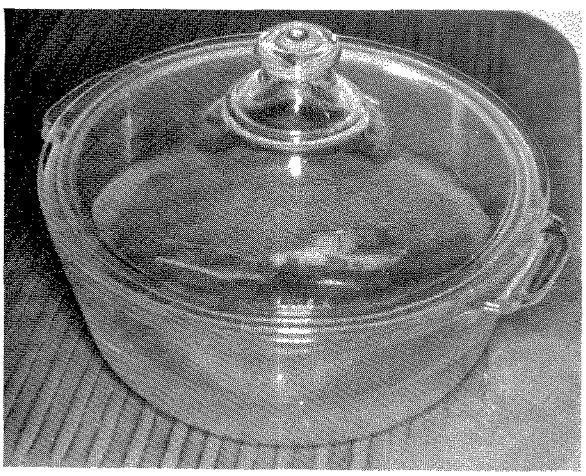


Fig. 7-42. Impression placed immediately in 2% aqueous solution of potassium sulfate.

moval is accomplished in a direction as nearly as possible parallel to the long axes of the teeth."*

After the tray has been removed from the mouth it must be examined carefully for sharpness of cavity outline or distorted and ruptured areas (Fig. 7-41). If satisfactory, the impression is washed gently in water at room temperature to remove the saliva and small particles and placed immediately in a 2% aqueous solution of potassium sulfate (Fig. 7-42).

*From Skinner, E. W., and Phillips, R. W.: The science of dental materials, Philadelphia, 1960, W. B. Saunders Co.

Ropy saliva

If a thick or ropy saliva is encountered, the impression should be washed thoroughly and carefully with a very thin mix of plaster of Paris or stone before placing it into the potassium sulfate solution.

A small amount of powdered stone, the same as that to be used for the cast, or a fine plaster of Paris is placed in the impression, and the inside is scrubbed gently with a soft, wet brush to cut the saliva and debris and thereby to produce a better cast. Then the impression is washed out very carefully and is placed into the potassium sulfate bath.

Pinledges and pinlays

The technique developed by Shooshan,[3] together with new types of drills and the use of graded nylon bristles, has simplified the reproduction of the cavity preparation by the indirect impression method and the construction of the wax pattern.

The reversible hydrocolloid impression material is the material of choice in the taking of pinledge or pinlay impressions.

Sized Perlon pins* or nylon bristles are fitted, prepared, and positioned in the pinholes of the preparation with a special inserting pliers, prior to the taking of the impression.

Perlon pins are of a nylon material and because of their uniformity of size, especially in roundness and consistency of diameter size, are the impression pin material of choice. They afford a more precise result with regards to strength and fit of the finished cast pin.

The Perlon pins with flat heads are available in three sizes (Nos. 6, 7, and 8) to correspond with the drill sizes (5 mm. and 6 mm. lengths) and are color coded:

Drill size		*Perlon pin*			
mm.	*inches*	*No.*	*mm.*	*inches*	*Color*
0.6	0.024	6	0.58	0.023	Lavender
0.7	0.028	7	0.68	0.027	Orange-red
0.8	0.032	8	0.78	0.031	Lime-green

The Perlon pins are slightly smaller in size than the corresponding drill and give a snug fit (Fig. 7-43).

The Perlon pins are placed in the prepared

*J. F. Jelenko & Co., Inc., New Rochelle, N. Y.

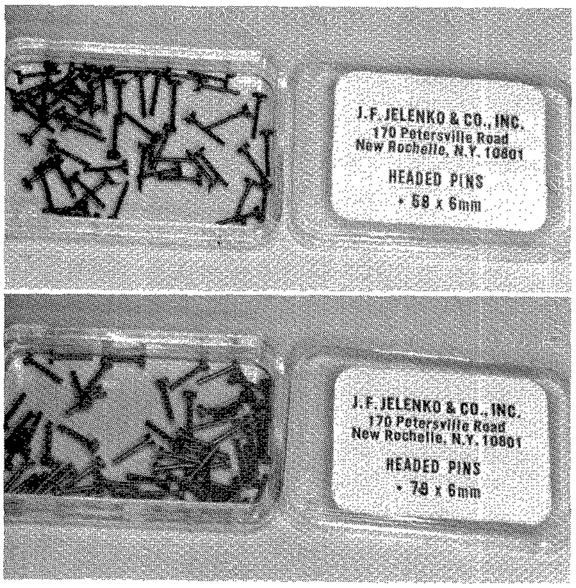


Fig. 7-43. Sized Perlon pins with flat heads.

pinholes, making sure that they do not bind on being removed and also that the impression tray does not contact any of these pins. Contact of the tray with any of the pins will place them under tension, and release of this tension upon removal of the impression will cause a displacement of the Perlon pins.

The water-jacketed tray, which has been prepared with wax or modeling compound stops for seating and stability, is loaded with agar hydrocolloid and placed in the tempering bath. The fluid hydrocolloid from a small syringe is ejected around each headed Perlon pin, and the pins are held in place with the tip of the index finger (of the hand not controlling the small syringe) until they are covered with the hydrocolloid material, at which time the index finger is moved away carefully at a right angle so that the pins are not dislodged.[4] This operation should be rapid and deliberate.

To avoid premature chilling, when all the pins and the remainder of the preparation are covered with a liberal amount of impression material, the tempered tray with the water-soaked outer layer of hydrocolloid scraped off is positioned and held passively and steady for a full five minutes to chill it adequately. It then is removed with a quick snap and examined carefully for detailed reproduction of the preparation and correct position of the pins, making sure that there has not been any displacement of the pins. Now it is washed gently in water at room temperature to remove the saliva and any small particles and is placed immediately in a 2% aqueous solution of potassium sulfate.

Salient facts about agar hydrocolloids (reversible)

1. Inaccurate hydrocolloid impressions may be caused by the following:
   a. Movement of tray during gelation
   b. Removing impression from mouth too soon
   c. Teasing out of impression rather than removal with a quick snap
   d. Storage of impression before pouring
   e. Chilling with water at very low temperatures
2. Rough or chalky surfaced casts are caused by the following:
   a. Impression not treated with a 2% aqueous solution of potassium sulfate
   b. Incorrect water-powder ratio for stone
   c. Cast or die removed from impression before thirty to forty-five minutes or cast or die left too long before separation
   d. Excess water or solution not blown from mold
   e. Too much vibration during pouring

Rubber base—two-mix technique

Preliminary preparations

The technique for impression taking with Thiokol and silicone is very similar. I use the Elasticon* material, which is furnished in two viscosities—a tray type and a syringe type. The syringe type is of a lower viscosity so that it will inject readily into the prepared teeth. (See Fig. 7-44.)

A custom-made tray is constructed, making use of a study cast of the case at hand. Two layers of Tenax† baseplate wax are adapted over the teeth of the study cast, extending at least a tooth beyond the ones to be included in the impression. The unprepared tooth or soft tissue acts as an anterior and posterior stop in positioning the tray properly during impression taking. The tray is made with Formatray,* which is a quick-setting acrylic material.

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*Kerr Mfg. Co., Detroit, Mich.

†S. S. White Dental Mfg. Co., Philadelphia, Pa.

After the tray has been prepared, the Elasticon adhesive is applied lightly to all inner and peripheral surfaces and permitted to dry (Fig. 7-45).

After the syringe is prepared (Figs. 7-46 to 7-50), which is used to apply the thinner material, the tray, Elasticon mixing pads, spatulas, and dappen dish are laid out (Fig. 7-51).

Tissue displacement has been accomplished, and cotton roll or Fiber-Lint is positioned to absorb moisture.

Technique

1. Heavy-bodied Elasticon material is dispensed on a mixing pad—4 inches for a small bridge tray. Use 2 drops of heavy-bodied Elasticon accelerator (red) per inch of heavy-bodied Elasticon base material. (See Fig. 7-52, *A*.)

2. Syringe Elasticon material is dispensed on another mixing pad—4 inches for a small bridge tray. Use 1 drop of syringe Elasticon accelerator (yellow) per inch of syringe Elasticon base material. (See Fig. 7-52.)

The mixing pads should be of heavy stiff paper, and the spatulas should be slightly flexible and should have straight sides.

3. Mix syringe Elasticon base and accelerator a maximum of thirty seconds. Thorough mixing is necessary if the accelerator is to be impregnated throughout the mass. Mixing and loading of syringe must be completed in one and one-half minutes (Fig. 7-53).

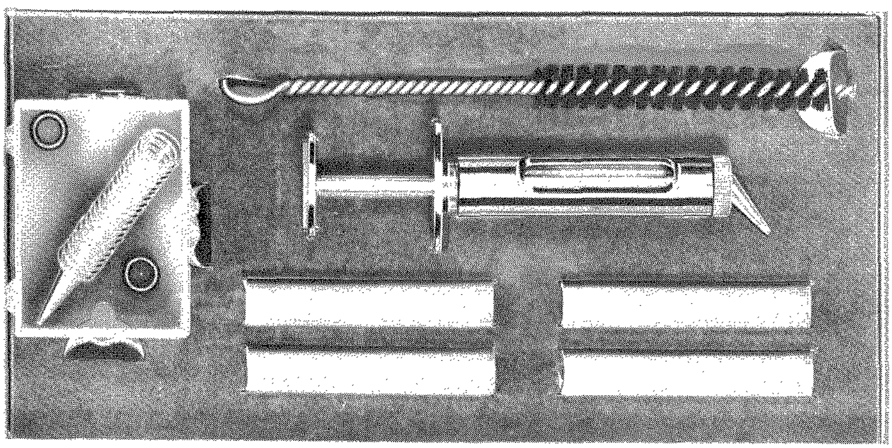


Fig. 7-44. Versatile syringe for all rubber base impression materials.

Fig. 7-45. Apply Elasticon adhesive lightly to all inner and peripheral surfaces of tray and permit to dry. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

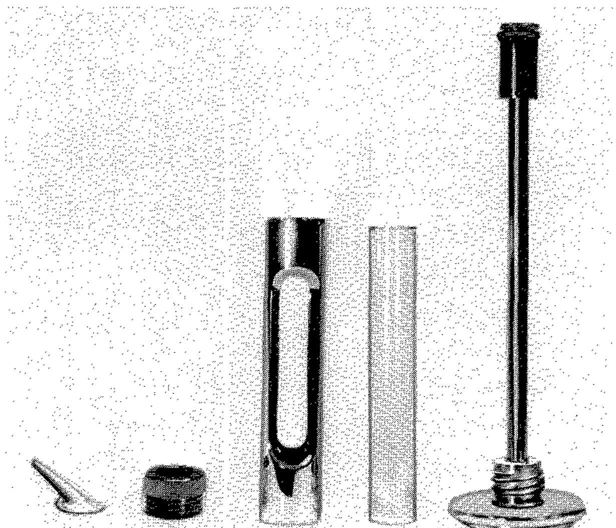


Fig. 7-46. Syringe completely disassembled. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

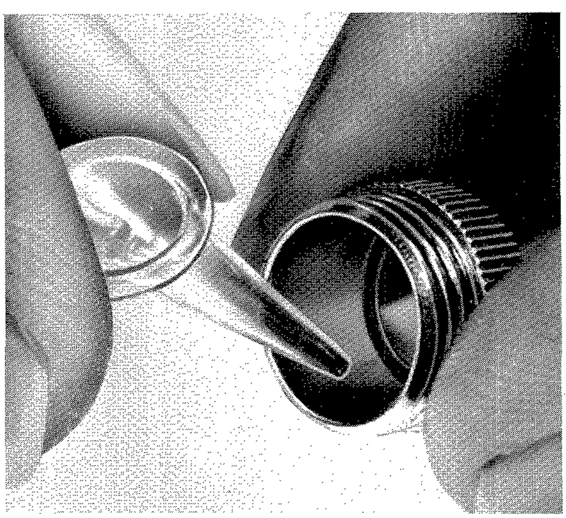


Fig. 7-47. Insert plastic tip into tip retainer and screw retainer into metal barrel. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

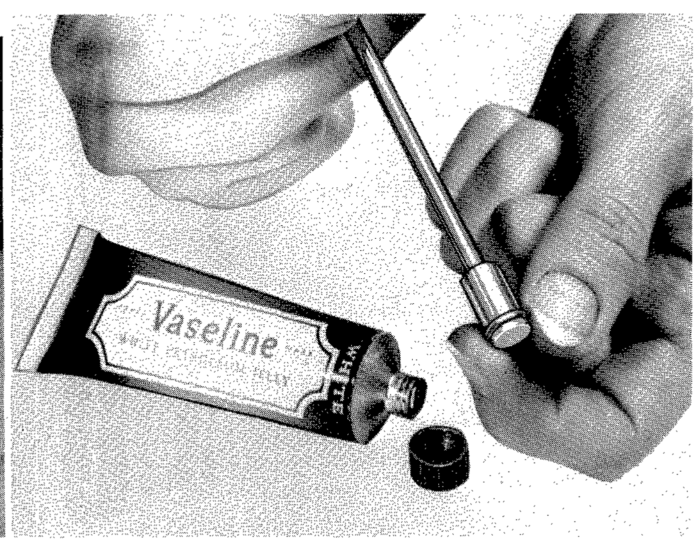


Fig. 7-48. Lightly lubricate rubber ring washer with petroleum jelly and wipe off excess with tissue. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

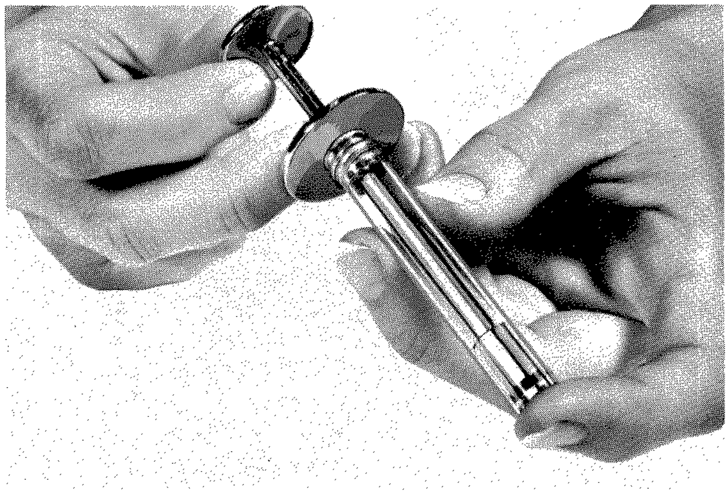


Fig. 7-49. Insert plunger into plastic sleeve and press forward until flush with end of plastic sleeve. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

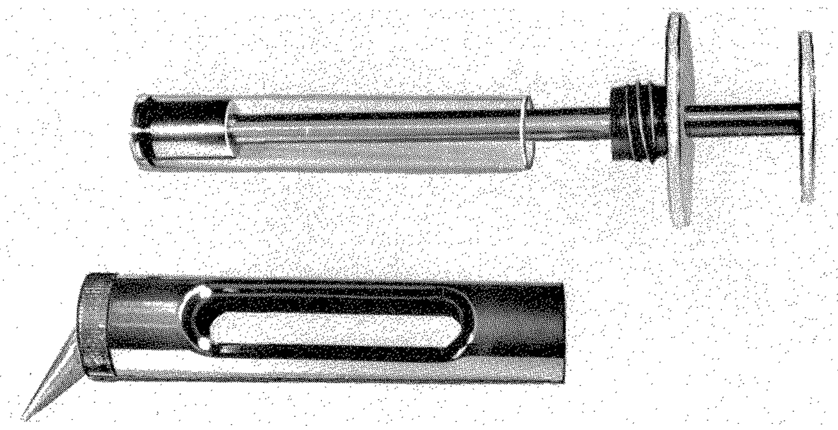


Fig. 7-50. Prepared syringe set aside until syringe Elasticon has been mixed. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

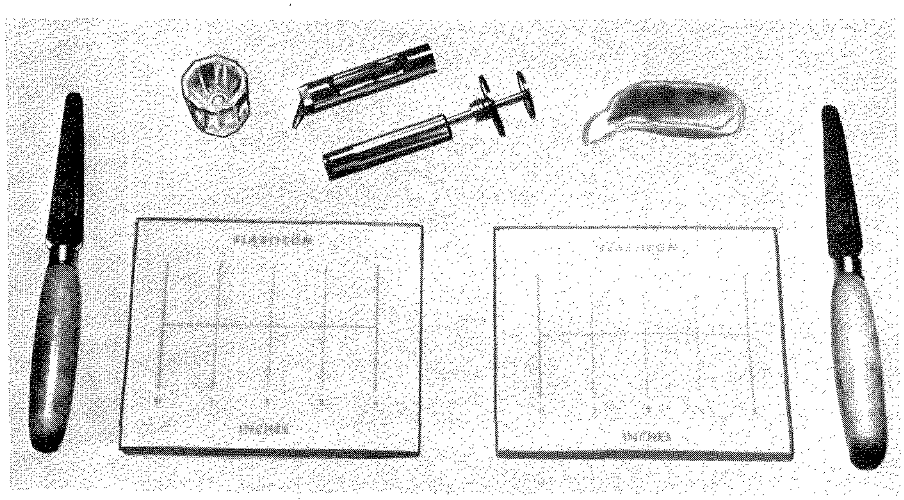


Fig. 7-51. Elasticon mixing pads, spatulas, and dappen dish laid out. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

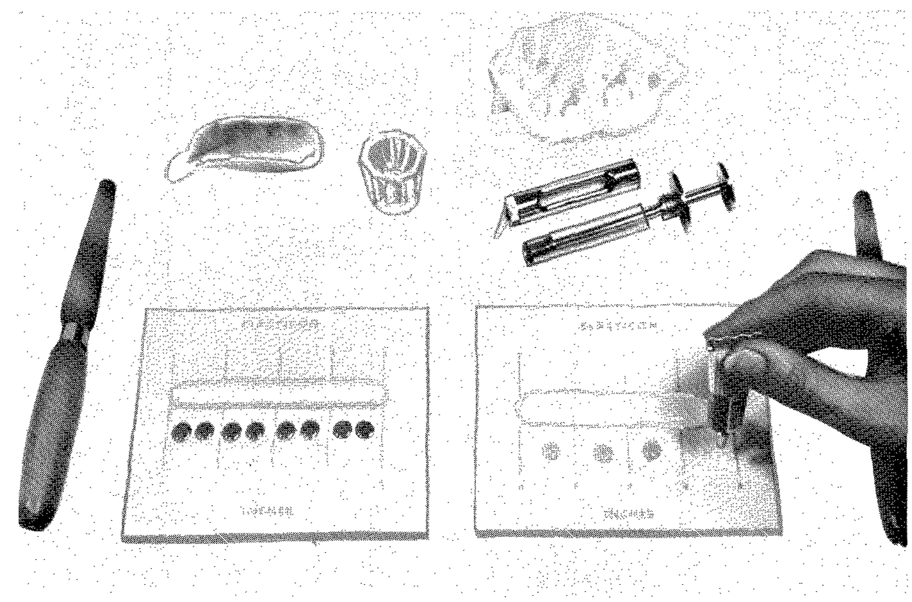
A  B

Fig. 7-52. A, Heavy-bodied Elasticon material dispensed on mixing pad—4 inches for a small bridge tray. Use 2 drops of heavy-bodied Elasticon accelerator (red) per inch of heavy-bodied Elasticon base material. **B,** Syringe Elasticon material is dispensed on another mixing pad—4 inches for a small bridge tray. Use 1 drop of syringe Elasticon accelerator (yellow) per inch of syringe Elasticon base material. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

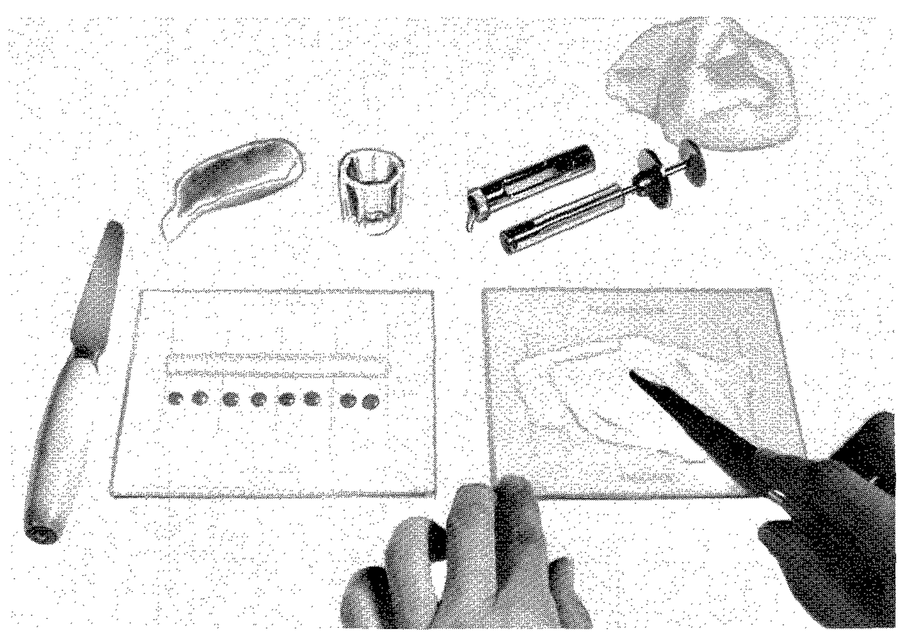


Fig. 7-53. Mix syringe Elasticon base and accelerator a maximum of thirty seconds. Mixing and loading of syringe completed in one and one-half minutes. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

4. Pick up the entire mix of syringe Elasticon and transfer it to a dappen dish. Load the syringe from the dappen dish. (See Figs. 7-54 to 7-58.)

5. Mix heavy-bodied Elasticon base and accelerator. Thorough mixing is necessary if the accelerator is to be incorporated completely throughout the mass. Complete the mix within forty to forty-five seconds (Fig. 7-59). The tray must be loaded with heavy-bodied Elasticon and seated in the mouth within two minutes.

6. Spread heavy-bodied Elasticon over all adhesive-covered surfaces of the tray and set tray aside (Fig. 7-60).

7. Dry prepared teeth and gingival crevices, and with the syringe inject syringe Elasticon into the subgingival crevices and the preparations, being careful not to trap air between the preparation and the material.

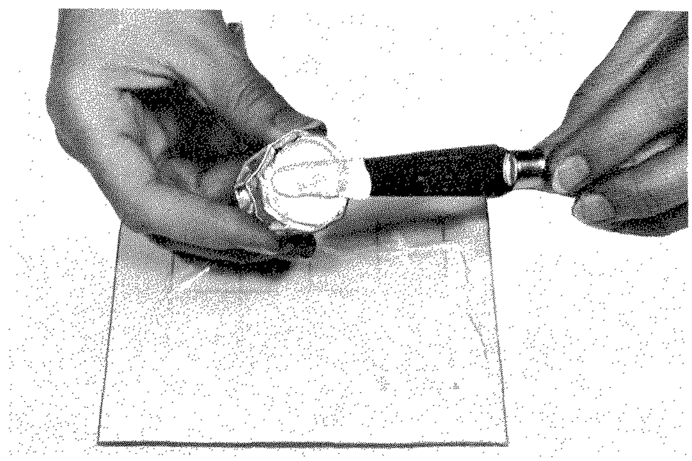


Fig. 7-54. Pick up entire mix of syringe material and transfer to dappen dish. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

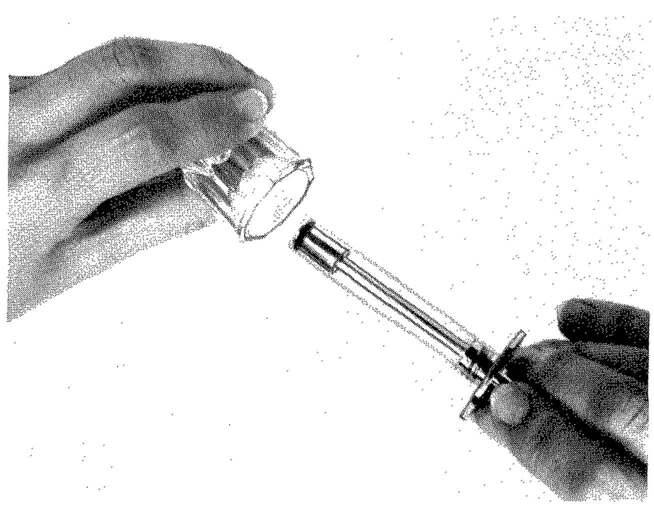


Fig. 7-55. Insert plastic sleeve of syringe with plunger into filled dappen dish. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

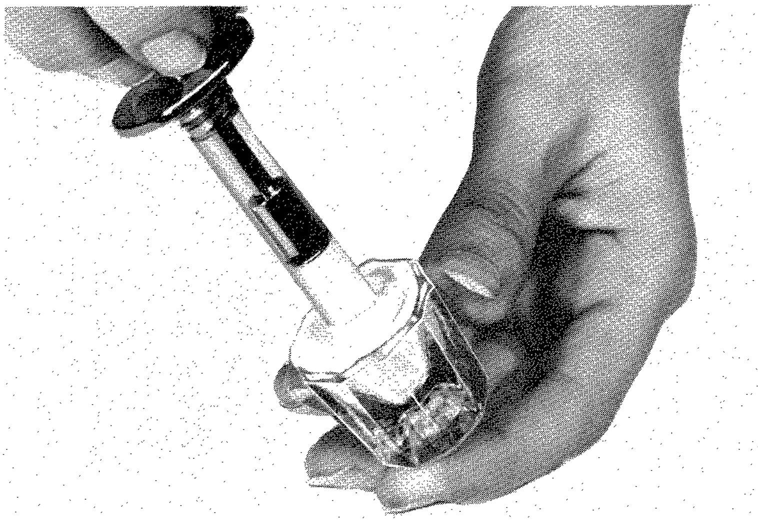


Fig. 7-56. With locking disk forced against plastic sleeve, draw plunger back slowly to fill sleeve. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

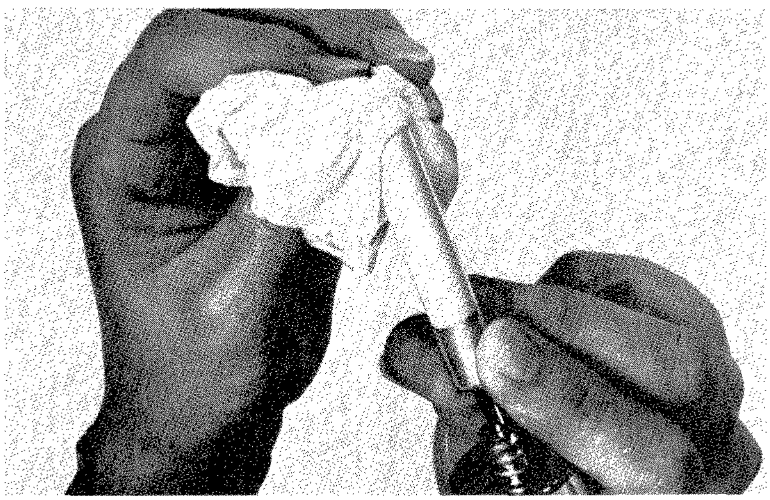


Fig. 7-57. Grasp plastic sleeve at rear end and wipe opposite end free of all syringe Elasticon. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

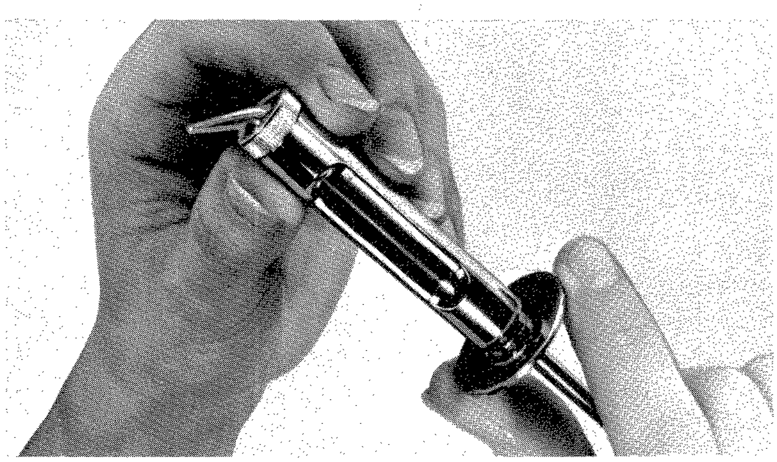


Fig. 7-58. Place filled plastic sleeve into metal barrel of syringe and screw locking disk down as far as possible. Tighten securely. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

8. Pick up the tray that is loaded with the heavy-bodied material, and seat to place with a rocking motion, holding the tray firmly in position until impression material has completely set—approximately ten minutes from beginning of syringe mix.

9. Remove impression, rinse, and dry with a gentle blast of air.

Examine the impression carefully for preparation details, being sure that all margins and at least 0.5 mm. beyond have been copied accurately. Pour immediately to avoid any possibility of dimensional change. (See Figs. 7-61 and 7-62.)

This impression technique is best accomplished by two persons mixing simultaneously—the assistant mixing the syringe material and the dentist the heavy-bodied material.

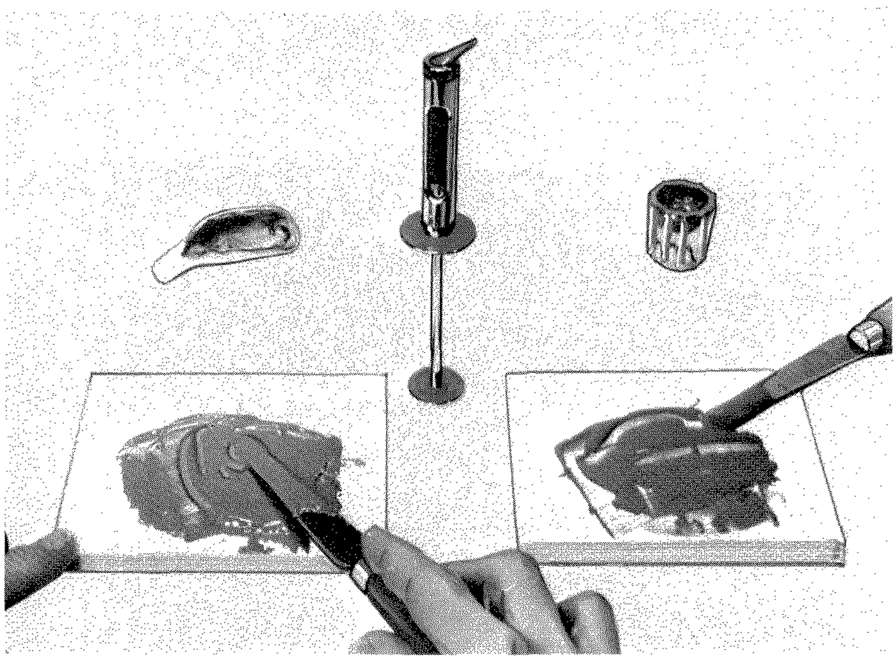


Fig. 7-59. Mixing of heavy-bodied Elasticon base and accelerator. Complete the mix within forty to forty-five seconds. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

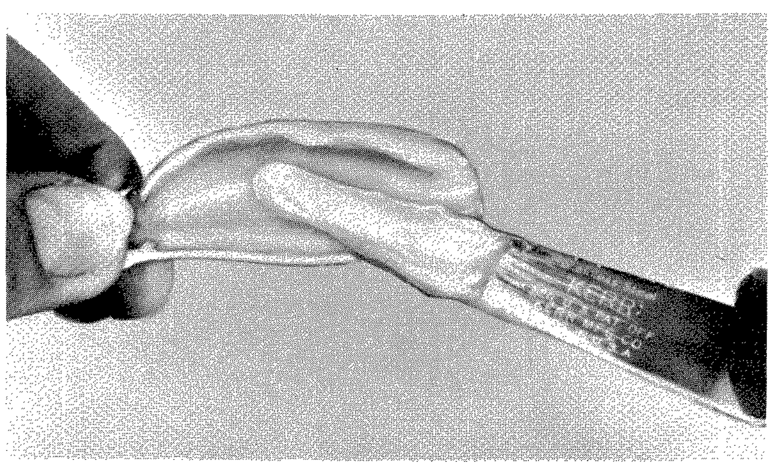


Fig. 7-60. Spreading of heavy-bodied Elasticon over all adhesive-covered surfaces of tray. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

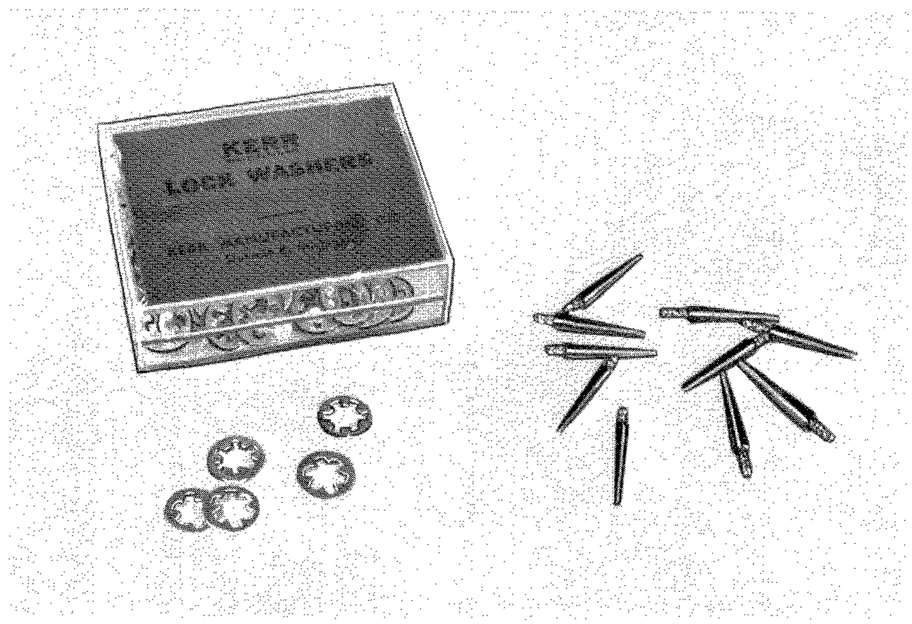


Fig. 7-61. Lock washers provide necessary anchorage between two pours of stone, and dowel pins are used to produce individual removable dies. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

Fig. 7-62. Allow first pour of stone to set; then apply one or more coats of separating medium (Super Sep) over areas of dies that are to be removable. (Courtesy Kerr Mfg. Co., Detroit, Mich.)

TREATMENT OF IMPRESSION BEFORE AND AFTER POURING OF STONE

All impressions should be poured within ten and fifteen minutes after removal from the mouth. It must be remembered that no hydrocolloid impression should be left exposed in the air for longer than two or three minutes. If an impression is allowed to dehydrate, subsequent immersion in water before pouring does not produce an accurate die. The hydrocolloid will imbibe the amount of water lost, but it will be done at the expense of a distorted die or cast, which is caused by the release of stresses within the impression. Phillips[2] sums it up thus: "Consequently, the dental stone cast should be constructed as soon as possible after the impression has been obtained, not only to prevent troublesome effects due to imbibition and syneresis, but also to minimize the possible distortions due to relaxation of stress."*

The impression was placed in a 2% aqueous solution of potassium sulfate to accelerate the setting of the stone die or cast, which is poured in the impression, and to give a smooth, dense surface to the stone. The impression can be poured after five, ten, or fifteen minutes in the potassium sulfate solution, but the period of time must not exceed fifteen minutes. "It has been shown that the hardening solution may affect the dimensional stability of the hydrocolloid impression. This effect varies with the chemical employed, its concentration, and the composition of the gel. For this reason, the hydrocolloid impression should not be immersed in the hardening solution for more than ten to fifteen minutes since only the surface layer of the gel need be saturated with the solution. Usually, a period of five minutes is sufficient to provide such a saturation."*

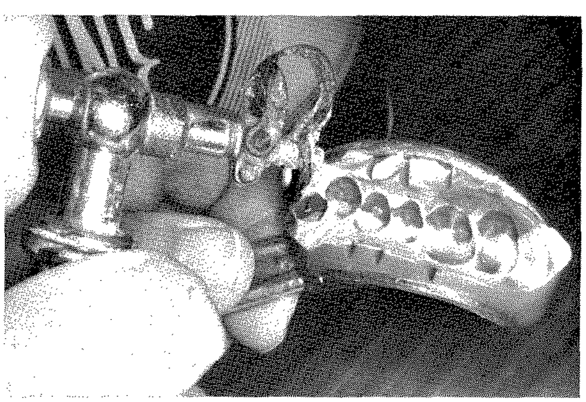


Fig. 7-63. Do not dehydrate surface of impression. Surface must have moist appearance to avoid adherence of gel to cast surface.

While the impression is undergoing this treatment, preparation is being made for the stone mix. Before pouring the cast all excess and droplets of potassium sulfate solution are blown carefully out of the impression. Do not dehydrate the hydrocolloid surface, or the gel will adhere to the surface of the cast upon its removal. The surface of the impression should have a moist appearance (Fig. 7-63).

Pouring the cast

Types and correct use of stone

The type of stones to be used for the dies and casts are the newer Hydrocal stones, which have been specially prepared for the indirect technique; these stones possess a minimum amount of setting expansion and a maximum amount of surface hardness and smoothness.

Routine fabrication of dense, smooth dies and casts is very essential and can be accomplished by following the manufacturer's directions and adhering to a careful, standardized procedure.

The water-powder ratio always should be measured correctly, following the manufacturer's directions, because a variation influences surface smoothness as well as strength and setting expansion (Fig. 7-64).

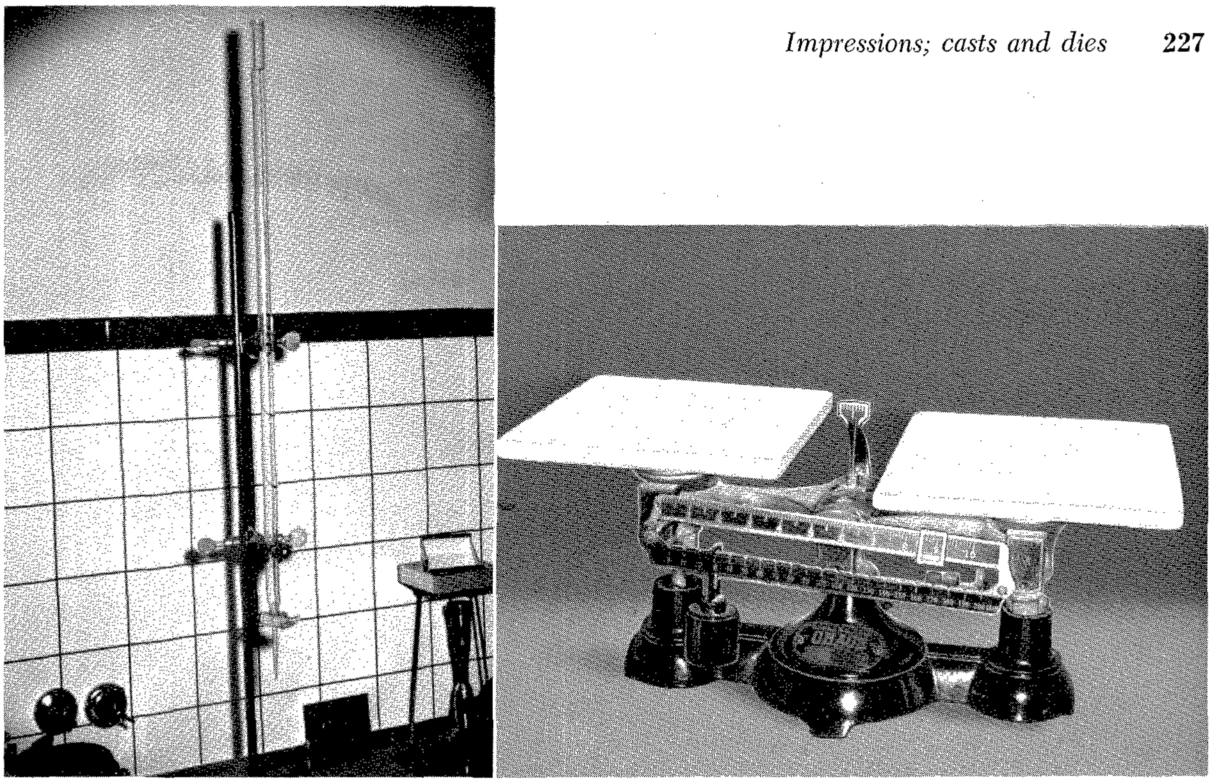
Mechanical spatulation, preferably under vacuum, is valuable in assuring a smoother, denser, and stronger die or cast (Fig. 7-65).

Powder and water also may be combined by hand mixing as well as by mechanical mixing under vacuum, and both these methods produce satisfactory results if properly carried out. In mechanical mixing care must be taken that the mixing time be comparatively short. Overmixing produces too rapid a set and also tends to increase slightly the setting expansion.

Phillips[5] has shown that the rate at which stone is flowed into the impression has a very significant effect upon the surface of the die, as

*From Skinner, E. W., and Phillips, R. W.: The science of dental materials, Philadelphia, 1960, W. B. Saunders Co., pp. 103, 105, 106.

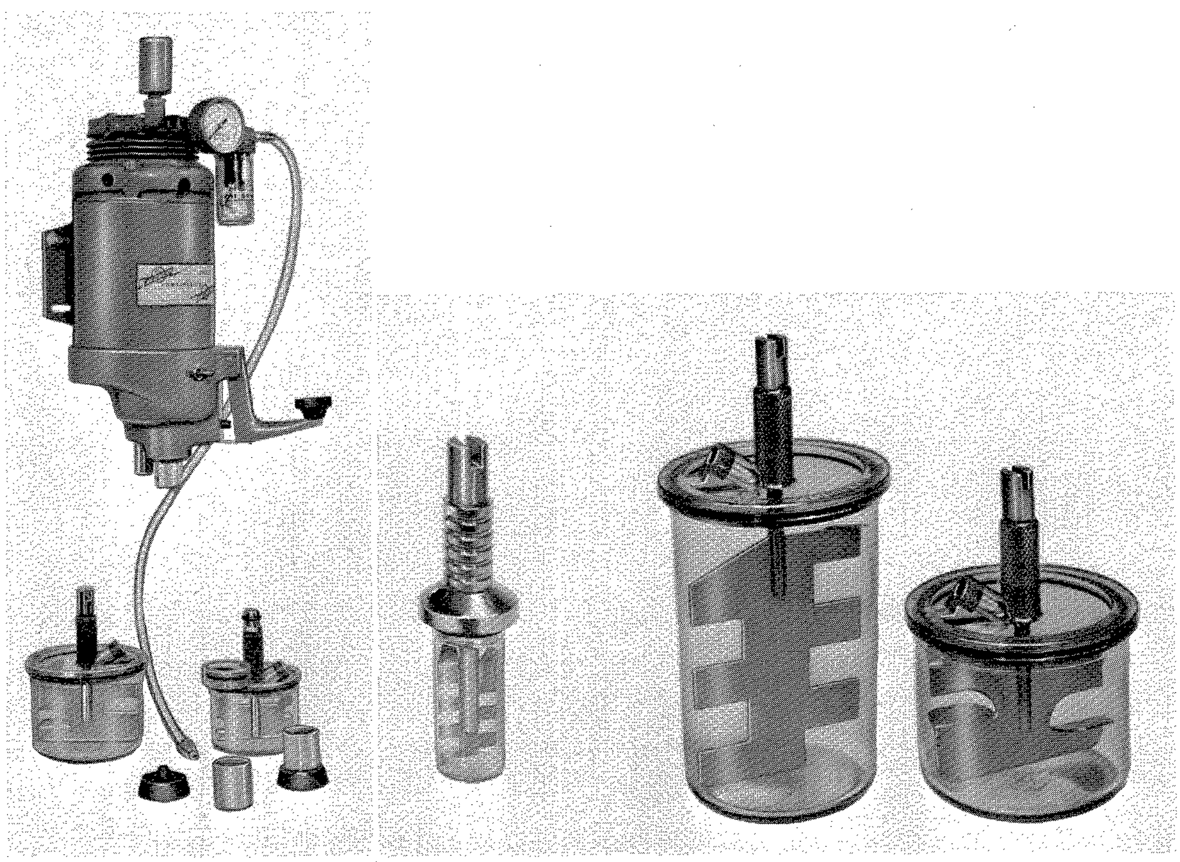
A



B

Fig. 7-64. Accurate measuring devices for water-powder ratio. **A,** Burette, **B,** Scale.

A



B

Fig. 7-65. Means of mechanical spatulation. **A,** Power mixer and Vac-U-Spat. **B,** Die mixer and Vac-U-Mixer. (Courtesy Whip-Mix Corp., Louisville, Ky.)

does the amount of vibration that accompanies the flowing of the stone into the impression. Use mild agitation or vibration. It also is important that the stone be added slowly and in small quantities. Put the stone in one section of the impression, and allow the stone to flow into the other parts of the impression from this initial point of application. (See Figs. 7-66 to 7-69.)

While the stone is setting, the poured impression is placed into a humidor in an atmosphere of 100% humidity.

The poured impression should never be put in the same solution as that used to immerse the impressions coming from the chair. It is thought that the salt from the stone comes out in the solution and very soon enriches the solution so that succeeding impressions are warped.

Another method that is used by some men for pouring up the hydrocolloid impression is to vibrate gently the properly mixed stone into the impression, using small increments of stone until the cavity portion is filled completely. A portion of the remaining stone is dried partially by compressing it in a towel, placing it on top of the softer material in the impression, and lightly vibrating for a few seconds to create a union of the two parts. This results in a very hard stone die or cast.

Fig. 7-66

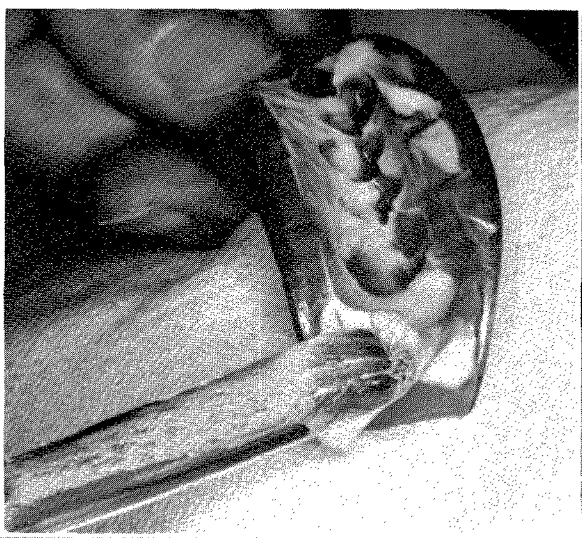


Fig. 7-6

Fig. 7-68

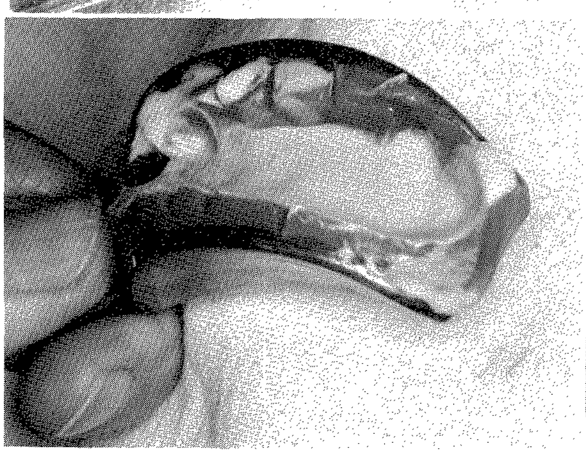
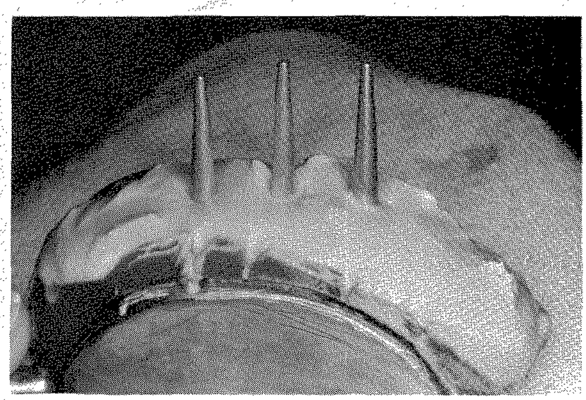


Fig. 7-6



Figs. 7-66 to 7-69. Correct pouring of small elastic impression. Put stone in one section of impression and allow it to flow to other parts of impression, using mild vibration and adding stone slowly and in small quantities. Position dowel pins and place immediately in a humidor.

Dowel pins

Before the impression is poured, if removable stone dies are desired, dowel pins may be suspended in position by means of straight banker's pins and sticky wax or use can be made of the Mann paralleling instrument (Figs. 7-70 to 7-72), or they may be placed in position, after the initial pour, in previously marked areas.

Figs. 7-70 to 7-72. Mann paralleling instrument is excellent for suspending dowel pins into position.

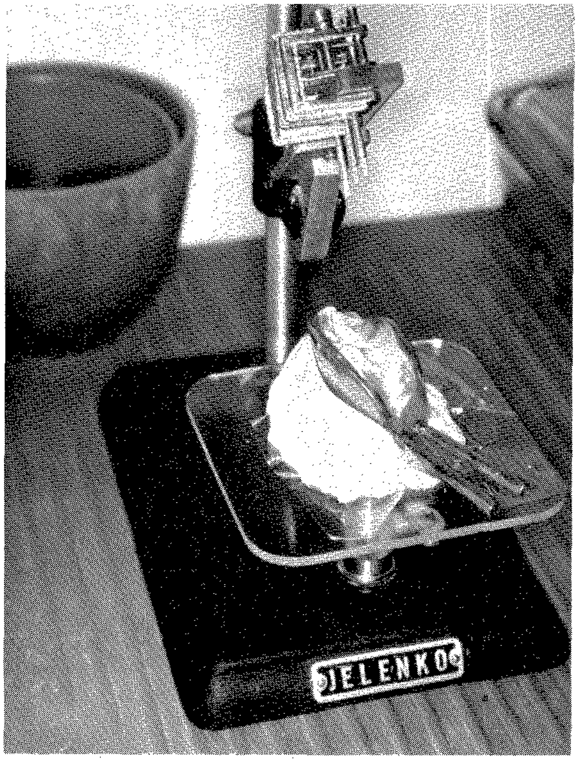


Fig. 7-70. Impression (with moist cotton in cavity area) is positioned on base of paralleling instrument by means of quick-setting impression plaster.

Fig. 7-71. Dowel pins aligned so that they center correctly in each preparation area and are parallel to each other. Stone poured and pins lowered into position.

Fig. 7-72. Whole assembly is covered with a wet towel to obtain an atmosphere close to 100% humidity.

Fig. 7-73

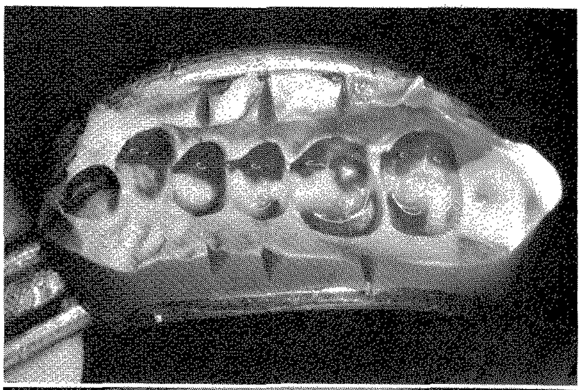
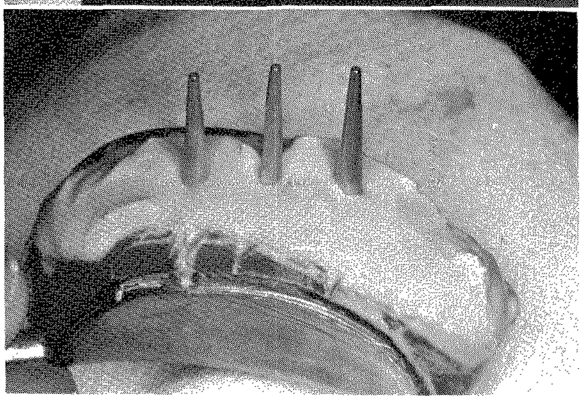


Fig. 7-74



Figs. 7-73 and 7-74. Dowel pins can be placed in position, after initial pour, in previously marked areas (small **V**-shaped "cutouts").

(Figs. 7-73 and 7-74). The Di-Lok technique is also very good.

After the poured impression has been in the humidor for thirty minutes, a second mix of stone (if dowel pins are used) of a different color but with identical physical properties is added to the first mix and is returned immediately to the humidor for another thirty minutes (Figs. 7-75 to 7-77). This step is very useful in die separation because, when the saw cut reaches the stone of the second color, we know that the cut has been completed.

After being in the humidor for sixty minutes from the time of the initial pour, the cast is separated from the impression (Fig. 7-78). Premature separation will cause a rough surface. No attempt should be made to work on the die or cast (such as waxing and carving) until the stone has hardened fully, approximately twenty-four hours later.

Trim the dies while still damp, if possible, to avoid chipping. Properly trimmed dies give

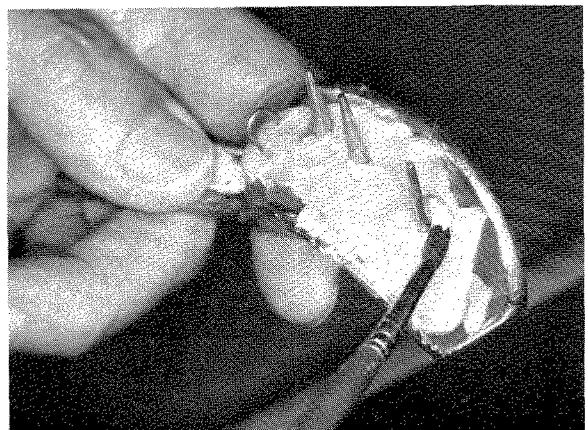


Fig.

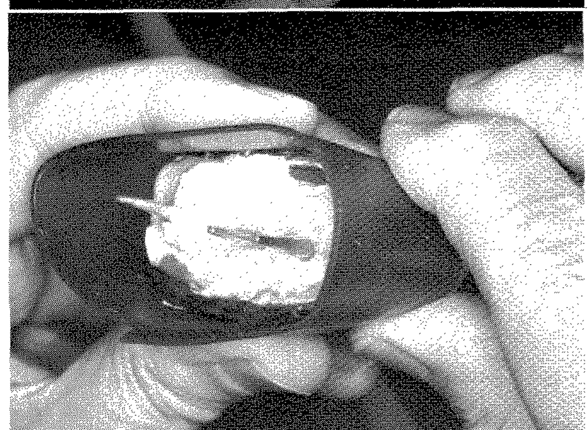


Fig.

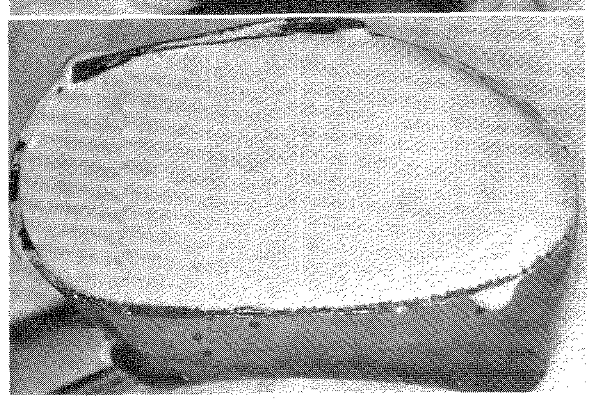


Fig.

Figs. 7-75 to 7-77. After poured impression has set, a coat of separating medium is applied over areas of dies that are to be removable, the impression is boxed and poured with a stone of a different color but identical physical properties. A stone of different color for this second pour is necessary for convenience in die separation.

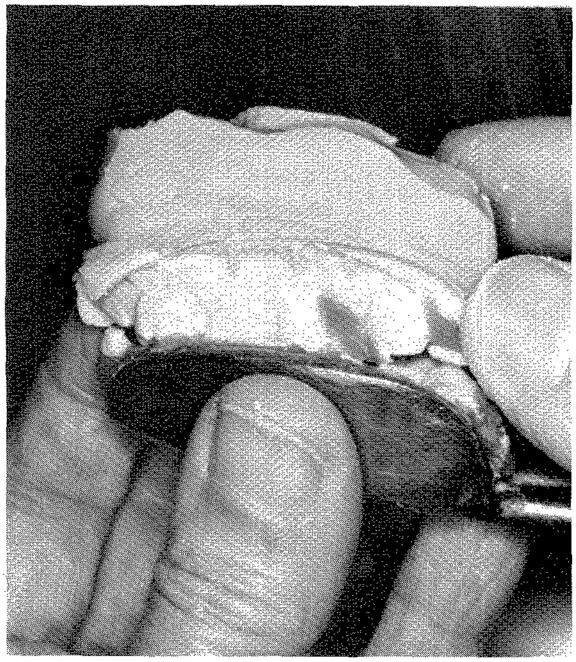


Fig. 7-78. Carefully separate cast from impression after it has been in humidor for forty-five to sixty minutes. Premature separation causes rough surfaces.

good access to all cavity margins; therefore the proper removal of stone bulk around the root portion is necessary. This allows for the proper use of the carving tool while contouring the margins of the wax patterns.

Important factors in use of gypsum products

Docking points out some very important factors to consider when gypsum products are used:

1. "Particle size, setting time, expansion and strength are the important physical factors, and some manufacturers furnish this data on the product label.

2. "The mixing ratio is the key to the proper use of gypsum products. Plaster, artificial stone, and the extra strength die stones differ physically, but are based on the same chemical entity—calcium sulfate hemihydrate. Their chief physical difference lies in the compactness and uniformity of the crystals. With an artificial stone, less water is required for a given consistency than with plaster. The water-powder ratio recommended by the manufacturer usually can be relied upon to give the optimum properties for a particular product.

3. "One of the ways of producing relatively gross distortion of the impression is to invert the filled impression and press it firmly down into a heap of stone on the bench.

4. "Soaking in water, glycerin, or oil was not found to improve the surface hardness or abrasion resistance, and it definitely reduced the crushing strength of the stones investigated.

5. "Although plasters and stones are commonplace materials, they require care in handling for best results. This entails the selection of suitable products for the work in hand, correct proportioning for optimum strength and hardness, careful spatulation and pouring to minimize porosity, and adequate precautions concerning any impression materials and separating media that come into contact with them."*

Copper tube–modeling compound impression

When to use

I use the copper tube–modeling compound impression when retraction of the gingival tissue to take a hydrocolloid or rubber base impression is impossible without radical procedures. This applies only to full veneer crowns.

Technique

An annealed copper band is selected as soon as the peripheral outline of the preparation has been established. The band should fit the cervical margin snugly and should be festooned to fit slightly over the shoulder or chamfer. Be sure to smooth the edges of the band, to stone the inner surface of the band at the gingival edge for about 2 mm., ensuring a positive seal of the compound to the band, and to have the band parallel to the long axis of the tooth. Be sure that the festooned band will stay firmly in place when tested for rocking with finger pressure. Mark the labial or buccal surface of the band for identification. (See Fig. 7-79.) The above procedure must be executed with great care so that the gingival tissue is not damaged.

Soften the compound by means of dry heat

*From Docking, Allan R.: Plaster and stone, D. Clin. N. Amer., pp. 727-735, Nov., 1958.

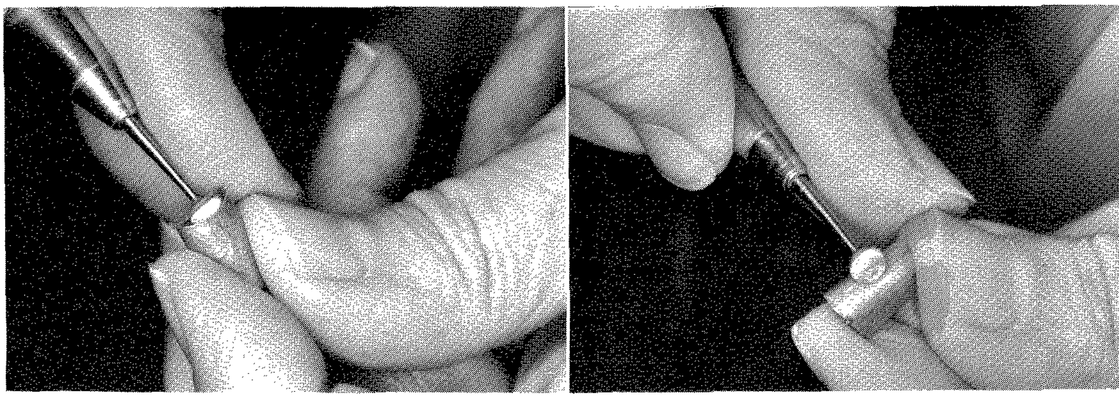


Fig. 7-79. Copper band prepared to fit cervical margin snugly, going slightly over shoulder or chamfer. Smooth edges, stone inner surface of band at gingival edge for 2 to 3 mm. to get a positve seal of compound to band, and mark facial surface for identification.

tempering the surface, which will contact the tooth in hot water. Seat the filled band carefully on the prepared tooth, which has been slightly lubricated with petroleum jelly, and when it is in position, which will be evident when a little compound is forced out at the cervical area, put pressure on the impression material with a finger. Chill with tepid water, or hold without chilling for three minutes, and remove the band with a steady vertical pull after all excess compound has been removed subgingivally and occlusally. The impression also can be removed with the aid of a Baade pliers or the Rubin copper tube impression remover in the long axis of the tooth. Never rock or twist the band impression when removing it from a tooth. (See Figs. 7-80 and 7-81.)

Examine the impression very carefully for all preparation details. In some instances the impression is rebased with George copper die electroconductive wax (Fig. 7-82). This particular type of wax does not harden completely when it sets so that care must be taken to prevent distortion. Impressions taken with copper bands can temporarily detach the gingiva from the root, but the removal of all particles of impression material from this area will be followed by a healing of the gingival margin.

Making the die

The die from this impression can be copper-plated, or a die can be made of stone.

Fig. 7-80. Position copper tube–modeling compound impression with great care. Chill with tepid water or hold without chilling for three minutes. Remove with steady vertical pull after excess compound has been removed subgingivally and occlusally.

A B C D E F G

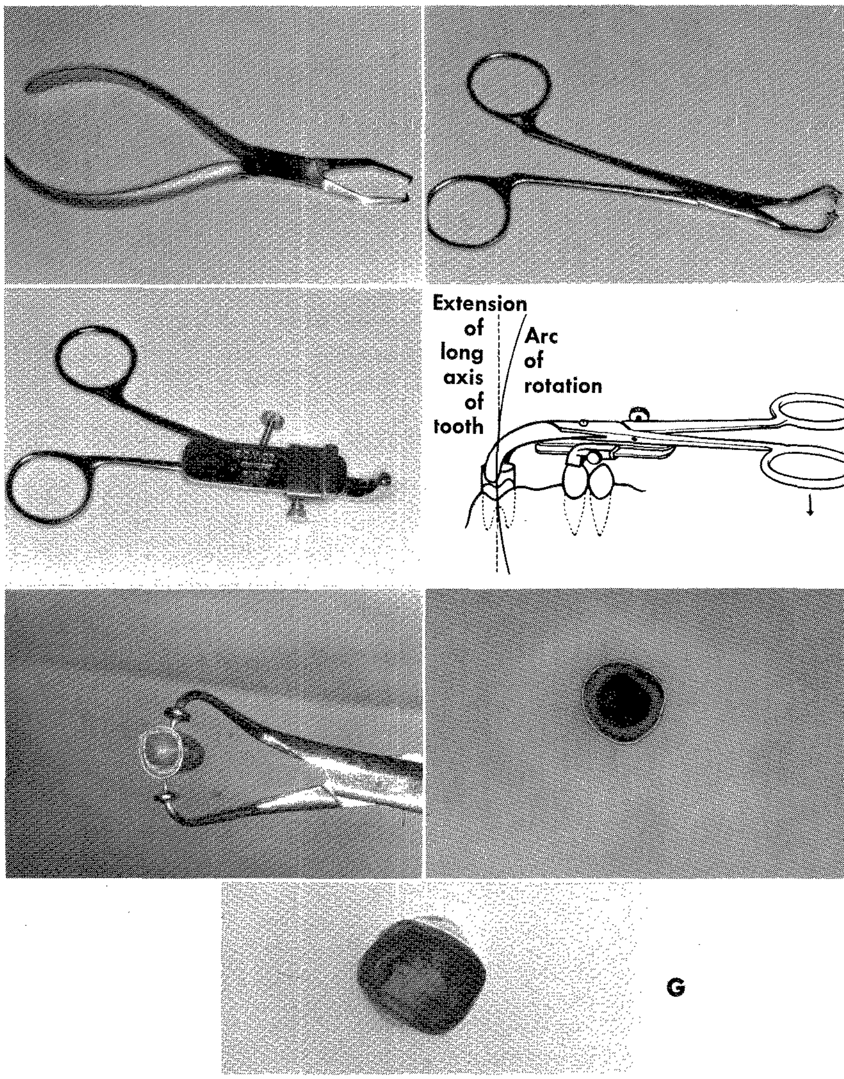


Fig. 7-81. Special pliers such as Rubin and Baade can be used in removal of copper tube–modeling compound impressions. (**D** courtesy Buffalo Dental Mfg. Co., Brooklyn, N. Y.)

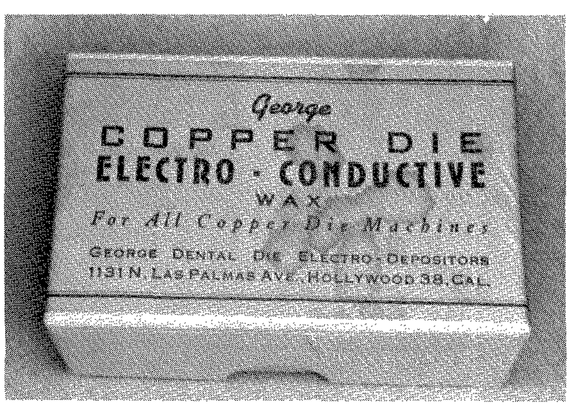


Fig. 7-82. Copper tube–modeling compound impression rebasing material for greater accuracy.

Pouring the impression in stone

Wrap the band with a piece of 30-gauge casting wax extending 8 to 10 mm. beyond the cervical margin.

Again, remembering the need of following the manufacturer's instructions as to the recommended water-powder ratio, carefully spatulate the mix and introduce small increments of stone into the impression by the use of mild vibration, thereby avoiding any imperfections or voids in the finished die. When the impression has been filled with stone, insert a Jelenko or Ney brass dowel pin to ensure a good handle when the pattern is being waxed (Fig. 7-83).

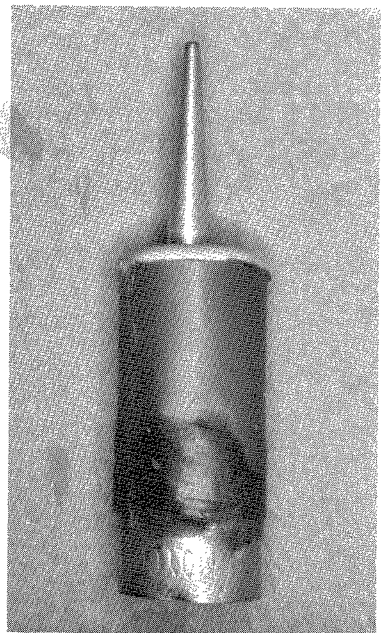
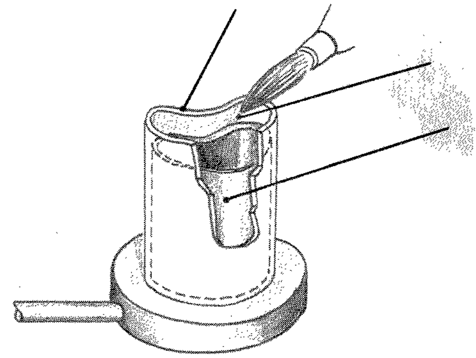


Fig. 7-83. Copper tube–modeling compound impression wrapped with a piece of 30-gauge wax extending 8 to 10 mm. beyond cervical margin. Fill with stone and insert brass dowel.



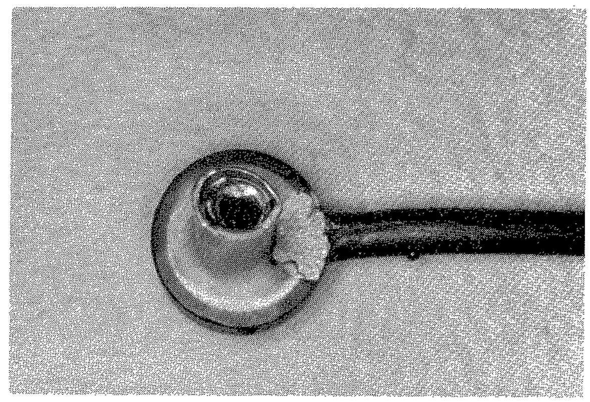


Fig. 7-84. Tube impression attached to cathode platform. It has a 2 mm. collar of wax (protection skirt), which is metallized with the impression.

Copperplating the impression

Copperplated dies offer dimensional accuracy and edge strength, making it possible to obtain fine margins. They offer good surface strength and therefore, may be swaged against; they will not contaminate precious metals.

For proper contact, trim any excess compound or wax at the closed end of the band to expose the edge of the copper band and ensure metal-to-metal contact with the cathode platform. Wash the impression, dry it thoroughly, and attach it to the cathode platform with sticky wax. Cover the joint of the holder and platform with wax.

Adapt the usual 28-gauge wax chimney closely to the band after it is attached properly to the cathode platform, as previously described. Trim the wax to within 2 mm. of the band, and metallize this 2 mm. collar of wax with the impression, using Flash* or Aqua Dag.† In other words, the impression is made conductive by metallizing it with graphite (Fig. 7-84). Apply this with a small brush, using a rotary motion and making sure that every surface and angle is metallized thoroughly and is extended to the 2 mm. collar of 28-gauge casting wax. The metallized 2 mm. chimney plates a copper protection skirt,[7] this added area obviating the possibility of the dentist or the technician marring the definitive marginal area of the die by the accidental slip of the stone, disk, or bur that is used in its trimming. Use compressed air very carefully to force all excess graphite from the impression and to dry the surface.

Over this metallized 2 mm. chimney adapt another layer of 28-gauge wax in the usual way, leaving it unmetallized. Wind this layer of wax tightly around the band and lute it together securely, forming one waxed unit with the cathode platform and covering all metal surfaces. The metallized impression is now ready for the tank.

Wet the impression in copper electrolyte, retaining a little of the electrolyte in the im-

*Hanau Engineering Co., Inc., Buffalo, N. Y.
†Acheson Colloid Corp., Port Huron, Mich.

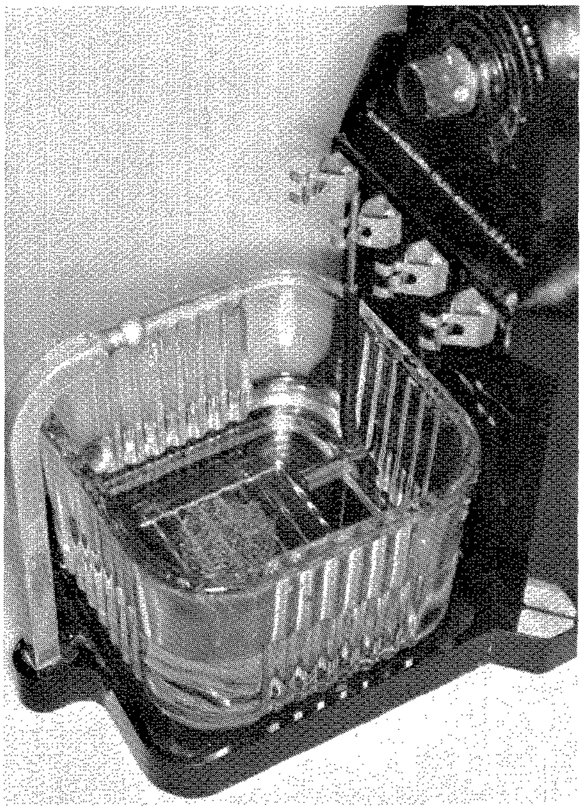


Fig. 7-85. Metallized impression on cathode platform is lowered into electroforming unit. Cathode holder is inserted into cathode clip of unit.

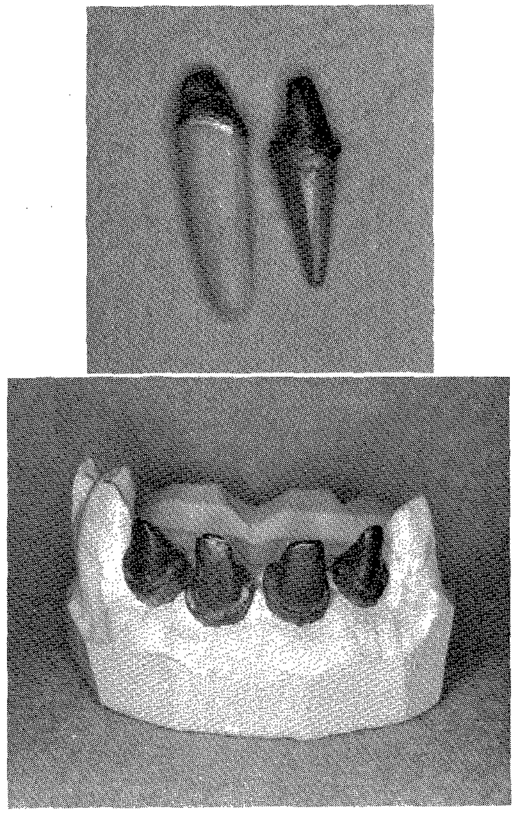


Fig. 7-86. Base or root of copperplated die can be made of plastic or low-fusing metal.

pression, and sprinkle control powder over the impression so that all metallized areas are covered thinly with this powder. With a medicine dropper containing some copper electrolyte, mix control powder by playing the liquid back and forth from the dropper to the impression until the blue of the electrolyte has disappeared and a copper-colored sludge has been created.

Wash the impression under the tap or, if necessary, use a forced stream of water, since the impression must be clean of all sludge. Insert the cathode holder into the cathode clip of the electroforming unit, avoiding trapped air. To eliminate the possibility of air entrapment it is advisable to fill the impression with some electrolyte such as ethyl alcohol before the cathode is lowered into the bath. (See Fig. 7-85.)

Start the electroplating at 1/2 of 1/10 (0.05) ampere and allow the impression to remain in the bath at this amperage for about twenty minutes, after which it should be removed and examined to see that the electroplating is being uniformly deposited. If so, replace it in the copper sulfate bath for eight to ten hours or overnight, raising the current to 0.1 ampere.

After completion of the deposit, remove the impression from the cathode support and wash under the tap, neutralize with sodium bicarbonate, wash again, and dry with air. Box with wax or Mystik tape to receive the stone, clear plastic, or low-fusing metal for a base or root. If a low-fusing alloy such as Dialoy* is used, coat the surface of copper with a film of 50% zinc chloride, which acts as a flux and permits a union of the low-fusing alloy with the copper.[9] Lucia[8] advocates reinforcing the plated band with soft solder and attaching a metal stem to the solder, thus ensuring a crush-proof die.

When this base material has set, warm the impression and remove the die, which should be cleaned to remove all traces of debris. Then the base can be trimmed to the desired shape. (See Fig. 7-86.)

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*J. M. Ney Co., Hartford, Conn.

Temporary coverage

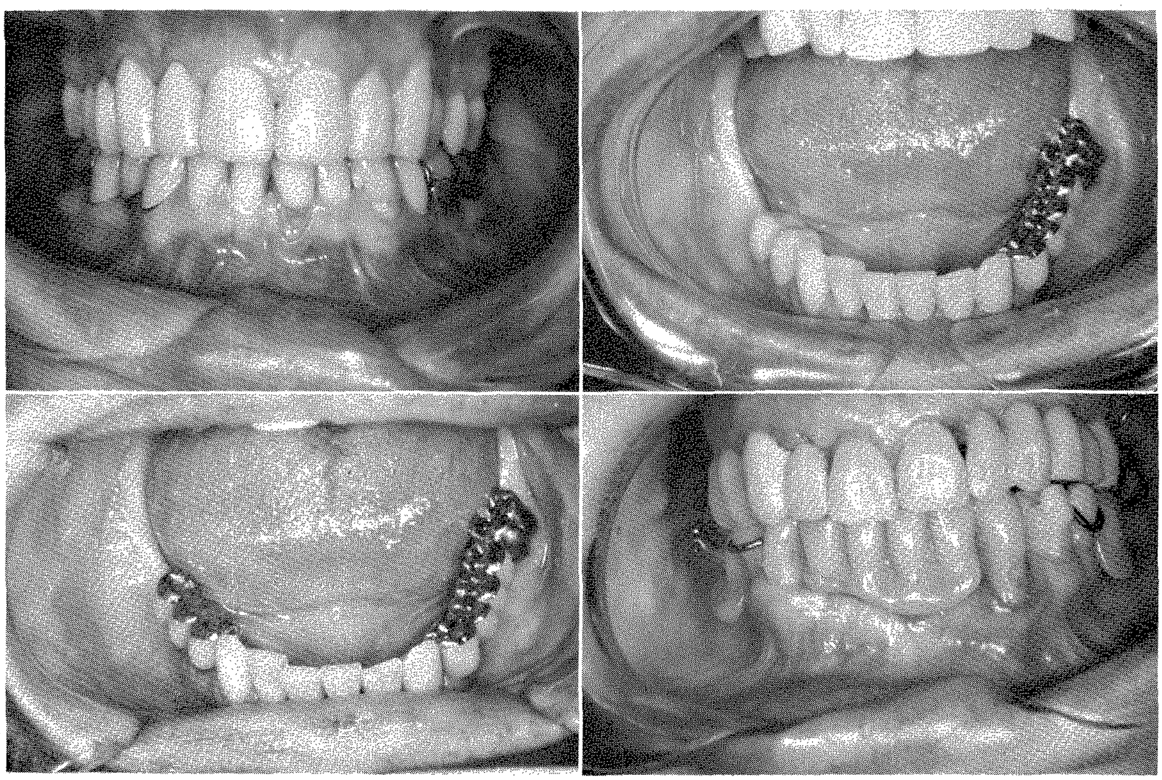
Necessity for temporary restorations

After the teeth have been prepared and the impressions taken the next step is the construction of well-made temporary restorations.

Good "temporaries" is a must because of the importance to seal freshly cut areas, especially the cervical finish lines, and to obviate the possibility of forces being introduced that would cause positional tooth changes to take place. This type of coverage, provided coronal contours, embrasures, contact areas, margins, and occlusal form are executed properly, will maintain the necessary positional relationships in the interval between preparation and placement of the permanent restoration. Also it will allow hyperemic pulps, which were caused during tooth preparation, to recover and possibly to form secondary dentin because of the temporary sedative cement used. It also serves to test parallelism of abutment preparations and to determine the correct vertical dimension, esthetic possibilities, minor tooth movements, status of temporomandibular joint disorders, questionable teeth, and state of health of the periodontal tissues before the construction of the final restoration.

I feel that one cannot compromise this phase of the operation. The consumption of time and nervous energy is costly, economically and physically, if inadequate temporary restorations are constructed because of breakage, displacement, gingival irritation, positional changes, etc. Gold or gold-acrylic temporary restorations should be made for all patients except the ones that can be completed in a very short span of time. (See Fig. 7-87.)

A



B

C

D

Fig. 7-87. Temporary restorations must be adequate and gingival irritation should not occur. **A,** Adequate upper temporary acrylic resin splint extending from right second bicuspid to left cuspid. **B,** Well-formed acrylic resin splint (lower right side) that did not cause gingival irritation and allowed placement of permanent restoration in a healthy environment, **C. D,** Inadequately constructed temporary acrylic resin splint caused gingival irritation—upper right lateral, cuspid area, and left central, lateral area.

Construction of temporary restorations
Technique 1 (acrylic temporaries)

1. An alginate impression is taken of each arch, hinge-bow transfer made, and centric bite taken for mounting on an anatomic articulator. This allows for the making of the acrylic splints before any tooth preparations have been started in the mouth.

2. Mounted casts are equilibrated for gross discrepancies, and the teeth on the casts are prepared to conform approximately to the anticipated preparation in the mouth. Slight underpreparation allows for an easier seating of the acrylic splint shell (Fig. 7-88).

3. The cast tooth preparations are lubricated with a die lubricant, and the case is waxed with great care. Attention is given to coronal contours, embrasures, occlusal form, and replacement of missing teeth (Fig. 7-89).

4. The wax form is removed from the cast and processed in acrylic, being sure to use one of proper shade. After processing, the wax form is returned to the mounted casts and occlusal and other adjustments are made, including an intracoronal reaming of each restoration with a suitable bur leaving a form of eggshell thickness (Fig. 7-90).

5. Holes are punched with a suitable bur all along the lingual surface, which later (see step 8) will allow for a correct seating of the

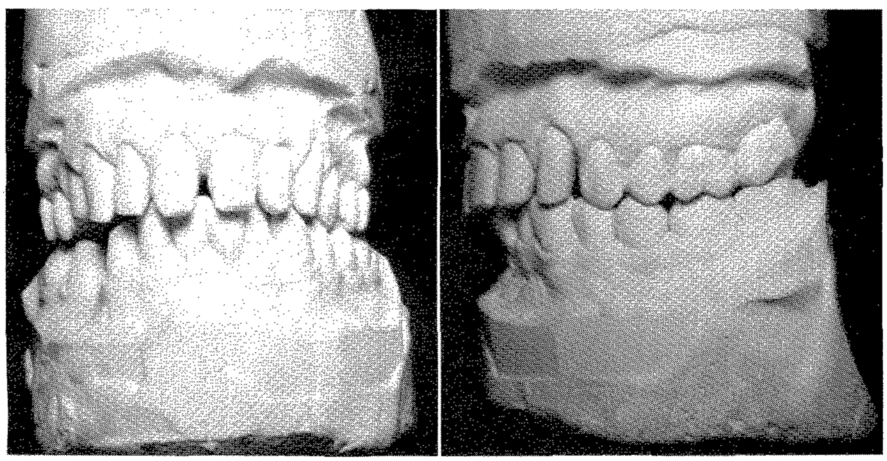
A

B

Fig. 7-88. Underpreparation of teeth on mounted casts to conform approximately to anticipated preparations. **A,** Anterior view. **B,** Side view.

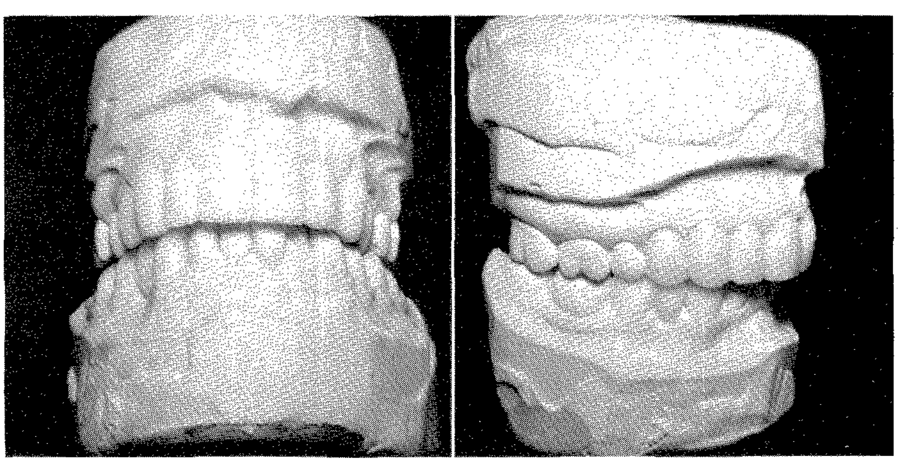
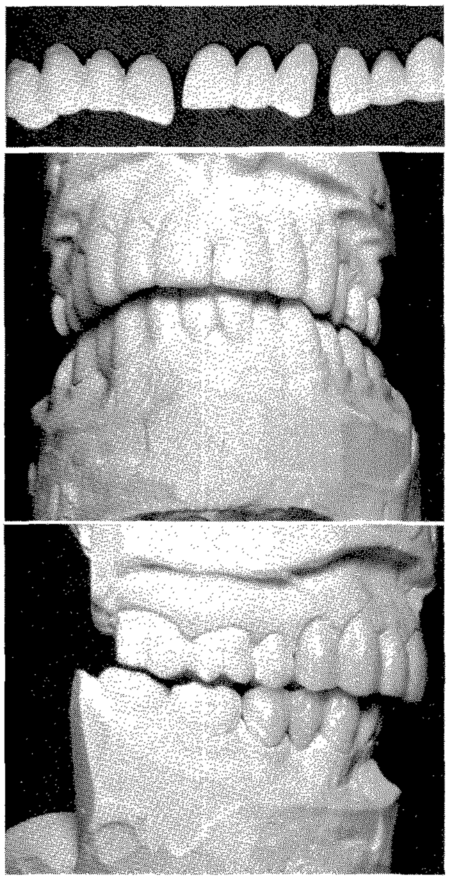
A

B

Fig. 7-89. Case waxed with great care, giving attention to coronal contours, embrasures, and occlusal form. **A,** Anterior view. **B,** Side view.



A

B

C

Fig. 7-90. Processed wax forms returned to mounted casts; adjustments made, including an intracoronal reaming of each restoration leaving a form of eggshell thickness. **A,** Processed forms. **B,** Anterior view after adjustments and intracoronal reaming. **C,** Side view.

filled splint because of the problem of hydraulics (Fig. 7-91).

6. The abutment teeth in the mouth are prepared, and the acrylic splint is tried in to test for complete seating. The acrylic shell usually is thin enough and flexible enough to fit over any prepared tooth, but, if it binds, the internal surface causing the interference is reamed out. Also make sure that there is no displacement of the splint shell in centric closure. If so, make necessary occlusal adjustments.

7. Preannealed, soft gold bands,* developed by Amsterdam,[11] are fitted carefully and festooned to the cervical finish line. Do not extend any part of the band into bifurcation or trifurcation undercut areas. After gingival adaptation the bands are removed and trimmed so that the occlusogingival height of the band does not exceed 1 mm. on the facial surface and 4 mm. on the proximal and lingual surfaces. Serrations are cut around the occlusal periphery of each band for retention of these bands in the acrylic.[11]

8. The prepared teeth are dried and lubricated with Splint Lube,* as are the soft tissues, the gold bands are reseated, the processed acrylic splint is filled with a mix of "quick-cure" plastic† and is seated over the prepared teeth contacting the serrated festooned bands. The patient is instructed to close the teeth slowly in centric relation, and excess acrylic is molded around the gingival margins of the teeth making sure that no gold bands are exposed. Excess flash on the lingual surface, where holes were punched, is removed while it is soft. After a short wait of approximately one minute, the bridge or splint is lifted slightly away from the gingival margin several times while the lining acrylic is setting in order to prevent binding when it is fully set. This is repeated several times

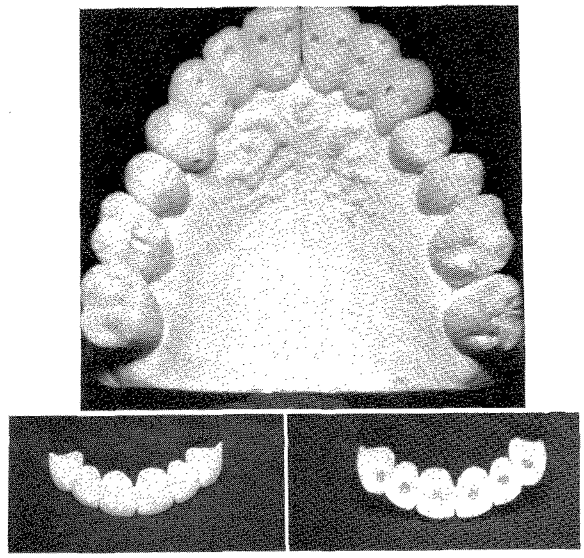


Fig. 7-91. Holes punched (with suitable bur) on lingual surface that subsequently will allow for correct seating during rebasing because of problems of hydraulics.

*J. M. Ney Co., Hartford, Conn.

*Williams Gold Refining Co., Buffalo, N. Y.

†Lang Dental Mfg. Co., Chicago, Ill. (Jet); Kerr Mfg. Co., Detroit, Mich. (Temp-Span).

during the setting process, the patient always closing in centric position after each slight lifting of the splint. The shell is cooled with water to prevent overheating.

9. After the final set the complete acrylic splint is removed. This procedure may necessitate gentle taps from a mallet on a gold plugger or the use of a reverse hammer crown remover moving from one area to another until the splint is released.

10. The gold bands must be attached firmly to the acrylic and in correct position. A thin mix of quick-cure acrylic is brushed around the exposed margins of the gold bands, care taken to keep any part of this mix out of the internal surfaces of the crowns.

11. The excess acrylic should be trimmed away, a recheck made in the mouth for correct form and fit, and the splint removed and polished.

12. It is ready now for cementation. This procedure can be used for full-arch or quadrant splints.

Technique 2 (acrylic temporaries)

Acrylic splint shells also can be made directly from alginate impressions taken of stone casts that were formed from the impressions taken in the mouth. In this technique rearrangement of coronal and occlusal forms is not as accurate as in technique 1.

1. An alginate impression is taken of each arch prior to tooth preparations. Hard stone casts are formed from these impressions.

2. Edentulous areas, if any, are filled in with acrylic teeth or properly molded wax, undercuts are waxed in, and the desired form on the abutment teeth is made by the addition of wax.

3. An alginate impression of the prepared cast is taken.

4. The next step is the construction of a thin shell of acrylic. Excess moisture is removed from the impression with a gentle blast of air, and the desired shade of acrylic, or preferably one of a shade lighter, is painted into the impression with a small sable brush. The brush is dipped into a dappen dish containing the liquid or monomer, and then a generous amount of powder is picked up by the moistened brush from a second dappen dish and is applied in the impression so that a uniform layer of acrylic will result. This process is continued, using a gentle blast of warm air after each layer is painted on and also tilting the impression to move the soft acrylic evenly and to prevent the formation of very thick sections. Armsterdam[11] flows a comparatively loose mix of "quick-cure" acrylic into a gently warmed alginate impression.

5. When set, the acrylic shell is removed carefully from the alginate impression. Any thin overextensions are removed with a small pair of scissors, and thick areas inside the shell are reamed out intracoronally with a suitable round bur, leaving a form of eggshell thickness. Holes are punched all along the lingual surface, which later (see step 8) will allow for a correct seating of the filled splint because of the problem of hydraulics.

6. The abutment teeth in the mouth are prepared, and the acrylic splint is tried in to test for complete seating. The acrylic shell usually is thin enough and flexible enough to fit over any prepared tooth, but, if it binds, the internal surface causing the interference is reamed out. A check should be made to be sure that there is no displacement of the splint shell in centric closure. If so, the necessary occlusal adjustments should be made.

7. Preannealed, soft gold bands, developed by Amsterdam,[11] are fitted carefully and festooned to the cervical finish line. No part of the band should extend into bifurcation and trifurcation undercut areas. After gingival adaptation, the bands are removed and trimmed so that the occlusogingival height of the band does not exceed 1 mm. on the facial surface and 4 mm. on the proximal and lingual surfaces. Serrations are cut around the occlusal periphery of each band for retention of these bands in the acrylic.[11]

8. The prepared teeth are dried and lubricated with Splint Lube, as are the soft tissues; the gold bands are reseated, the processed acrylic splint is filled with a mix of "quick-cure" plastic and is seated over the prepared teeth contacting the serrated festooned bands. The patient is instructed to close the teeth slowly in centric position, and excess acrylic is molded around the gingival margins of the teeth making sure that no gold bands are exposed. Excess

flash on the lingual, where holes were punched, is removed while it is soft. After a short wait of approximately one minute the bridge or splint is lifted slightly away from the gingival margin several times while the lining acrylic is setting in order to prevent binding when it is fully set. This is repeated several times during the setting process, the patient always closing in centric occlusion after each slight lifting of the splint. The shell is cooled with water to prevent overheating.

9. After the final set the complete acrylic splint is removed. This procedure may necessitate gentle taps from a mallet on a gold plugger or the use of a reverse hammer crown remover moving from one area to another until the splint is released.

10. Make sure that the gold bands are attached firmly to the acrylic and are in correct position.

A thin mix of "quick-cure" acrylic is brushed around the exposed margins of the gold bands, care being taken to keep any part of this mix out of the internal surfaces of the crowns.

11. The excess acrylic should be trimmed away; a recheck in the mouth should be made for correct form and fit, and the splint removed and polished.

If a change in vertical dimension is indicated, make use of an anterior acrylic stop to determine and hold the desired dimension, and add soft pads of acrylic to the occlusal surfaces of the splint or splints, and have patient close placing a piece of tinfoil, which prevents adherence to the opposing splint, or the opposing restoration during the set of the acrylic. In many instances more trimming and carving is necessary for the establishment of correct form and function with this method than with technique 1.

12. The splint is ready now for cementation. This procedure can be used for full-arch or quadrant splints.

Gold and gold-acrylic temporary restorations

These restorations are used for mouths that are not seriously involved periodontally and are free of temporomandibular joint disturbances. This type of a mouth can be prepared one quadrant at a time.

Technique. The first quadrant to be prepared is the lower right posterior region. Before preparations are started a rebased Tenax wax* bite is taken for the construction of "temporary temporaries" made of acrylic.

The Tenax wax is softened in a water heater or a bunsen burner, and a piece of tinfoil (0.002-inch thickness) is placed between two thicknesses of the wax like a sandwich. The "bite sandwich" is adapted on the lower right posterior teeth (in this particular instance), and the patient is told to close in centric position. After chilling, the bite is removed and dried. The upper portion of this bite is completely "candled" with a rope of Tenax wax, that is, in each tooth depression, and then the lower part of the bite (which has not been candled as yet) is seated on the lower teeth, and again the patient is instructed to close in centric position. This is chilled, removed, and dried with a blast of air, and the surplus wax on the upper part trimmed. The lower part of the bite is now completely "candled" with a rope of Tenax wax, the rebased upper portion seated carefully, and the patient told to close in centric position. It is chilled, removed, and dried, and the surplus wax trimmed. Some wax is removed in the gingival finish line area to allow for a greater bulk of acrylic for proper finishing purposes. We now have a rebased wax bite, which will allow for great accuracy of duplication of the coronal surfaces of the teeth before preparation (Fig. 7-92).

Preparations, partial or full coverage, are completed and elastic impressions taken. If possible at this time, two impressions are taken, one (and a bite) for the gold "temporaries" and one for the "finish dies" in the construction of the permanent restorations at the proper time. If indicated, copper tube–modeling compound impressions are taken for the construction of "finish dies."

The rebased Tenax wax bite is used now for the construction of the fast-curing acrylic "temporary temporaries." The prepared lower teeth and surrounding soft tissues are dried and lubricated with Splint Lube. A doughy mix of fast-curing acrylic (Temp-Span or Jet) is placed, in this case, in the lower section of the rebased bite, and the top of the acrylic mass is lubricated lightly with Splint Lube. The upper section of the rebased bite is seated carefully and

*S. S. White Dental Mfg. Co., Philadelphia, Pa.

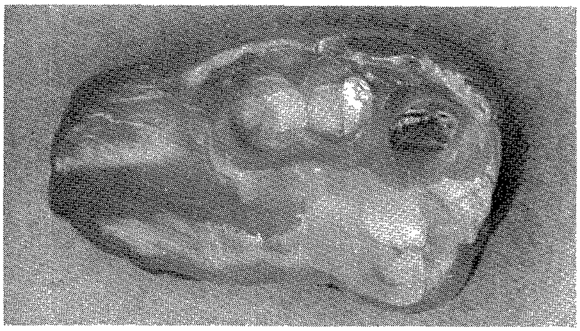


Fig. 7-92. Rebased wax bite, which will allow for great accuracy of duplication of coronal surfaces of teeth as they were before preparation. This method is excellent in construction of temporary acrylic crowns in many instances.

accurately, and the patient is told to close. Excess acrylic that seeps out of the bite is removed and used as a guide to the setting of the acrylic. When the final set has taken place, the wax bite is removed, and the lower acrylic splint is removed making use of a reverse hammer crown remover or gentle taps from a mallet on a gold plugger. The excess acrylic is trimmed away, and embrasures and cervical finish lines are established properly.

The acrylic splint is reseated to be sure that it seats accurately, without a rock. The occlusion is checked, after which it is removed, polished, and cemented with a temporary cement. This method is excellent for the construction of full crowns, three-quarter crowns, onlays, or other variations in the preparations.

One of the casts made from the elastic impression is mounted on a simple Crescent articulator* making use of the bite taken after the preparations were completed.

Any gross irregularities on the opposing model are cut away, and the gold temporaries are made to this newly established relationship. If possible, this temporary restoration is made in the form of a fixed splint for ease of removal and recementation during the various procedures used in mouth rehabilitation. The processing of acrylic veneers is completed in areas where indicated.

At the next appointment the gold temporaries are cemented wth temporary cement. The upper teeth in the right posterior quadrant are prepared as indicated by the lower gold restorations. A temporary acrylic splint is made for the upper right quadrant, using the rebased wax technique as previously described.

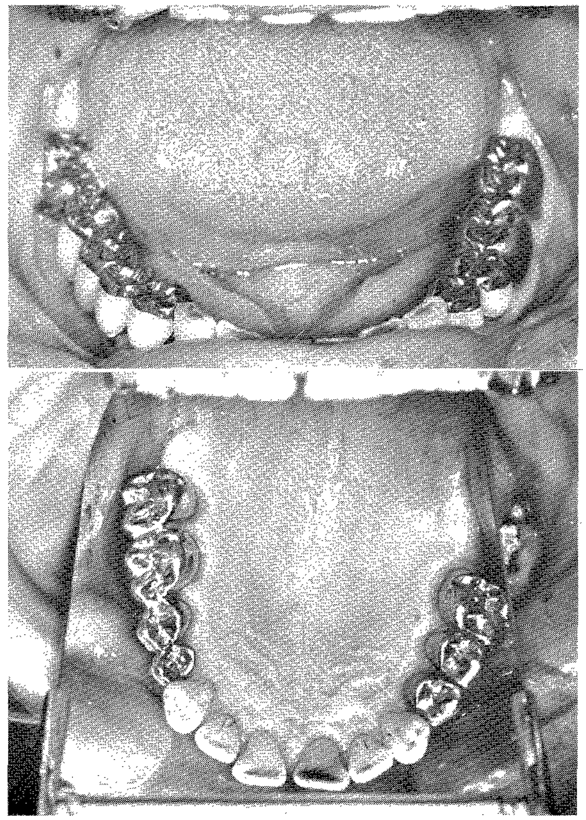


Fig. 7-93. Completed and cemented (zinc oxide–eugenol) temporary gold and gold-acrylic veneer restorations.

The same procedure is followed for the quadrants on the left side.

At this stage of the operation the gold temporaries have been cemented with temporary cement on the lower right and left posterior quadrants, and temporary acrylic splints have been cemented temporarily on the upper right and left posterior quadrants.

The upper acrylic restorations are removed, the prepared teeth are cleaned, and a full elastic impression is taken of the upper arch. Also a full elastic impression is taken of the lower arch with the gold temporaries in place. A hinge-bow transfer and centric relation bite (the patient is guided back into a centric bite as the upper gold temporaries will be made in correct centric) are taken. The upper and lower stone casts are mounted on an anatomic articulator with the

*Crescent Dental Mfg. Co., Chicago, Ill.

use of this bite and transfer. The upper gold temporary restorations are made and cemented with temporary cement (Fig. 7-93). The case is checked out for centric position and, if necessary, is equilibrated for lateral excursions directly in the mouth.

All restorations, although temporary, should be checked for accuracy of marginal fit, absence of rock or spring, correct relationship of coronal contours and embrasure patterns to gingival tissues to avoid "wash-outs" (leading to sensitivity and caries), and gingival irritations resulting in inflammation. We must not recreate pathology after it has been cured.

Mouths with serious periodontal involvements and temporomandibular disturbances

In mouths with more serious periodontal involvements and temporomandibular joint disturbances or muscle spasm, the temporary restorations must be constructed with the best occlusion possible to obtain at this particular stage of rehabilitation. It must be done on a completely adjusted anatomic articulator. The carvings and castings are made as accurate as possible, and at least one remount for adjustment is made before temporary cementation (Fig. 7-94).

Why all this painstaking work for a temporary or treatment restoration? By these means we have a better chance of obtaining correct interocclusal records, intermaxillary relations, and intra-arch relations. A better centric relation than the patient presented at the beginning of treatment allows healing and changes in the right direction to take place. As more remounts are made at various intervals and as changes occur, more stability and better occlusal relations are attainable. Periodontal tissues are brought within physiologic limits, temporomandibular joint symptoms subside, and joint stability is achieved.

A stable relationship must be obtained before permanent restorations are made. Temporary partial dentures, in conjunction with fixed restorations, also are constructed, when indicated, in cases of mouth rehabilitation. Care and thought in design and technical execution are most important.[12] (See Figs. 7-95 to 7-99 for treatment of the pulpless tooth.)

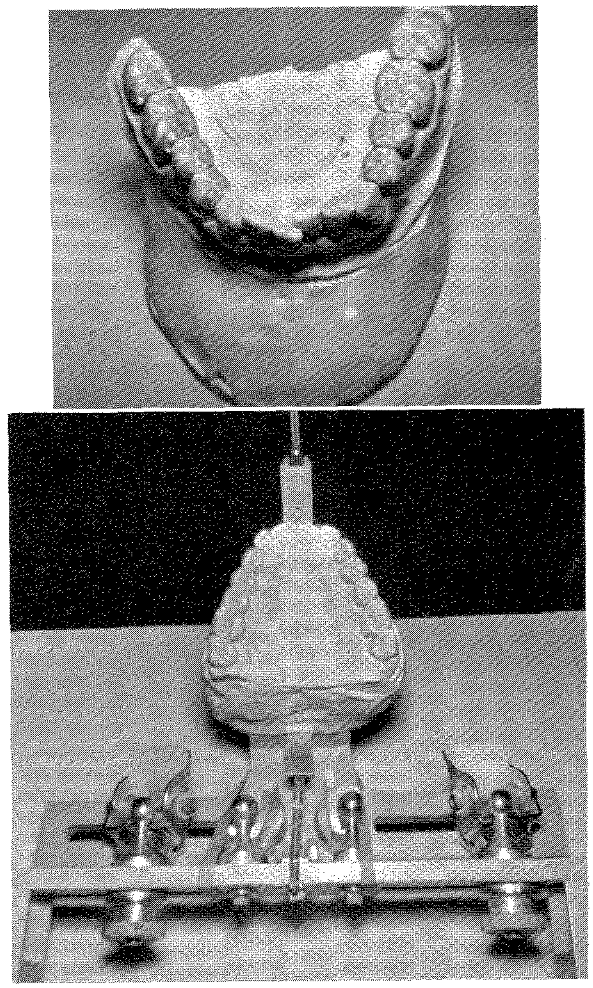


Fig. 7-94. Castings on mounted casts after first remount in case with temporomandibular joint disturbance.

Figs. 7-95 to 7-99. Series of illustrations showing various phases of construction of restorations for pulpless teeth, using agar hydrocolloid as impression material.

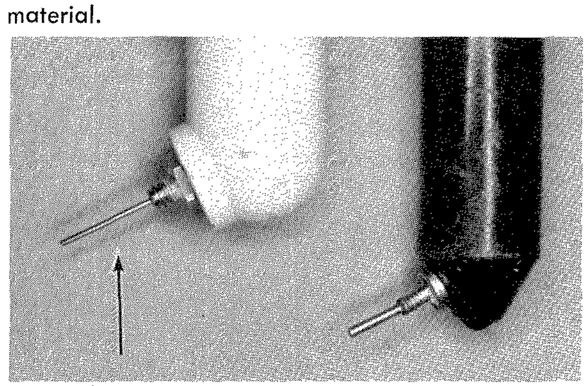


Fig. 7-95. Syringe with a special long needle for obtaining impression of prepared canals.

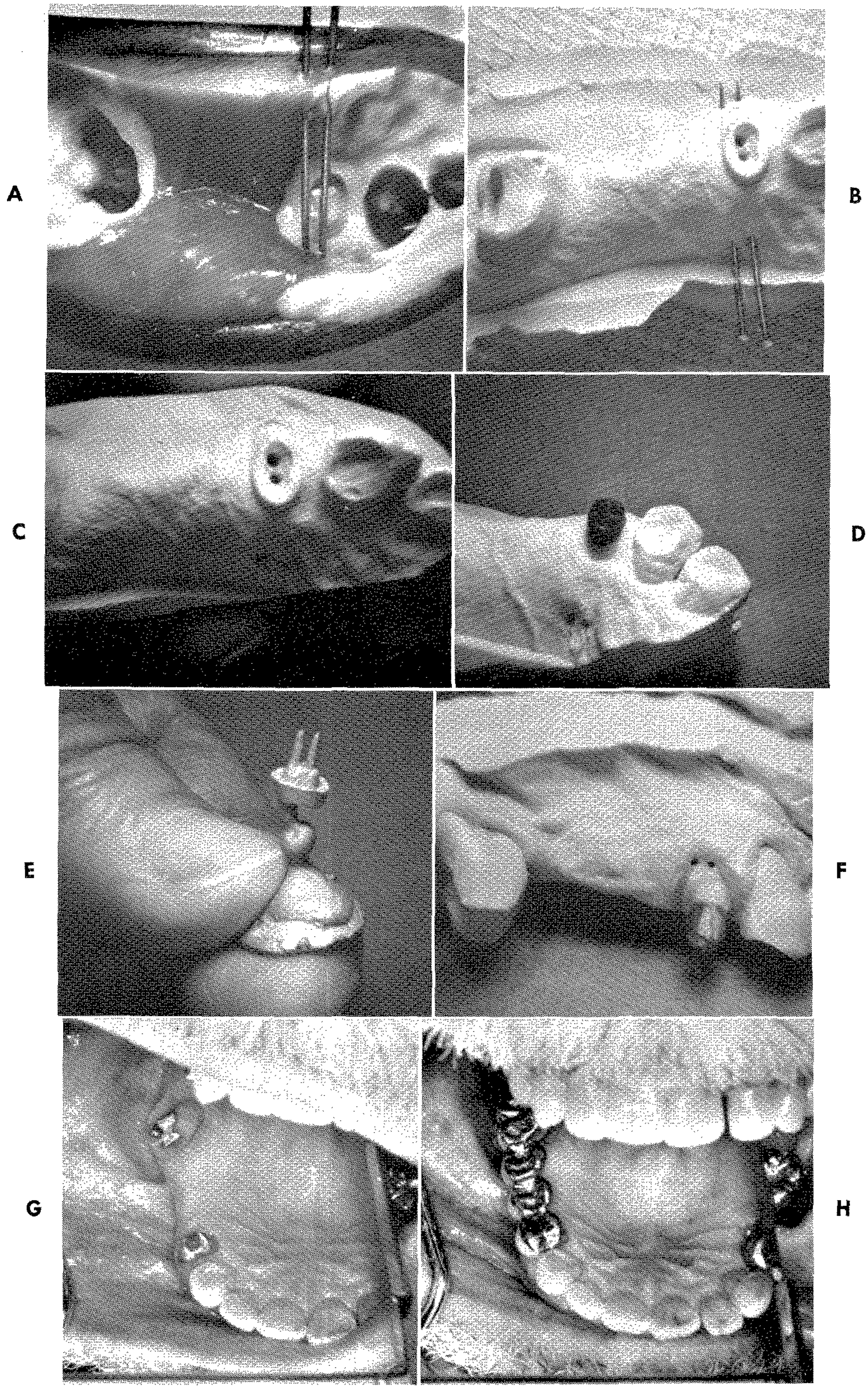


Fig. 7-96. A, Impression. **B** and **C,** Die and cast (one with banker pins still in position, other with pins removed). **D,** Wax-up. **E,** Post-anchorage cast gold core. **F,** Post-anchorage cast gold core shown on cast. **G,** Post-anchorage cast gold core in patient's mouth. **H,** Complete bridge in patient's mouth.

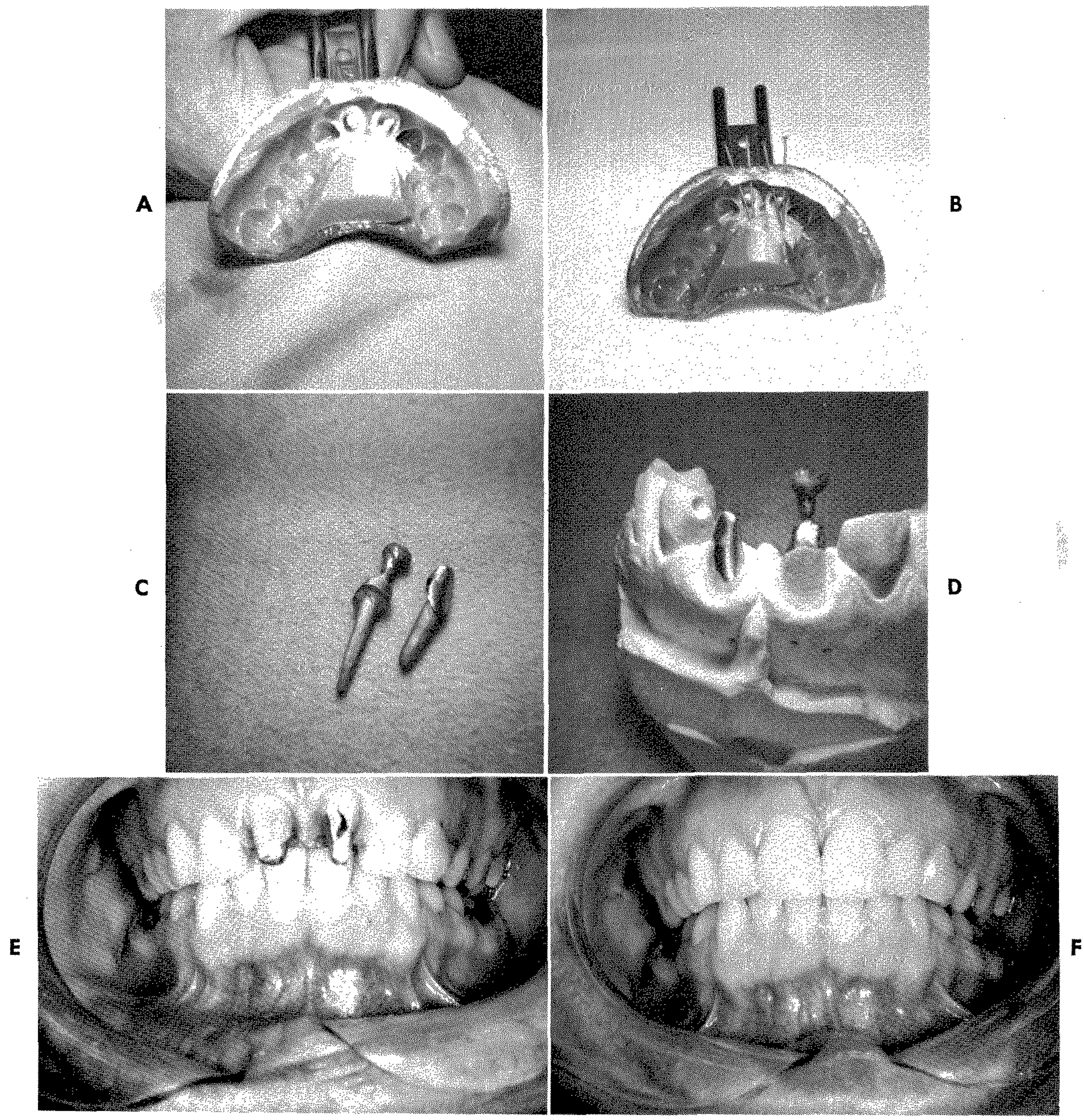


Fig. 7-97. Case of pulpless central incisors. **A,** Impression. **B,** Treatment of impression with banker pins before pour up. **C,** Post-anchorage cast gold cores. **D,** Cores on cast. **E,** Cemented cores. **F,** Completed case in mouth.

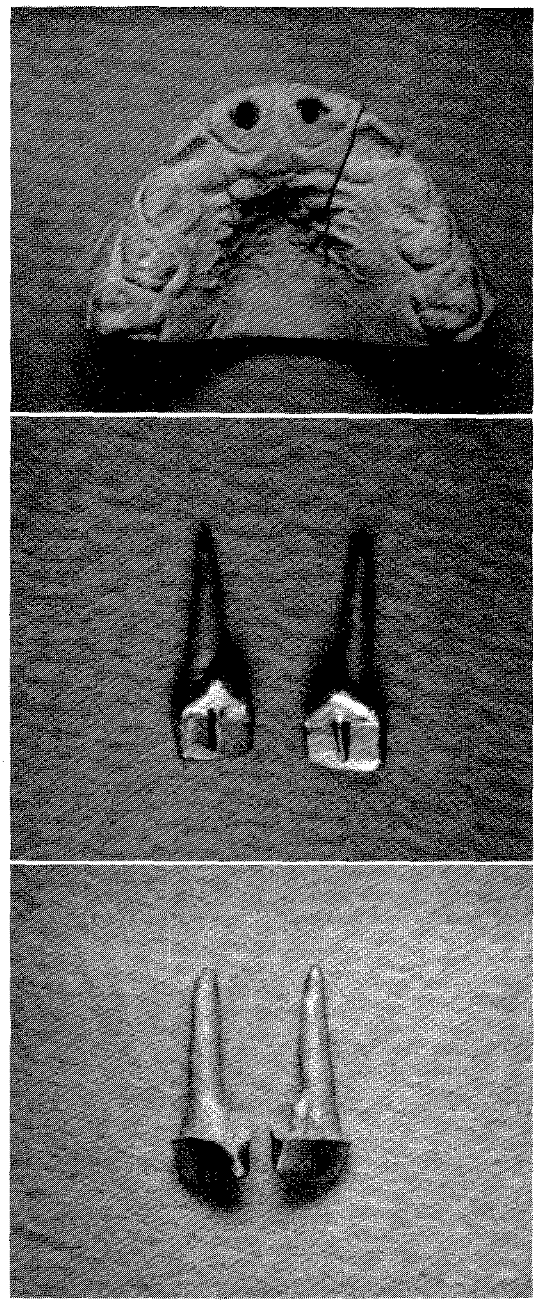
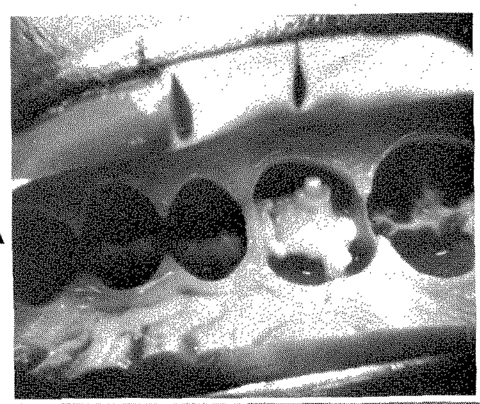


Fig. 7-98. Case of child 10 years old, involving upper central incisors. **A**, Cast. **B** and **C**, Labial and lingual views of post-anchorage cast gold cores.

A



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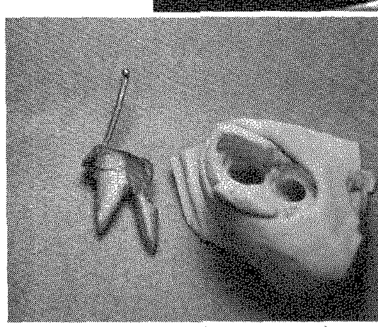

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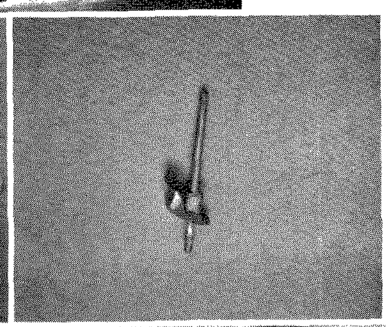

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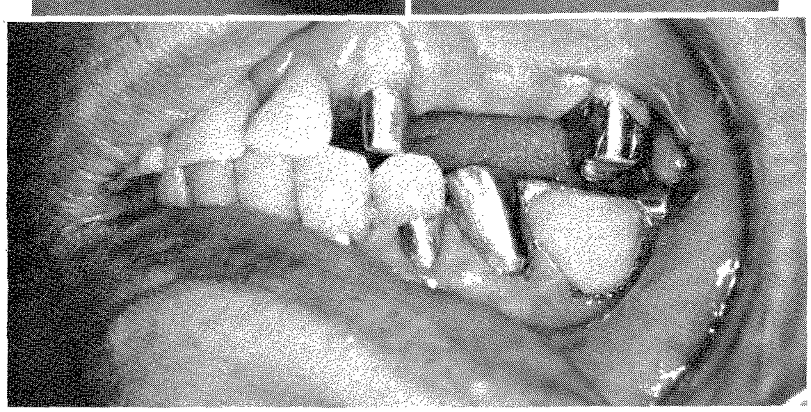


Fig. 7-99. A, Impression of pinholes with agar hydrocolloid. **B,** Post-anchorage cast gold core for an upper molar. **C,** Post-anchorage core making use of an endo-post. **D,** Cemented post-anchorage cast gold cores—cuspid and second molar.

REFERENCES

1. La Forgia, Anthony: Mechanical-chemical and electrosurgical tissue retraction for fixed prosthesis, J. Prosth. Den. **14**:1107-1114, 1964.
2. Phillips, R. W.: Hydrocolloid impression materials; technical considerations. In Skinner, E. W., and Phillips, R. W.: The science of dental materials, Philadelphia, 1960, W. B. Saunders Co., pp. 103, 105, 106.
3. Shooshan, E. David: A Pin-ledge casting technique—its application in periodontal splinting, D. Clin. N. Amer., pp. 189-206, March, 1960.
4. Courtade, Gerard L.: Creating your own "dentin," D. Clin. N. Amer., pp. 805-822, Nov., 1963.
5. Phillips, R. W., and Ito, B. Y.: Factors affecting the surface of stone dies poured in hydrocolloid impressions, J. Prosth. Dent. **2**:390, 1952.
6. Docking, Allan R.: Plaster and stone, D. Clin. N. Amer., pp. 727-735, Nov., 1958.
7. Weinberg, Lawrence A.: Atlas of crown and bridge prosthodontics, St. Louis, 1965, C. V. Mosby Co., p. 35.
8. Lucia, Victor O.: Modern gnathological concepts, St. Louis, 1961, C. V. Mosby Co., p. 368.
9. Bassett, R. W., Ingraham, Rex, and Koser, J. R.: An atlas of cast gold procedures, Buena Park, Calif., 1964, Uni-Tro College Press, pp. 48, 130.
10. Skinner, E. W., and Phillips, R. W.: The science of dental materials, Philadelphia, 1960, W. B. Saunders Co., pp. 103, 105, 106.
11. Amsterdam, Morton, and Fox, Lewis: Provisional splinting—principles and technics, D. Clin. N. Amer., pp. 73-99, March, 1959.
12. Granger, E. R.: Practical procedures in oral rehabilitation, Philadelphia, 1962, J. B. Lippincott Co., pp. 260-265.

Chapter 8

Casting

Wax pattern

GENERAL CONSIDERATIONS

A properly made wax pattern is an absolute necessity if an accurate fit of the cast restoration is to be achieved.

It has been pointed out that wax variables are probably the greatest material obstacle to accurate reproduction of cast restorations. Recent research work by Hollenback and Rhoads[1] shows that inlay waxes are a comparatively stable group of materials, and, although extremely small changes in dimension take place, they are insufficient to be detected clinically. In other words, wax is a stable material, provided it is handled correctly.

A knowledge of the individual characteristics of coronal form is of extreme importance in the development of the wax pattern. The ability to reproduce the coronal shape of a tooth with proper contour to afford proper tissue protection and stimulation and a good esthetic effect is of the utmost importance. Good functional occlusion is impossible to obtain without a good working knowledge of the occlusal characteristics of each tooth.

To obtain an accurate reproduction of the cavity surfaces the following must be considered.

1. The wax is applied best in a melted state since fewer strains are set up in this way. To avoid shrinkage the wax should be added in small successive layers and compressed with a finger while cooling. This produces a pattern that is denser, with a smaller degree of internal strain and better surface adaptation.

2. Undercut areas within the confines of the margins of the preparations in the die should be blocked out before waxing so that distortion on withdrawal of the pattern is prevented. The use of a high-fusing relief wax or a water-soluble poster paint[2] is advocated for this purpose before the dies are lubricated.

3. The wax pattern should be fabricated in a temperature environment as normal as possible—not directly under a light bulb or too close to a bunsen burner. Wax expands when heated and contracts when cooled. This expansion has been estimated to be 0.02% for each degree Fahrenheit of temperature change. Therefore shrinkages should be kept to a minimum. Working in an area of the laboratory that is as draft-free as possible can avoid change of dimension of the wax pattern with change of temperature.

4. Waxes of various melting temperatures, such as softer green inlay wax* for the inner core and marginal adaptation and harder blue inlay wax† for outer veneering to allow for better carving conditions are used.

5. Improper heating and overmanipulation produce stresses in the wax. When these stresses are relieved, the casting will be doomed through distortion, no matter how carefully the subsequent steps are carried out.

6. Temperature changes incident to investing of the wax pattern and the setting of the

*Slaycris Laboratories, Portland, Ore.
†Kerr Mfg. Co., Detroit, Mich.

investment serve to change or release pattern strains, which may produce both pattern and mold distortion.

7. Improper adaptation of the wax to the die and marginal adaptation and film thickness of the lubricant used can be the causes of ill-fitting castings.

8. Chilling the wax pattern too rapidly should be avoided since this will increase strains and distortions.

9. With the indirect technique, wax is applied to the dies in a melted state, and wax in this condition exhibits the greatest degree of linear thermal shrinkage. To compensate for this shrinkage all gingival margins of the patterns must be remelted and readapted carefully with finger pressure to the extent of 1 to 2 mm.

10. The wax pattern must be invested immediately upon removal from the die to avoid strain release with its resultant dimensional change and warpage.

11. Investing more than one pattern on a *single sprue former* is contraindicated because of the danger of distortion through uneven expansion.

12. When carving wax over stone dies, a warm instrument and one that is blunt rather than sharp should be used to avoid damaging the die. Excess wax is removed with a burnishing action from the wax toward the margin.

Preparation of the die

The necessity of obtaining removable dies, which maintain precisely the same relationships

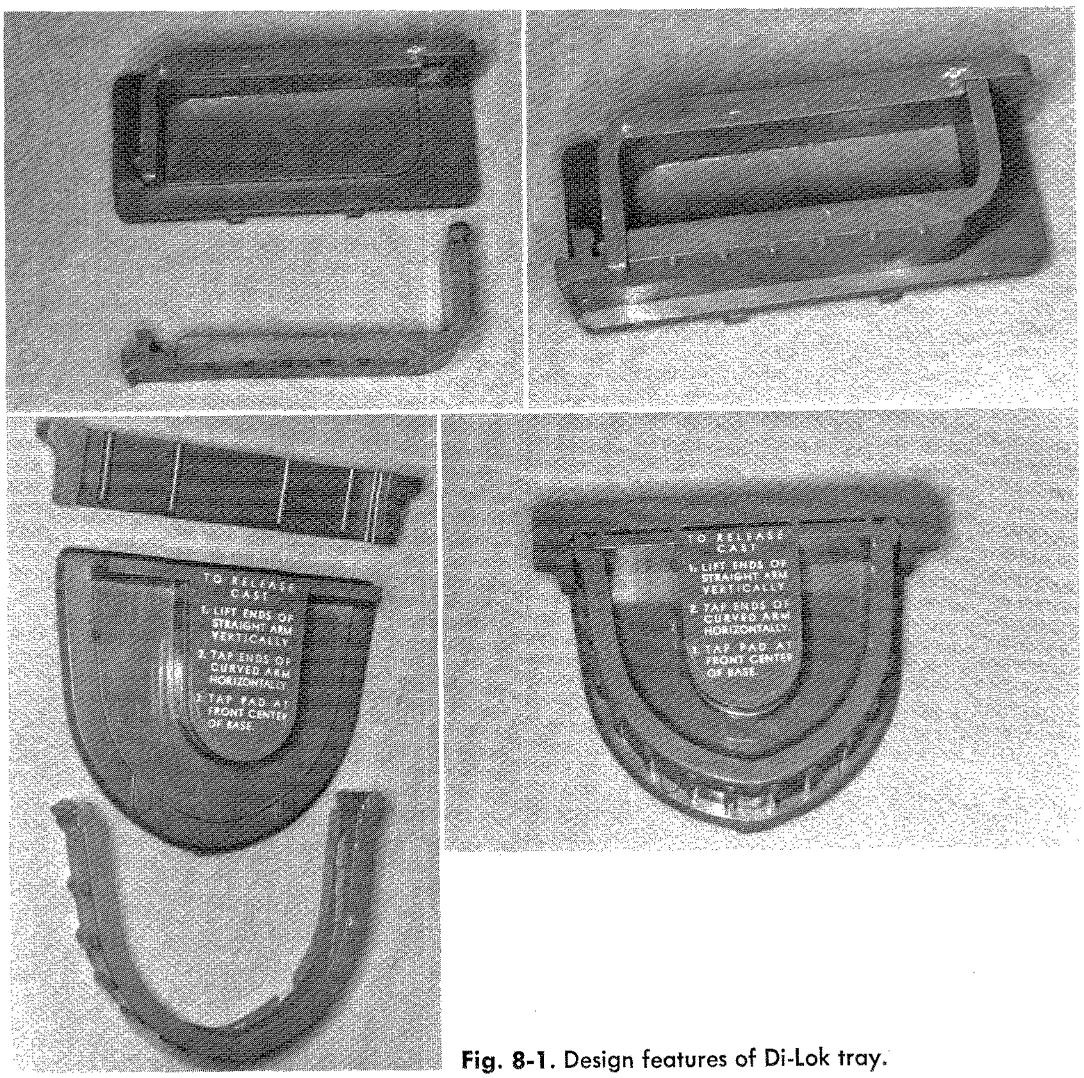
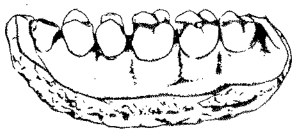
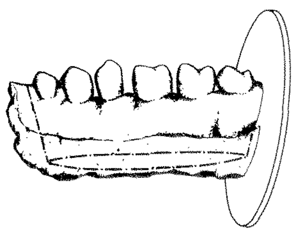


Fig. 8-1. Design features of Di-Lok tray.



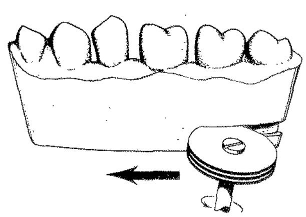
A

Stone model of three adjacent inlay preparations as recovered from an elastic impression.



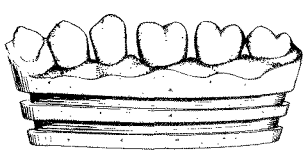
B

Base of model is tapered on model trimming machine.



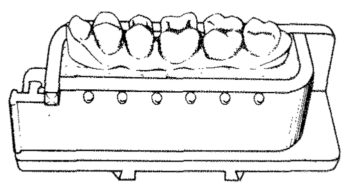
C

Undercuts in base of model are created with Joe Dandy discs or any other instrument suitable for scoring.



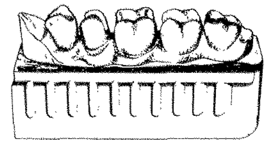
D

Model prepared for insertion into tray. It should now be soaked in water for a minute or two.



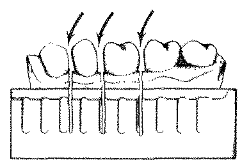
E

Tray has been filled two-thirds full of soft stone of a different color and model inserted.



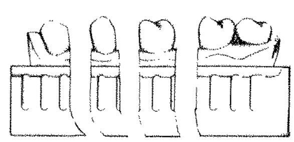
F

A new precision base for the model has been formed by the tray.



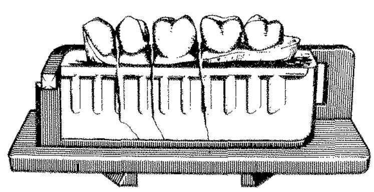
G

Vertical cuts adjacent to the prepared teeth are made to a depth of three-quarters of the base with a No. 0000 saw.



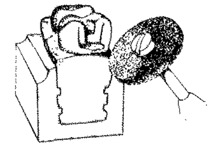
H

Dies are made removable by fracturing the remaining stone base beneath the saw cuts with finger pressure. It is best to make these fractures after each saw cut is made.



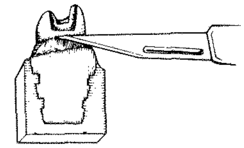
I

The fracture lines in the base together with the boxing, shoulders and ribs of the tray permit reassembly of the parts of the model with the extreme accuracy inherent in a plaster impression. The dies are maintained in the exact same position they had when the model was solid.



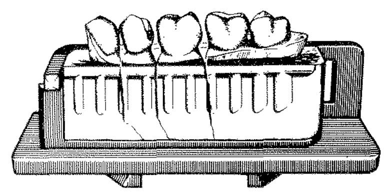
J

Excess stone gingival to the preparation is grossly trimmed with an abrasive wheel.



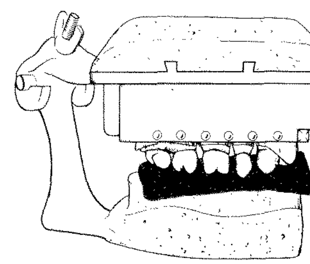
K

A scalpel blade is used to trim the remaining excess stone below the gingival margin for at least 2 millimeters.



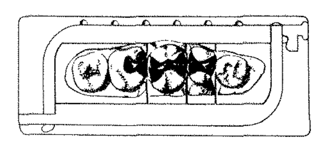
L

The trimmed dies are now assembled in the tray and the model ready to be articulated.



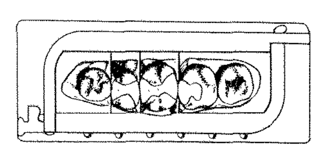
M

The model is articulated with the counter using a wax bite. The dies are now ready to be waxed up.



N

Wax patterns are checked for contact and occlusion. This may be done with great precision because there is no movement to these dies in either lateral or vertical directions when they are in position in the tray.



O

Castings may be checked for contact with dental floss and occlusion with articulating paper just as they would be in the mouth.

Fig. 8-2. Di-Lok technique for quadrant models. (Courtesy Surgident, Ltd., Los Angeles, Calif.)

to adjacent teeth for marginal adaptation and contact areas that they had when the model was solid, cannot be overemphasized. It is important that the dies have no movement in any direction.

Di-Lok technique

The design features of the Di-Lok tray are shown in (Fig. 8-1).

Following is the Di-Lok technique (Fig. 8-2).

The "finish die" impression has been treated and poured (Chapter 7) and is ready now for the preparation of the removable dies.

The base of the cast is tapered on a model trimmer. It should fit loosely into the Di-Lok tray, and the base should extend approximately 15 mm. below gingival margins of teeth.

Undercuts in the base of the cast are created with Jo-Dandy disks. Three 7/8-inch carborundum disks should be mounted on a mandrel. These undercuts lock the master cast into the new precision stone base that will be formed by the tray.

The prepared cast, which is now ready for insertion into the Di-Lok tray, is soaked in water for a few minutes. The tray is filled two-thirds full of properly mixed stone of a different color than the master cast but of the same physical properties, and the cast is inserted into the Di-Lok tray. (Stone is vibrated into the tray. Also some of this new mix is spread into the undercuts in the base of the master cast. Be sure the stone is of such consistency that the master cast will not sink too far into the tray by gravity.) A new precision base for the model has been formed by the tray.

Vertical cuts, which are adjacent to the prepared teeth, are made to a depth of three-quarters of the base with an ultrathin saw blade.

Dies are made removable by fracturing the remaining stone base, which is beneath the saw cuts, with finger pressure or pressure from a knife blade inserted into the cuts. These fractures should be made after each saw cut. The fracture lines in the base together with the boxing, shoulders, and ribs of the tray permit reassembly of the parts of the cast with extreme accuracy. The dies are maintained in the exact position that they had when the cast was solid.

Excess stone gingival to the preparation is grossly trimmed with an abrasive wheel. A scalpel blade is used to trim the remaining excess stone below the gingival margins. Dies must be trimmed properly to give good access to all cavity margins.

The ridge area of the cast for a fixed bridge also should be made removable, because it greatly facilitates the waxing of patterns.

Now the trimmed dies are assembled in the tray and are ready for articulation and waxing.

Wax patterns are checked for marginal adaptation and contact areas. This may be done with great precision because there is no movement to these dies in either lateral or vertical directions when they are in position in the tray.

Dowel pin technique

After the second pour has set sufficiently (Chapter 7), the impression is removed from the cast.

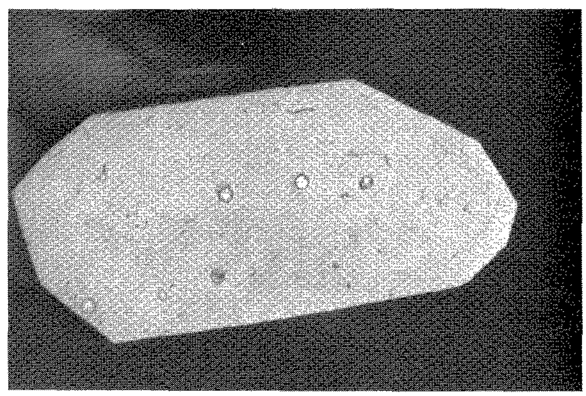


Fig. 8-3. Base of cast is trimmed on model trimmer and ready to be separated into individual removable dies.

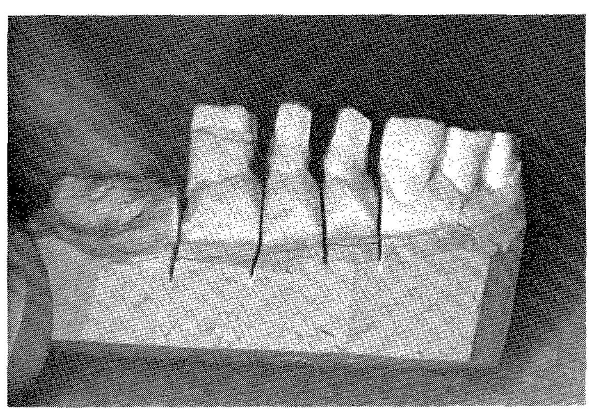


Fig. 8-4. Vertical cuts adjacent to prepared teeth made to depth of second pour (of a different color).

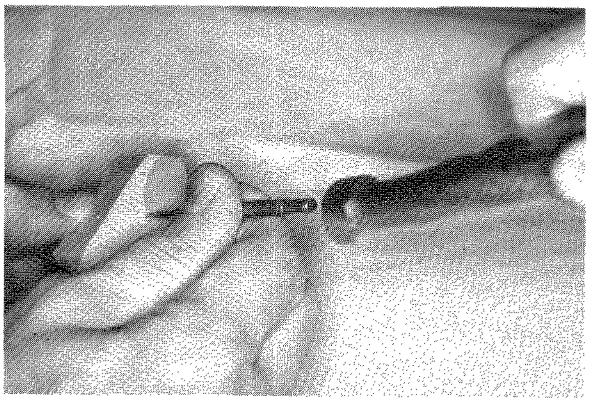


Fig. 8-5. Gently tap dowel pins with jeweler's peening hammer for removal of dies.

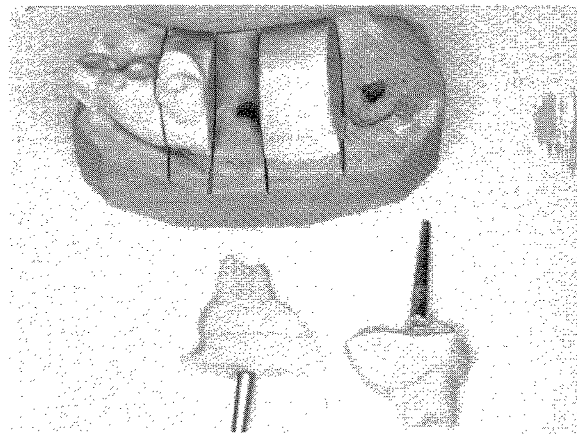


Fig. 8-6. Individual dies will separate from base.

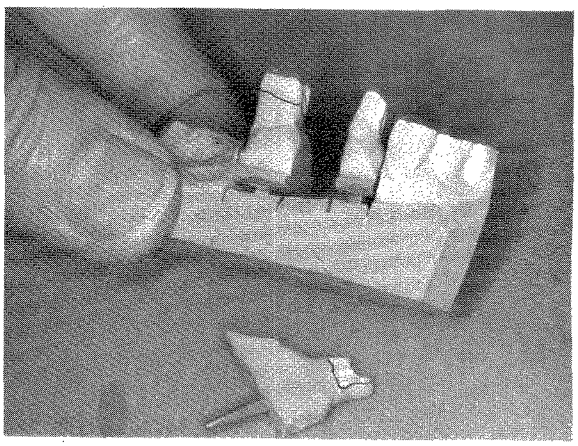


Fig. 8-7. Scalpel blade used to trim excess stone below gingival margins. Cavity margins outlined with marking pencil.

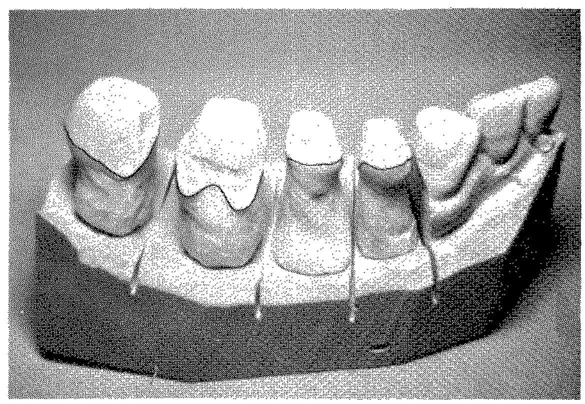


Fig. 8-8. Trimmed dies assembled in cast base ready for waxing.

The base of the cast is trimmed on a model trimmer and now is ready to be separated into the individual removable dies (Fig. 8-3).

Vertical cuts adjacent to the prepared teeth are made to the depth of the second pour, which is of a different color (Fig. 8-4).

Then the dowel pins are located on the base side of the cast and tapped gently with a jeweler's peening hammer (Fig. 8-5). The individual dies will separate readily from the base (Fig. 8-6).

Excess stone gingival to the preparation is grossly trimmed with an abrasive wheel. A scalpel blade is used to trim the remaining excess stone below the gingival margins. Dies must be trimmed properly to give good access to all cavity margins (Fig. 8-7).

The trimmed dies now are assembled in the cast base and are ready for waxing (Fig. 8-8).

Waxing

After the dies on the mounted master working casts have been separated and trimmed, the cavity margins are outlined with a red lead pencil, which facilitates the seeing of the exact marginal finish lines. The dies then are lubricated with Slikdie lubricant,* and the wax is

*Slaycris Laboratories, Portland, Ore.

melted onto the dies. Finger pressure on the wax while cooling it gives a better adaptation of the wax to the cavity surfaces of the dies.

Tweezers can be used to build up wax to exact axial contours, contacts, and occlusal relations. A No. 23 sickle explorer point also is useful for fine control and application of small quantities of wax.

After the wax patterns have been built up to the proper axial contours, contacts, and occlusal relations, the occlusal surfaces are dusted with zinc stearate powder, making use of a small camel's-hair brush as an applicator. The articulator is closed for observation of occlusal contacts (indicated by shiny, burnished spots). By adding and subtracting wax the desired oc-

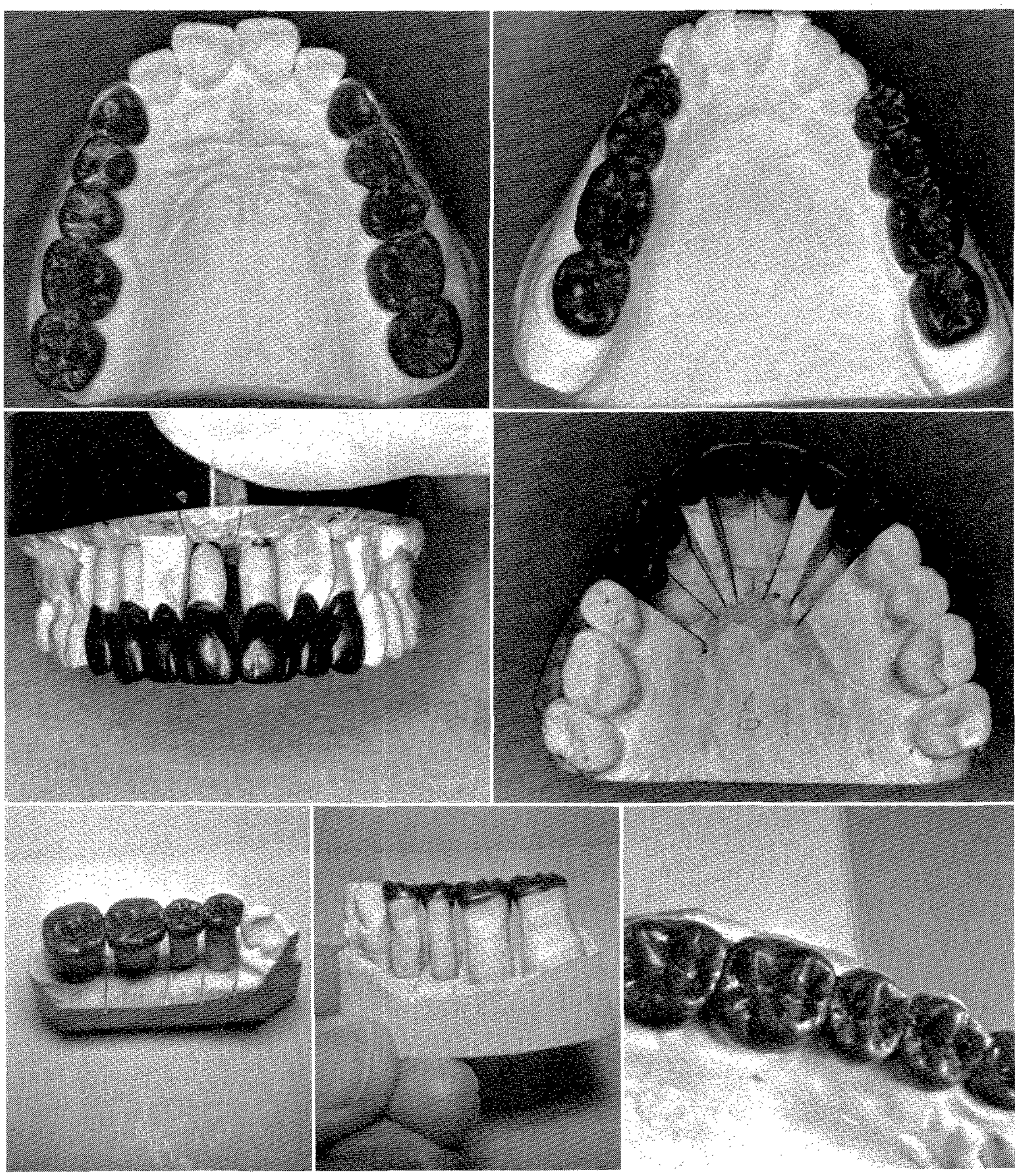


Fig. 8-9. Wax patterns that have been built up to proper axial contours, contacts, and occlusal relations. Dusting of zinc stearate powder for observation of occlusal contacts when articulator is closed.

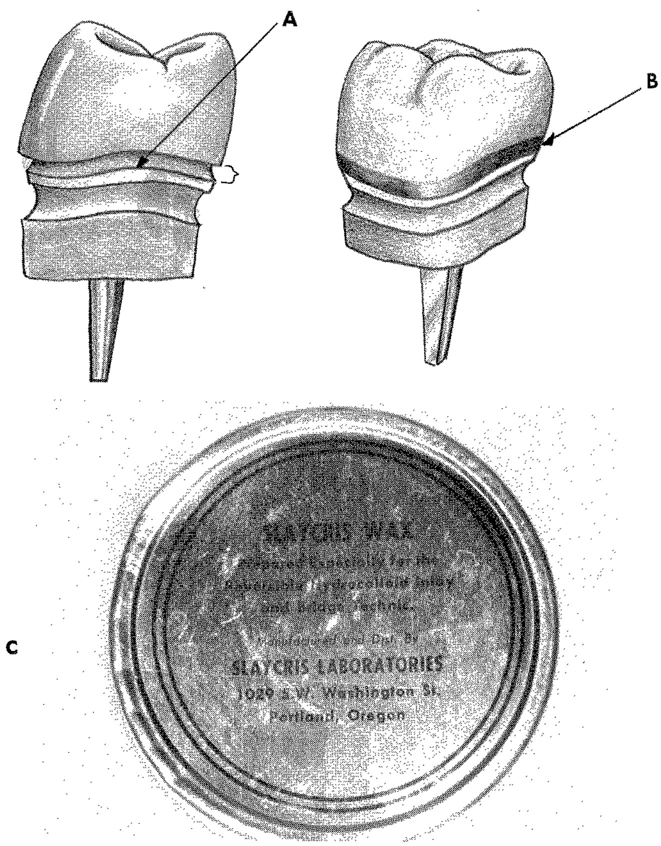


Fig. 8-10. A and **B,** Margins of wax patterns are "cut away" to depth of 1 or 2 mm. and a dead soft wax, such as Kerr's wax-up-wax or Slaycris green wax **(C),** is melted into these areas and adapted carefully for accurate marginal reproduction.

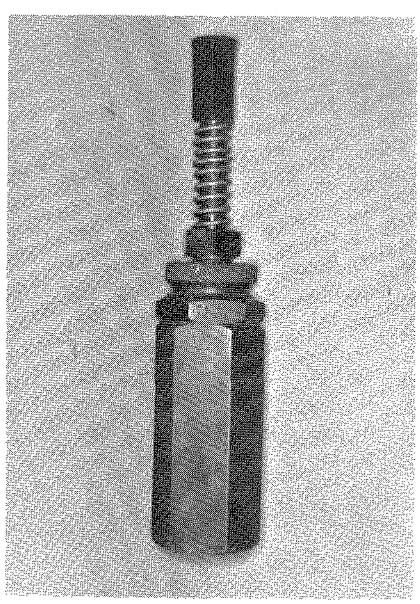


Fig. 8-11. Water swager.

clusion is established (step-by-step waxing procedure in Chapter 13). (See Fig. 8-9.)

Now the patterns are transferred to the "finish dies" for accurate marginal adaptation and development of contact areas. All margins of the patterns are "cut away" to the depth of 1 or 2 mm., and a soft wax such as Slaycris wax or Kerr's wax-up-wax, is melted into these areas and readapted carefully (Fig. 8-10). Finger pressure on the wax while it is cooling gives better adaptation of the wax to the marginal surfaces. Warmed blunt carvers, which are used with an ironing motion, will refine the margins without marring the edges of the stone dies and will allow for proper contours. The carver should be rolled over the margins, removing excess wax until refinement of the pattern is accomplished (when the red pencil outline is observed, final refinement has been attained).

The finished patterns are smoothed and polished with a piece of soft silk cloth.

If a closer adaptation of the wax pattern to the individual die is desired, one can resort to the process of swaging. This is valuable especially when metal dies are used since the metal tends to cool the wax rapidly, causing the wax to curl away from the margins.

Markley[3] points out that each brand of wax will have a critical optimum swaging temperature, near 114° F., which is determined by trial and error. The water swager should be kept in water at that critical temperature for a time prior to each use (Fig. 8-11).

The wax pattern on the die is covered with a piece of rubber dam tied with a rubber band or piece of dental tape so that it will not leak water; then it is put into the water swager and subjected to hydraulic pressure created by a few sharp blows from a hammer. The pattern then is removed from the swager, and any slight folds or excess is polished off the wax. Now it is ready for spruing.

Developing the pattern for pinledges

To withdraw the headed Perlon pins from the cast without fracturing the stone, wet the stone, grasp the Perlon pin firmly in a pair of college pliers, twist, and pull. This will leave a clean, sharp hole in the die.

Ponto-wire* (platinum in color), which is serrated and supplied in diameters that correspond to the size of the twist drill that has been used, is the wire of choice. It is available in sizes 0.021, 0.023, 0.026, 0.027, and 0.029 inch and is made of a nonoxidizing platinized alloy, which will form a good union when cast against. Its high fusing range and oxidation resistance allow it to be cast against with the gold alloys that normally are used in this technique. Ponto-wire is cut to the desired length and incorporated in the casting.

The die is lubricated, and the serrated pins are positioned into each of the pinholes (be sure the pins are free of burrs) and are joined by using a brush-on technique, employing a "quick-cure" acrylic such as DuraLay* (Fig. 8-12). This will connect the pins with a stable, rigid layer of plastic. Be careful not to have the plastic too wet or runny so that it does not flow into the pinholes and bind, and keep it away from the margins. The rest of the pattern now can be finished in inlay wax to the desired anatomic form (Fig. 8-13), after which it is ready for spruing.

Hollenback[6] feels that the position of the sprue pin is very important, and in patterns of two or more surfaces "the sprue pin should be mounted centrally in the occlusal portion of the pattern and parallel to its line of withdrawal."† He drills a hole with a twist drill mounted in a pin vise, slightly smaller than the hollow sprue pin, which then is heated carefully and carried accurately into place. A hollow sprue pin dissipates the excess heat more readily than a solid sprue pin. The pattern is removed, the sprue pin is grasped with a small pair of round-

*J. F. Jelenko & Co., Inc., New Rochelle, N. Y.

*Reliance Dental Mfg. Co., Chicago, Ill.

†From Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co.

A

B

C

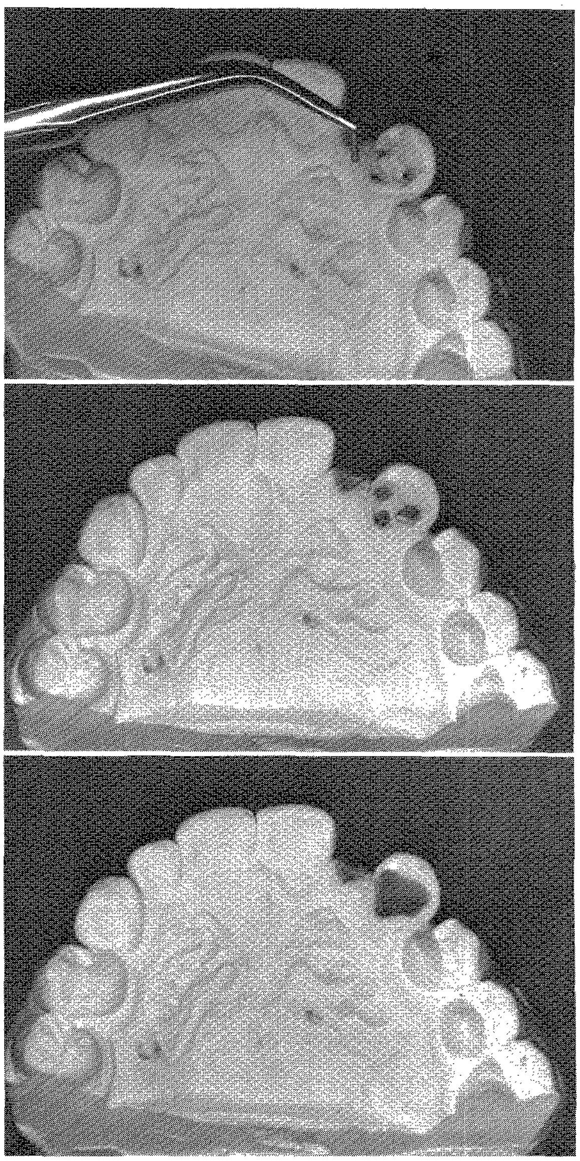


Fig. 8-12. A, Die lubricated and pin positioned in pinhole with Schwed pliers. **B,** All pins postioned in pinholes. **C,** Pins joined with DuraLay acrylic, using brush-on technique.

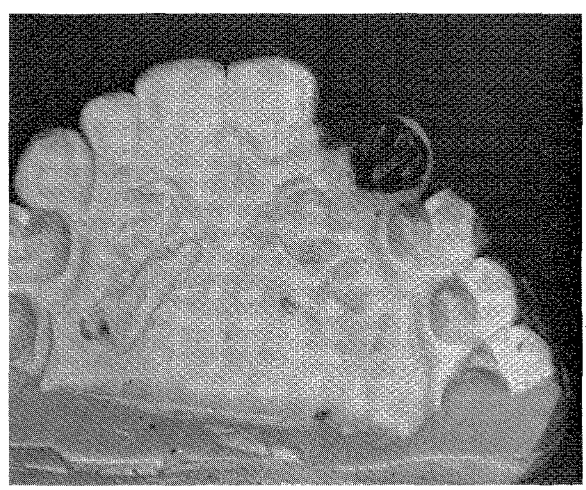


Fig. 8-13. Pattern completed with inlay wax to desired anatomic form.

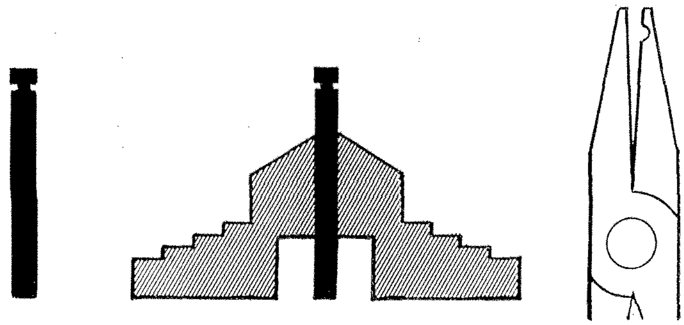


Fig. 8-14. A, Sprue former. **B,** Rubber crucible former with sprue former correctly placed. **C,** Roundnose pliers showing a notch in one beak. (From Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co.)

nose pliers, having a notch cut in one beak (which prevents slippage or rotation), and is positioned carefully into the crucible former. (See Fig. 8-14.)

Spruing

Great care must be exercised in the removal of the patterns from their respective dies to prevent distortion.

Importance of correct spruing

Attaching the sprues to the wax pattern is much more important to the success of the casting than generally is realized. Many small type castings are ruined by failure to carry out this step correctly. Spruing plays a very important role in achieving proper fit, density, and soundness of the casting, both internally and externally. The sprue is used to lead molten metal from the crucible into the mold cavity.

The diameter, length, and shape of the sprue are vital factors, as is its positioning.

The most widely used sprue is cylindrical, the gauge ranging from 10 to 18, with the average sizes being 10, 12, 14, and 16. The size of the sprue is dependent on the size of the pattern.

1. Use a 10-gauge sprue for full crowns, large three-quarter crowns, and large M.O.D.'s (if more than one sprue is used for the above types, 12-gauge sprues are recommended).
2. Use a 12-gauge sprue for medium-sized patterns.
3. Use a 14- or 16-gauge sprue for small patterns.

The sprue lengths are usually ¼ to ⅜ inch—they should not be longer than ⅜ inch and not shorter than ¼ inch. Large sprues should be used if possible, and they should be attached to the most bulky portion of the pattern. The sprue must be large enough to allow the molten gold to flow into the mold cavity as quickly as possible, but with the least amount of turbulence. It is felt that sprue design is one of the principal factors governing turbulence. Its axial direction must be such that uniform filling of the mold is possible in all its segments. Multiple sprues are used if there are separated bulky sections or if the casting span is large and thin-walled (Fig. 8-15).

A very common error, which results in shrink-spot porosity or pitted castings, is the use of too thin a sprue. To avoid this type of porosity the sprue must be situated and of a size and length to provide a reservoir of molten metal from which the casting can draw upon as it shrinks during solidification. In other words, the sprue by being large enough and positioned properly prevents the molten metal from solidifying before the metal in the casting proper solidifies.

Short, heavy sprues will minimize shrinkage porosity, provided steps are taken to avoid too much back-up thickness in the investment. This back-up thickness should not exceed ¼ inch, so that the air is allowed to escape through the back of the mold.

Orientation

Orientation of the sprues is important in producing complete castings.

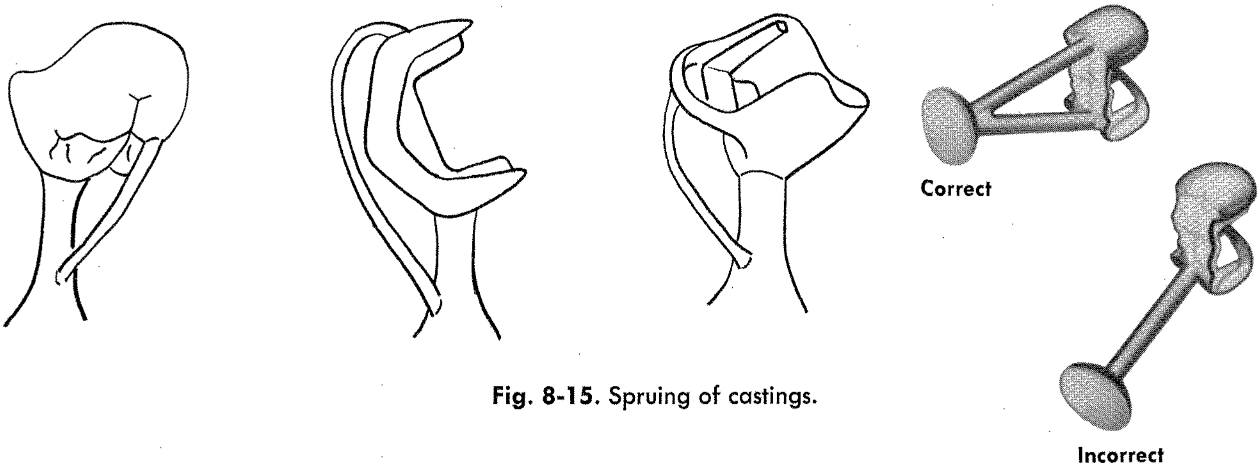


Fig. 8-15. Spruing of castings.

1. To prevent many incomplete castings the sprue(s) should be oriented so that the metal can flow in the line of force of the centrifugal casting machine. Placing the sprues at an angle to this line of casting force necessitates a change of direction of the metal flow, and this may be the cause of an incomplete casting.

2. Orientation of the sprue should be such that the metal will not strike directly against sharp projections of investment that might break off or produce turns that are difficult to negotiate.

3. The metal should not strike directly against metal backings, bars or copings—molten metal should be allowed to flow along metal forms rather than directly against them.

4. The molten metal should lead into the mold cavity as directly as possible.

5. A hopper should be used on every bulky casting and on all castings when they are cast by pressure.

6. Never sprue at a point in the casting that may be subject to stress.

7. As few sprues as possible should be used.

Mounting wax pattern on crucible former

Location of pattern in ring

In mounting the sprued pattern on the crucible former, it should be adjusted so that not more than ¼ inch separates the bottom of the casting ring from the nearest part of the wax pattern (Fig. 8-16).

The reason for this adjustment is that the air in the mold chamber must be forced out through the investment as the molten metal enters, and, if the bulk of investment is too great, the escape of these mold gases may be so slow that the gold will freeze before the mold is filled completely. This is one of the principal causes of incomplete castings and castings with rounded or short margins.

Causes and remedies for back pressure porosity

O'Brien[4] points out that the temperature of the investment mold was found to influence back pressure porosity, and this type of porosity is the result of mold gases not escaping quickly enough when the molten alloy shoots down the sprue channel. In other words, a lack of rapid

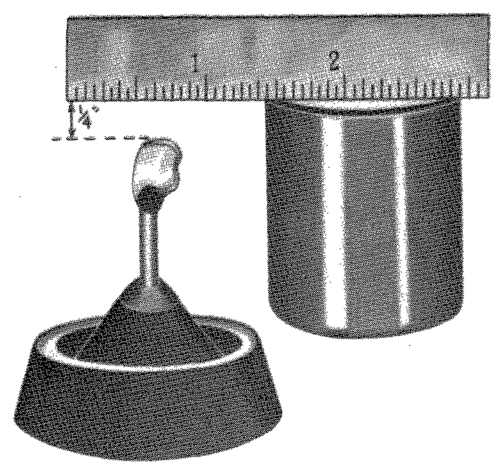


Fig. 8-16. Adjust sprued pattern on crucible former so that not more than ¼ inch separates bottom of casting ring from *nearest* part of wax pattern. (From Casting procedures. In Bridge and inlay book, Hartford, Conn., 1964, The J. M. Ney Co.)

venting for the hot gases in the mold cavity causes this phenomenon.

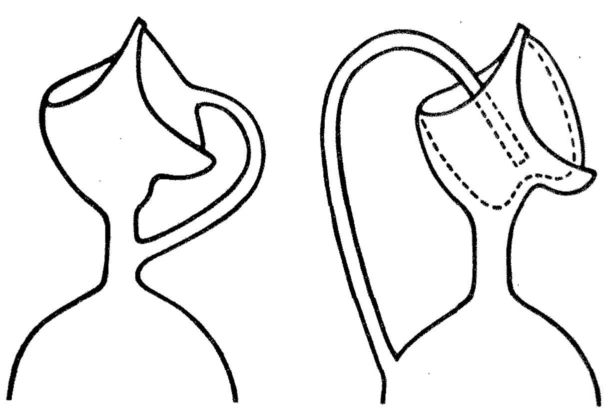
Turbulence and compression of these gases ensue in the investment core because the gases cannot find rapid escape. If the compressed gas exerts a back pressure that exceeds the casting pressure, then the trapped gas will force its way into the molten metal, thus causing porosity, that is, the air in the mold pushes back on the molten gold during the casting operation.

Recommendations for the correction of back pressure porosity

1. Since back pressure porosity occurs more generally in full-crown type castings, insertion of a wax rod into the core of the investment when investing the pattern will provide a good means of venting the hot gases quickly (Fig. 8-17). Attaching wax rods to the outside surface of the pattern does not reduce back pressure porosity.[5]
2. Proper sprue diameter, length, direction, and flaring are essential. Diameter of the sprue must be as great or greater than the greatest cross section of the pattern; otherwise, the sprue may solidify before the pattern portion. Flaring facilitates the flow of molten alloy into the mold.
3. Use of a reservoir also helps to eliminate this type of porosity (Fig. 8-18).
4. The distance from the top of the pattern to the outside of the investment is kept to ¼ inch.
5. Furnace temperatures above 1100° F. help eliminate this back pressure porosity condition. A higher mold temperature causes a slower rate of cooling and consequently allows more gold alloy to be drawn from the reservoir. Mold temperature and sprue thickness are of equal importance.
6. Increasing the number of turns on a centrifugal machine (instead of three turns use four turns) and increasing the casting pressure on a pressure casting machine (minimum 20 pounds) are helpful.
7. Performing the casting operation in a vacuum may be of great help to many operators.
8. Using more metal when casting so that a good sized button is left is an important precaution. Watch for sufficient metal and sufficient mold temperature.
9. Hygroscopic low burn-out techniques produce more of this porosity than high heat techniques, a condition that can be helped greatly by following the previously mentioned aids.

Surface, subsurface porosities, and gas inclusions

Surface porosity generally is visible as pits, voids, or depressions on the surface of the casting and sprue. It is referred to as *back pressure*



A B

Fig. 8-17. A, Special spruing for veneer crowns. **B,** Insertion of wax rod into core of investment when investing the pattern provides good means of venting hot gases quickly. (Courtesy J. F. Jelenko & Co., Inc., New Rochelle, N. Y.)

Fig. 8-18. Use of a reservoir helps eliminate porosity.

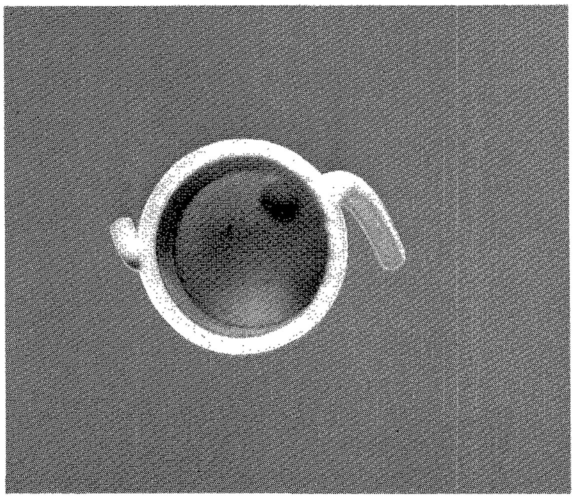


Fig. 8-19. Gas inclusions are globular voids caused by high casting temperatures, which favor the absorption of gases during melting.

porosity, and its basic cause is inadequate air escape through the mold pores.

Subsurface porosity usually consists of small voids located just below the casting skin. Factors that tend to produce this condition are high mold or metal temperatures.

Gas inclusions are globular voids that appear in the casting. This condition can be caused by high casting temperatures, which favor the absorption of gases during melting and, on cooling, these will reappear as gas inclusions in the casting (Fig. 8-19).

Shape of crucible former

The crucible former and ring should be clean and free of all old-set investment. The shape of the crucible former is also an important factor. If a pressure casting machine is used, the crucible should be rounded at the sprue hole. If a centrifugal machine is used, the crucible former should be in the nature of a broad cone.

Asbestos liner

It is advisable to use an asbestos liner in the inlay ring. Recent research work[7] has shown that asbestos liner material furnished by the manufacturers of casting investments reacts unfavorably on investments from a dimensional standpoint. The asbestos liner was determined to be the cause of the erratic behavior of casting investments.

Use should be made of Johns-Manville long fiber asbestos paper, 0.03 inch thick, serial No. SL-821. This fiber is made of a high-grade long asbestos fiber with a small percentage of organic binder. It is almost chemically inert, thereby preventing the erratic behavior of the investment material.

The asbestos liner should be cut accurately so that it makes a butt joint, and it is placed flush with the upper or open end of the ring. It is shortened sufficiently on the end of the ring, which sets on the crucible former so that a complete seal of the investment is maintained. Using an asbestos liner prevents investment contact with the metal ring, thereby allowing the investment to undergo its normal cycle of setting and thermal expansion without distortion. (See Fig. 8-20.)

The asbestos liner is moistened by capillarity, which is accomplished by placing the lined ring in a shallow vessel containing about ¼ inch of water.

The investment and metal ring do not expand at the same rate when heated, and the asbestos liner serves as a cushion, which allows the investment to expand freely, therefore having more freedom for thermal and setting expansion and also some hygroscopic expansion from the water in the liner. It also tends to prevent distortion or cracking of the mold because of this unequal expansion.

Cleaning the wax pattern

The wax pattern should be washed and cleaned thoroughly before investing with a 50-50 mixture of tincture of green soap and hydrogen peroxide. It is rinsed then in water (room temperature) and dried thoroughly. This will prevent a surface roughness, which is capable of preventing a good adaptation of the casting to the die or tooth. Then a wetting agent (Vacufilm*) should be used to reduce surface tension. It aids in the flow of the investment over the wax pattern and also can help in eliminating small air bubbles. The wetting agent on the wax pattern should be allowed to dry before applying the investment to avoid a water-film effect, and its effectiveness comes into play as soon as it is wetted by the investment mix.

*Kerr Mfg. Co., Detroit, Mich.

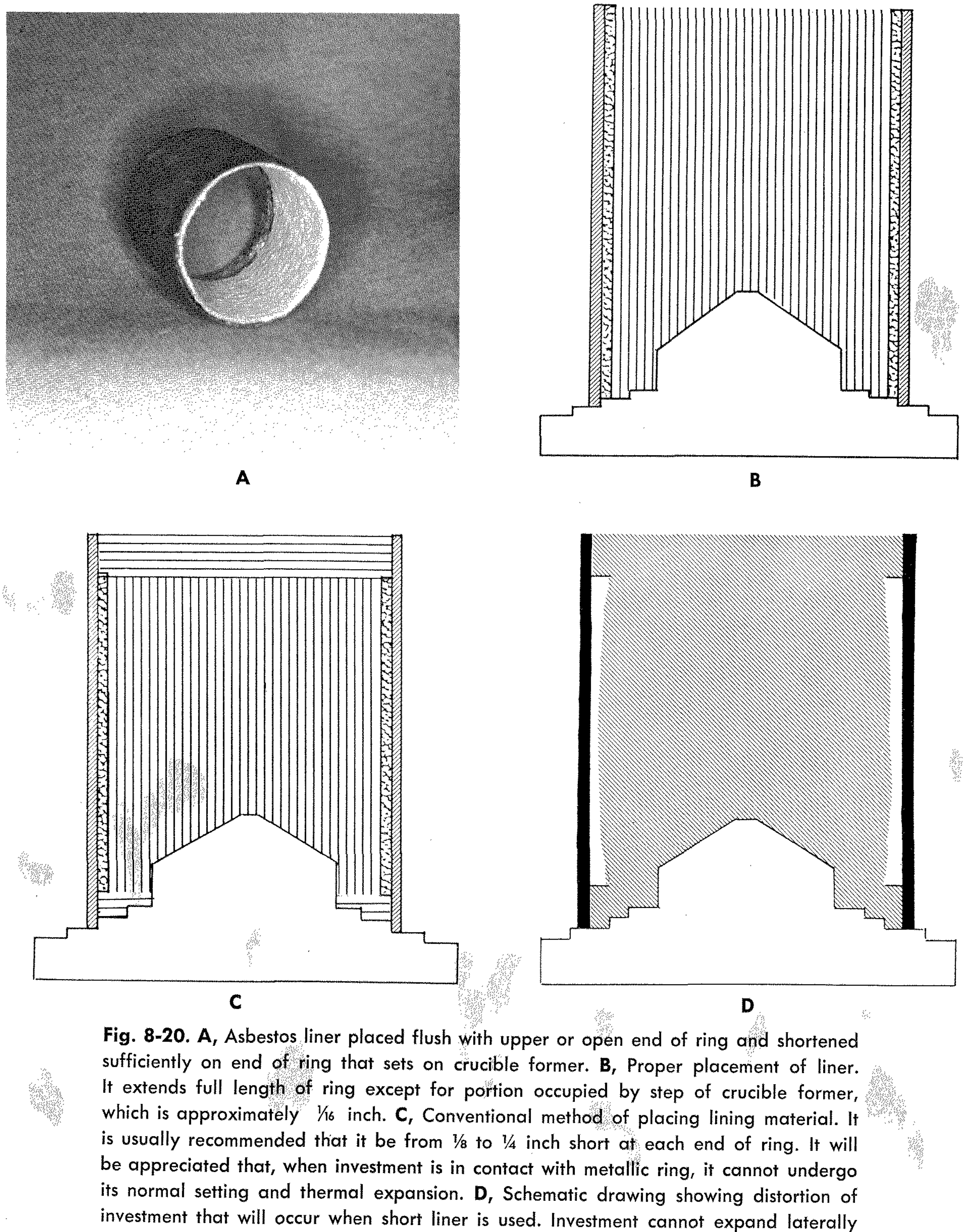


Fig. 8-20. A, Asbestos liner placed flush with upper or open end of ring and shortened sufficiently on end of ring that sets on crucible former. **B,** Proper placement of liner. It extends full length of ring except for portion occupied by step of crucible former, which is approximately 1/16 inch. **C,** Conventional method of placing lining material. It is usually recommended that it be from 1/8 to 1/4 inch short at each end of ring. It will be appreciated that, when investment is in contact with metallic ring, it cannot undergo its normal setting and thermal expansion. **D,** Schematic drawing showing distortion of investment that will occur when short liner is used. Investment cannot expand laterally at ends of ring. In central portion of ring it does expand laterally to a limited extent. Being confined at each end, investment and mold cavity are distorted. (**B** to **D** from Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co.)

Casting to dimension

CHOICE OF INVESTMENT TECHNIQUE

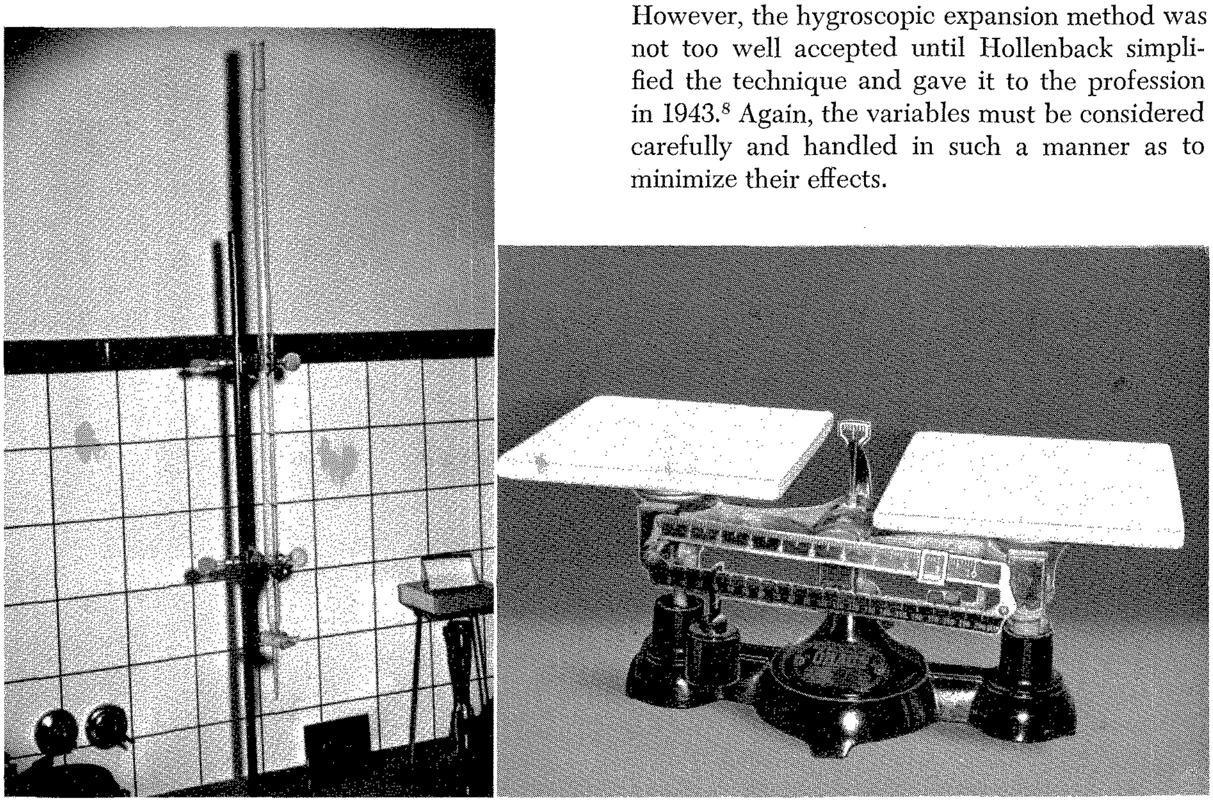
Concerning the problems of investing and investments, burnout, casting, handling of gold alloys, soldering, and techniques for their implementation, I have decided to describe those techniques with which I have experimented and which I have used for a long enough time to be able to judge the results, if not by means of a measuring microscope, at least by experienced clinical approach and good judgment. Techniques using thermal expansion, hygroscopic, expansion, and a combination of both will be considered at this time. It is a known fact that all methods have discernible advantages and limitations, and a complete understanding of the problem at hand, including one's own abilities, will enable one to select a technique that can work in his or her hands.

Inlay casting is not yet an exact science, but despite this fact, enough information now is available about the properties of the materials that are used and the effects of variations in manipulative procedures to standardize a technique so that consistently satisfactory results can be expected.

The thermal expansion method perhaps is controlled the most easily and accurately for compensating the casting shrinkage of gold. By putting the various variables together, remembering what has already been considered—cavity preparation, impressions and impression materials, die and cast materials, the wax pattern, spruing, positioning of the pattern in the ring, the asbestos liner, etc.—and referring to the charts or other information offered by the manufacturer of the materials to be used, it is relatively easy to develop a good technique and also a means of detecting and correcting errors that might creep into the technique.

The hygroscopic expansion technique is also an excellent one. If controlled properly, it will yield outstanding results in the form of well-fitting castings with smooth surfaces. This property of hygroscopic expansion in investments first was given to the dental profession by Carl Scheu in 1932. Probably all dental investments have some hygroscopic expansion, which can be produced by lining the inlay ring with asbestos. However, the hygroscopic expansion method was not too well accepted until Hollenback simplified the technique and gave it to the profession in 1943.[8] Again, the variables must be considered carefully and handled in such a manner as to minimize their effects.

A



B

Fig. 8-21. A, Burette for accurate measuring of water. **B,** Accurate scale for weighing correct amount of investment.

Thermal expansion technique

The wax pattern has been sprued properly, positioned in the ring on the crucible former, and cleaned and treated thoroughly, as was previously explained. Now it is ready to be invested. The materials of choice are Beauty-Cast,* Modern Materials† and Luster Cast.‡

*Whip-Mix Corp., Louisville, Ky.
†Modern Materials Mfg. Co., St. Louis, Mo.
‡Kerr Mfg. Co., Detroit, Mich.

Single-mix technique

The single-mix technique is used for all two-surface inlays and three-quarter crowns for anterior teeth.

1. Mix 50 grams of casting investment in 13 ml. of distilled water (room temperature). The water-powder ratio must be adhered to strictly. The water for all techniques is measured by means of a burette, and the powder is measured by means of an accurate scale (Fig. 8-21). To save time the assistant, in her spare time, can weigh the investment and place it into paper bags. To prevent moisture absorption about ¾ to 1 inch of silica gel is placed on the bottom of a wide-mouthed cookie jar, and a paper towel is placed over this material. The filled paper bags then are placed on top of the paper towel, and the lid is screwed very tightly on to the jar. In time the dark blue color of the silica gel turns white, but heating these crystals in a pan to about 300° to 350° F. will restore the dark blue color and drying properties. It can be used for a long time.

Fig. 8-22

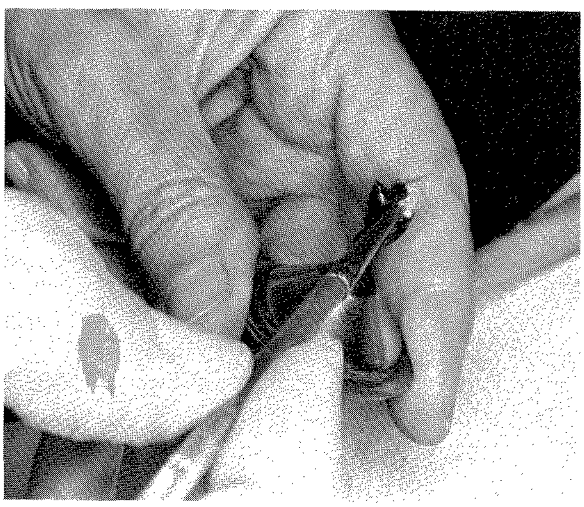


Fig. 8-23

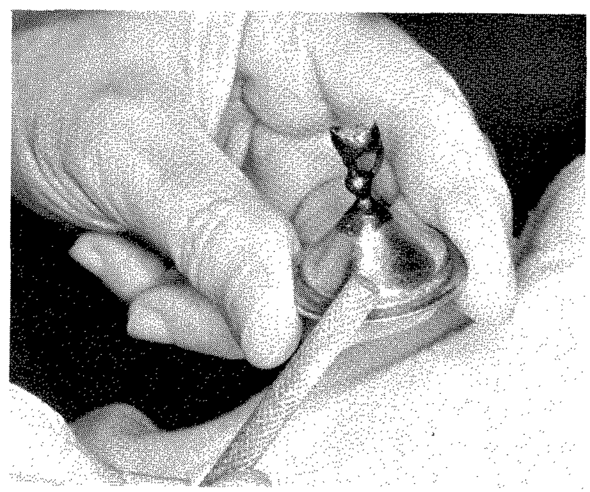


Fig. 8-24

Figs. 8-22 to 8-30. Series of illustrations showing an excellent method of investing a wax pattern when vacuum investing equipment is not available or desired. Mix (using correct water-powder ratio) is spatulated mechanically and pattern is painted carefully with the mix, carrying it into all grooves and angles. Investment can be applied with a small camel's-hair brush held lightly against a vibrator or by hand vibration using a serrated tool against base of crucible former. After pattern is covered with investment a light dusting of dry investment is applied, and mass is vibrated, drawing water away from surface leading to a denser mass and bubble-free surface. This step is repeated two or three times and then given a final dusting of dry powder.

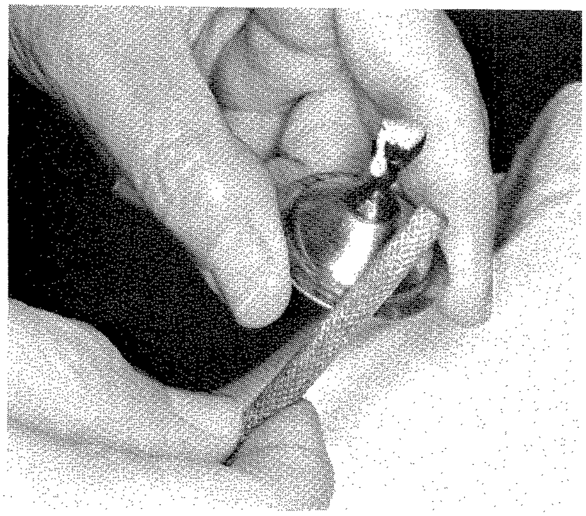


Fig. 8-25

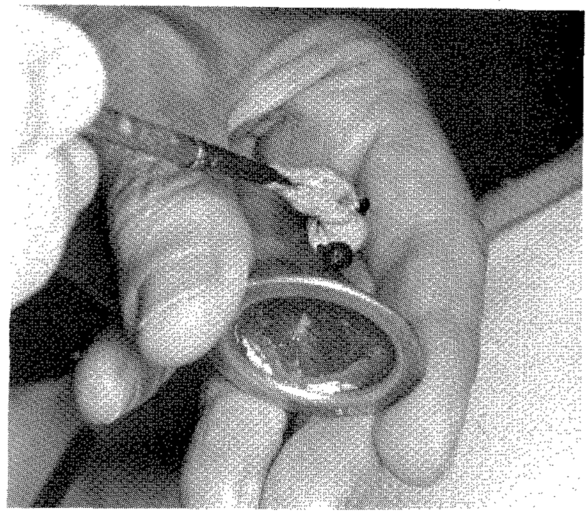


Fig. 8-26

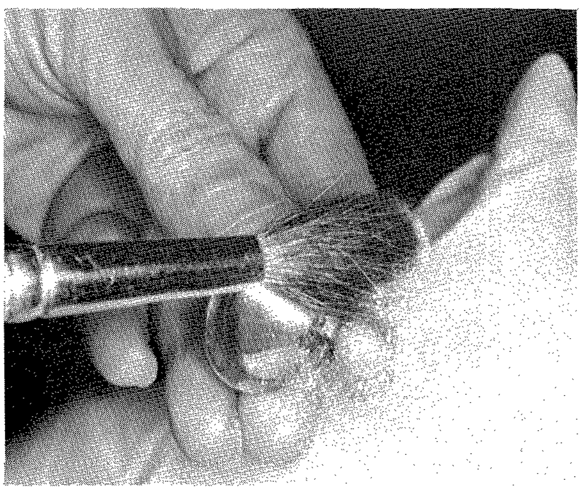


Fig. 8-27

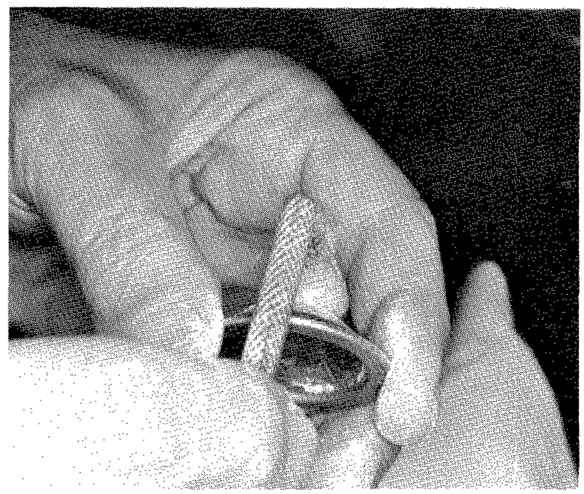


Fig. 8-28

Fig. 8-29

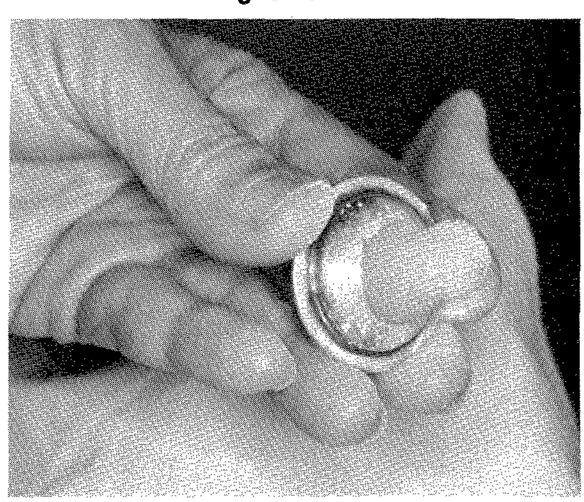


Fig. 8-30

2. Paint the wax pattern, being careful not to occlude air bubbles on the surface of the wax. The preferred method of mixing and investing is by vacuum. When vacuum investing equipment is not available, it is advisable to use a good mechanical spatulator because this method produces a smoother mix, freer from entrapped air bubbles, than hand spatulation. Paint the pattern carefully with the investment mix, being sure to carry it into all grooves and angles. A good method is to apply the investment with a small brush held lightly against a vibrator. After the pattern is covered, the investment may be blown off the surface, leaving a thin film and disengaging any large bubbles. The pattern then should be repainted and given a light dusting of dry investment powder. (See Figs. 8-22 to 8-30.)

3. Then seat the ring on the crucible former and fill with the balance of the mix to overflowing. Pour the investment from one side of the ring so that it runs down the side of the ring, filling it from the bottom upward to avoid trapping air (Figs. 8-31 and 8-32).

4. Allow the invested ring to stand until it has set thoroughly—for at least forty-five minutes to one hour. If it is allowed to stand overnight, it is advisable to soak the ring in water just before starting the burnout to prevent roughness on the surface of the casting.

5. Remove sprue former and sprue pin from the ring.

6. Burn out the wax, heating the investment and ring until a dull red glow (1200° to 1300° F.) can be seen down the sprue hole. Cast immediately to avoid a drop in temperature and consequent shrinkage of the mold.

Double-mix technique

The double-mix technique is used for all other castings such as M.O.D.'s, three-quarter crowns for posterior teeth, full crowns, and occlusal inlays.

1. Mix 25 grams of casting investment in 7 ml. of distilled water (room temperature). Spatulate mechanically or by vacuum.

2. Paint the wax pattern, being careful not to occlude air bubbles on the surface of the wax.

3. With a soft brush dust dry casting investment over the painted pattern and vibrate gently with a serrated instrument until powder is absorbed. By alternately applying the wet mix and dusting with the dry powder (three to four times), the wax pattern is encased in a ball of investment. This procedure allows for greater setting and thermal expansion. Allow the encased wax pattern to set five to ten minutes.

4. Then make another mix, using 50 grams of casting investment to 14 ml. of water.

5. Fill the inlay ring with mix. Immerse the painted pattern in water for a moment, and then insert it into the filled ring.

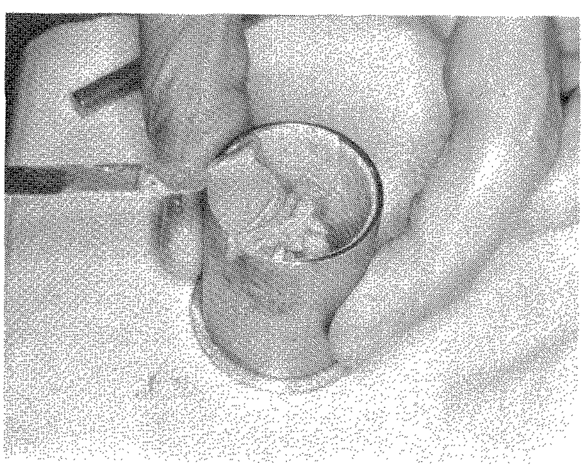


Fig. 8-31

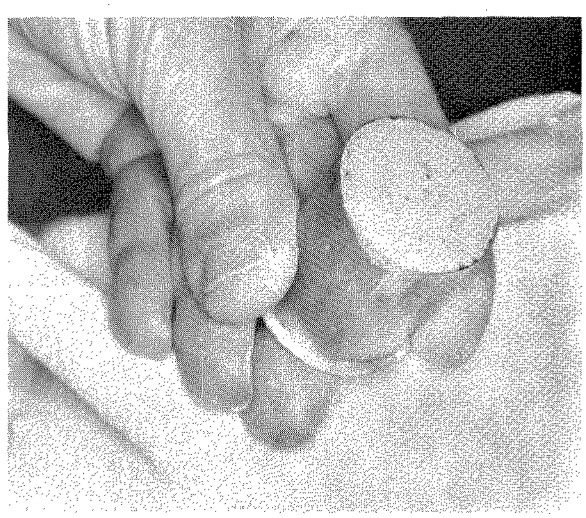


Fig. 8-32

Figs. 8-31 and 8-32. Ring seated on crucible former and filled with balance of mix to overflowing, pouring investment from one side of ring to avoid trapping air.

6. Allow the invested ring to stand for forty-five minutes.

7. Remove sprue former and sprue pin from ring.

8. Burn out the wax, heating the investment and ring until a dull red glow (1200° to 1300° F.) can be seen down the sprue hole. Cast immediately.

Excellent results are possible with this technique.

Hollenback method of investing

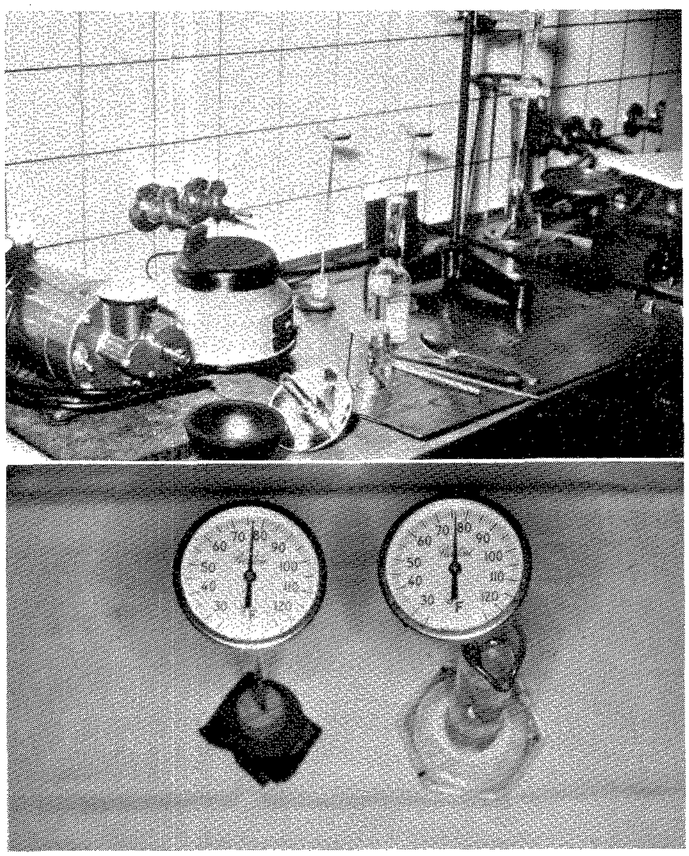
Technique

In this procedure it is of the utmost importance that all steps be carried out in such a way that change of dimension of the pattern with change of temperature is minimal. This can be accomplished best by working in as draft-free an area of the laboratory as possible for waxing and investing of the wax pattern and setting of the investment. In other words, close temperature control must be used in making and investing wax patterns. Use is made of two dial thermometers, one indicating water temperature and the other indicating air or room temperature. They must register the same temperature. (See Fig. 8-33.)

In patterns of two or more surfaces "the sprue pin should be mounted centrally in the occlusal portion of the pattern and parallel to its line of withdrawal. In this method of spruing the molten metal flows directly into the gingival portion of the mold."[*]

With a twist drill mounted in a pin vise a hole is drilled slightly smaller than the hollow

[*]From Hollenback, George M.: The control of erratic behaviors of casting investments, J. S. Calif. Dent. Ass. 30:159-162, 1962.



A

B

Fig. 8-33. A, Comparatively draft-free area of my laboratory for investing of wax patterns and setting of investment. Dimensional change in wax pattern because of temperature change is minimal. **B,** Two dial thermometers used—one indicates water temperature and the other air or room temperature, and they must register same temperature.

sprue pin. The sprue pin then is heated carefully and carried accurately into place (a hollow sprue pin dissipates the excess heat more readily). The pattern is removed, the sprue pin is grasped with a small pair of roundnose pliers, having a notch cut in one beak (which prevents slippage or rotation), and is positioned carefully into the crucible former.

The pattern is cleaned and treated as was previously explained and now is ready to be invested.

Use should be made of long fiber asbestos paper, 0.03 inch thick, serial No. SL-821.* It is almost chemically inert, thereby preventing the erratic behavior of the investment material (see discussion on asbestos liner). The asbestos liner should be cut accurately so that it makes a butt joint, and it is placed flush with the upper or open end of the ring. It is shortened sufficiently on the end of the ring which sets on the crucible former to maintain a complete seal of the investment. The asbestos liner is moistened by capillarity, which is accomplished by placing the lined ring in a shallow vessel containing about ¼ inch of water.

Cristobalite investment† is the investing material of choice in this technique. The water-powder ratio is 36 ml. of distilled water to 100 grams of casting investment. Preferably the vacuum method of investing is used, but use can be made of a good hand mechanical spatulator and investment applied with a small brush held lightly against a vibrator.

The invested flask is allowed to set for at least one hour in the draft-free area of the laboratory. At the end of this time the sprue pin is removed carefully, and the wax is eliminated by using the wax eliminator. This apparatus eliminates the wax from the mold and also washes out all the residual matter that may be left.

Procedure of wax elimination

"1. Grasp the crucible former and the ring firmly, the sprue former being held in a pair of flatnose pliers.

"2. Rotate back and forth several times and then slowly and carefully withdraw the sprue

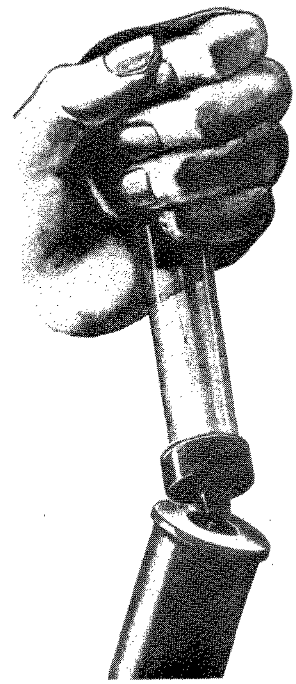


Fig. 8-34. Compressing bulb of wax eliminator and inserting its soft rubber tip in receptacle of crucible former.

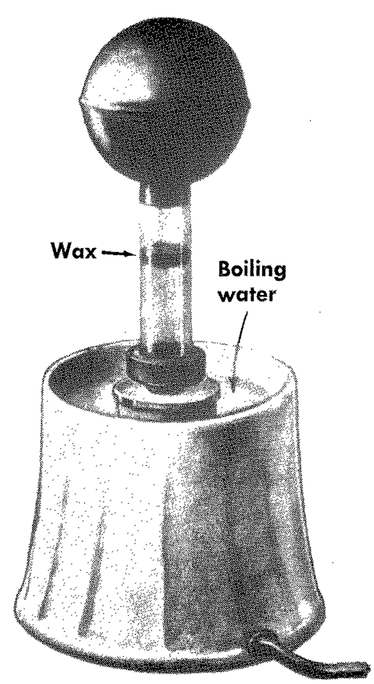


Fig. 8-35. Assembly (wax eliminator and invested ring) is placed in a vessel of boiling water. After a few minutes wax is softened and drawn into glass barrel of eliminator, thereby washing mold clean.

*Johns-Manville Sales Corp., Chicago, Ill.
†Kerr Mfg. Co., Detroit, Mich.

former. This will leave an open passage to the wax pattern.

"3. The bulb of the eliminator is compressed and its soft rubber tip inserted in the receptacle of the crucible former [Fig. 8-34].

"4. The flask is now placed in a vessel of boiling water. In a short time (2 to 3 minutes) the wax will be softened and drawn into the glass barrel of the eliminator. During this process the mold is washed clean [Fig. 8-35].

"A partial vacuum, 10 to 11 inches of mercury, is drawn in the glass barrel of the eliminator.

"It might be assumed that this would roughen the surface of the mold. This assumption is erroneous."*

After wax elimination put the flask in a cold furnace, crucible down, and allow approximately thirty minutes to reach the desired casting temperature of 900° F. Keep it at this temperature for one hour, after which the casting is made immediately.

Allow flask to stand three or four minutes before plunging into water, to produce smoother castings with a better grain structure.

"The phenomenal accuracy of this process is partially due to the close maintenance of temperature during the formation of the pattern, the investing process, and the period while the investment sets."*

A plateau of considerable extent is established. (See Fig. 8-36.)

Castings made by this technique show very superior marginal fit (Fig. 8-37).

Hygroscopic technique (submerging in water bath)

The property of hygroscopic expansion in investment was given to the dental profession by Scheu in 1932, but not until Hollenback[8] in 1943 showed a simplified technique for obtaining accurate small castings did the hygroscopic method gain acceptance. In this method there is a larger setting expansion and a smaller thermal expansion, which is the opposite of a thermal expansion technique. According to Coy and Hall,[9] "the value of this technique is that it expands the wax pattern to approximately its volume at the flow point of the wax, which reduces the problem to one of compensating for the casting shrinkage of the gold."†

In the hygroscopic technique the warming

*From Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co.

*From Hollenback, George M.: The control of erratic behaviors of casting investments, J. S. Calif. Dent. Ass. 30:159-162, 1962.

†From Coy, Herbert D., and Hall, S. Guy: Hygroscopic investment expansion for small castings, D. Clin. N. Amer., pp. 625-636, Nov., 1958.

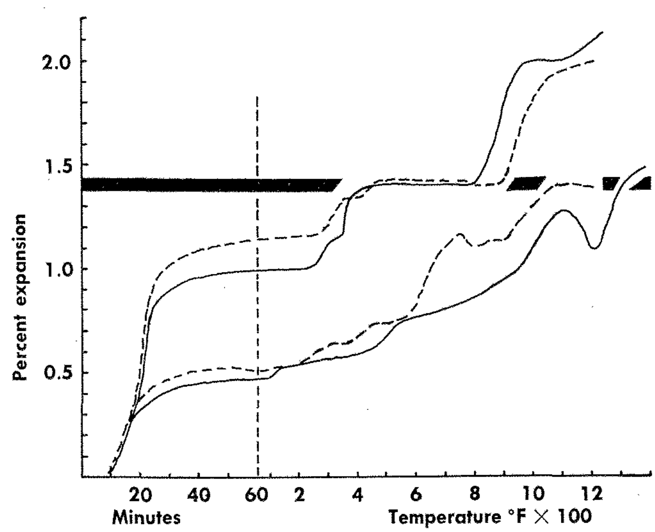


Fig. 8-36. Two lower graphs represent expansion curves of two Cristobalite investments when a full-length asbestos liner was used. Upper graphs show same two materials, using a full-length liner of long fiberglass paper. (From Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co.)

Fig. 8-37. Series of castings from practice, showing excellent marginal fit.

influence of the bath causes a wax pattern expansion and also serves to soften the wax, thereby reducing restriction to investment expansion for certain types of wax patterns.

Cavity preparation must be executed accurately; the wax pattern must be developed properly, keeping in mind the physical properties of wax; and the largest possible sprue that the pattern will accommodate—varying from 18- to 10-gauge should be used. The wax patterns should be thoroughly cleansed with a 50-50 mixture of tincture of green soap and hydrogen peroxide, rinsed in water (room temperature), and dried carefully. Then a wetting agent (Vacufilm) can be applied. The sprued pattern should be positioned correctly in the ring, which has been lined with long fiber asbestos paper, 0.03 inch thick, serial No. SL-821. The liner is

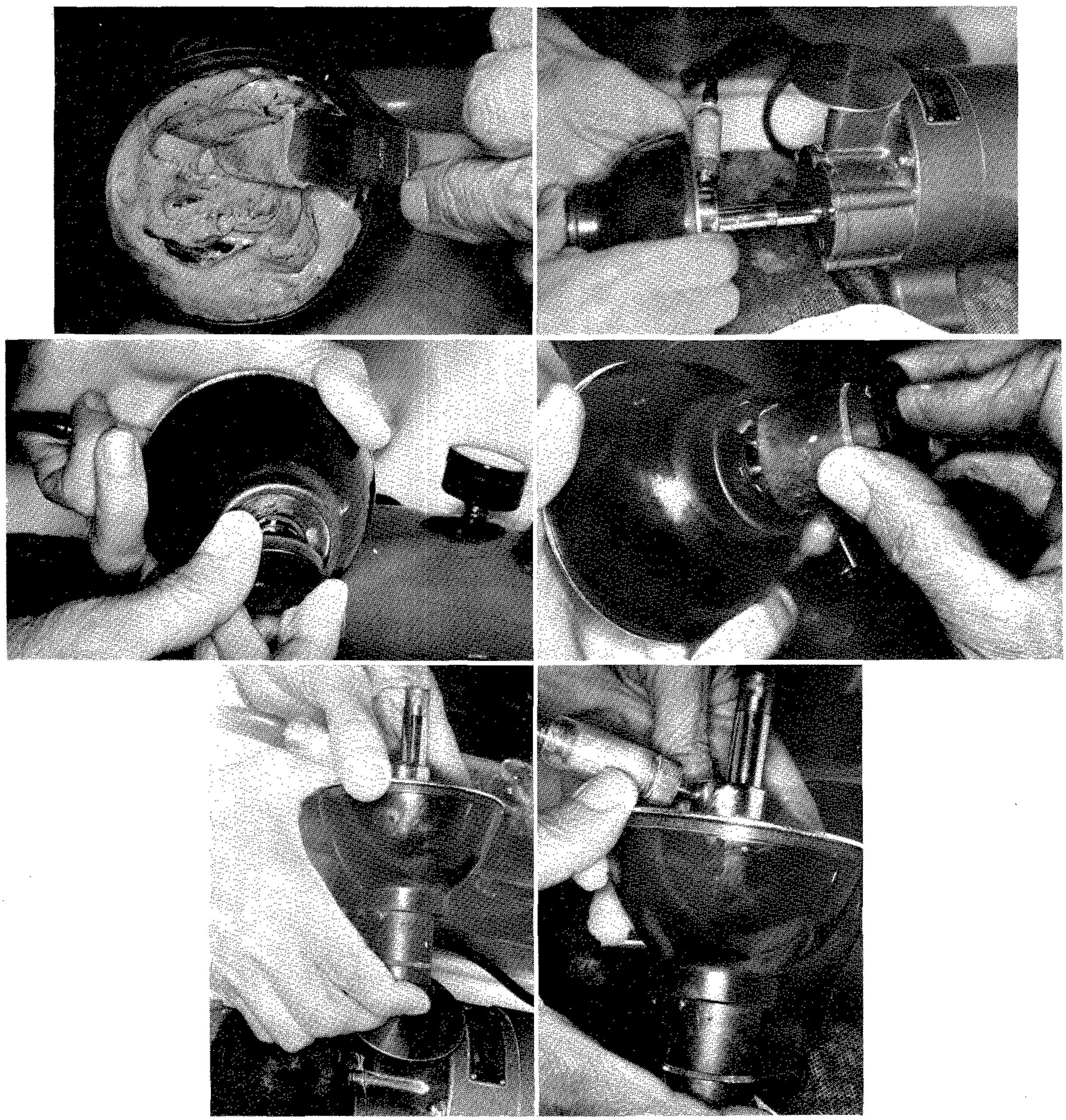


Fig. 8-38. Investing of a wax pattern by means of vacuum (Kerr and Whip-Mix Vac-U-Spat). See text.

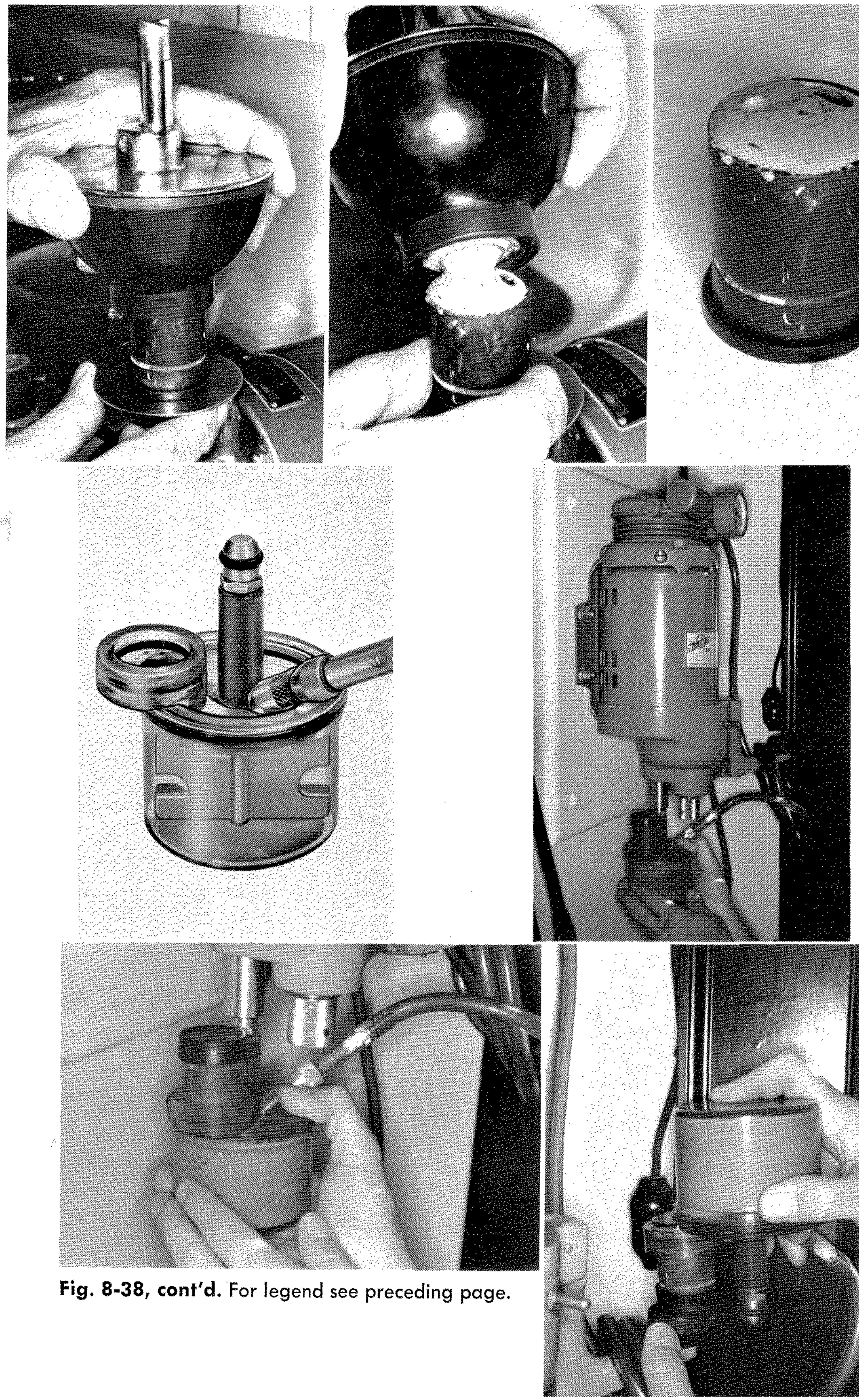


Fig. 8-38, cont'd. For legend see preceding page.

placed flush with the upper or open end of the ring and is shy of the end that has the rubber base by ⅛ inch so that a complete seal of the investment may be maintained. The asbestos liner is moistened by capillarity; it permits free lateral expansion of the mold, which otherwise would be prevented by the ring's unyielding wall. The ring now is placed on the crucible former.

The process of investing the pattern by means of a vacuum was developed by Hollenback[10] and is a method of mixing an investment material and surrounding the wax pattern in the prepared ring, both under the negative pressure of a vacuum.

The distilled water for the mix is measured accurately, using a burette, and is placed in the rubber mixing bowl after the hole in the bottom of the bowl has been closed by a rubber cork. The investment is weighed accurately with a metric scale. (Remember that the water-powder ratio to be used will control the size of the casting. Varying the water-powder ratio will give oversized and undersized castings; thicker mix has less water and gives more expansion, and thinner mix has more water and gives more shrinkage. Water bath temperature and burn-out oven temperature also are important factors.) The investment powder is placed in the bowl and puddled with a spatula, after which the cover, which has the mechanical spatula and drive shaft built into it, is placed tightly on the bowl, and the intake tube of the vacuum pump is attached. The cork is removed then, and the casting ring assembly is substituted. The vacuum pump is turned on, and the drive shaft of the mixer is engaged by the chuck on the vacuum apparatus. Under slow speed the mix is completed in about ten to fifteen seconds, and the drive shaft is disengaged. (See Fig. 8-38.) Phillips has shown that "vacuum investing produces a denser mass of investment, which results in slightly greater crushing strength of investment and also that the increased density of the investment in turn produces a denser gold surface."*

Now the entire assembly is held upright with the rubber base resting on the vibrator for about thirty seconds, in which time the investment will flow smoothly and evenly around the pattern and completely fill the ring. The rubber base is placed on the bench, and the vacuum intake tube is disconnected slowly and carefully, allowing the ring to separate from the mixing bowl.

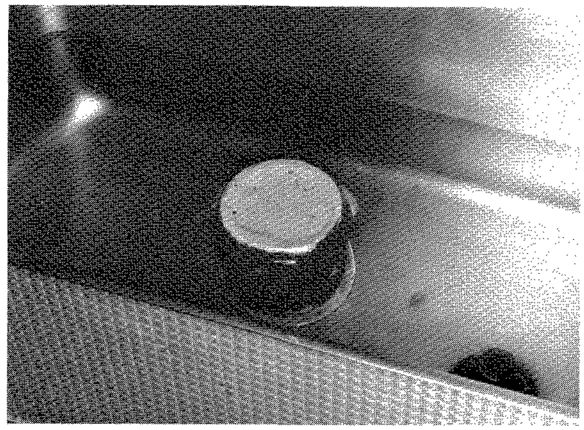


Fig. 8-39. Ring is submerged in a thermostatically controlled water bath at 100° F. for thirty minutes.

As soon as the investing process is completed, the ring is placed in a thermostatically controlled water bath at 100° F. and left there for thirty minutes (Fig. 8-39). The water must be deep enough to submerge the ring completely. The setting of the investment in a supersaturated condition will show much more than the normal setting expansion. Expansion suitable for the various gold alloys can be secured easily. Any desired degree of expansion can be obtained by merely changing the water-powder ratio.

The excess investment is trimmed off when the ring is removed from the water bath and the elimination of the wax is in order. Remove the sprue pin without disturbing the crucible former, and press the rubber tip of the wax eliminator with the bulb fully collapsed into the recess of the crucible former. Now the ring is submerged into a receptacle of boiling water, thereby softening the wax, which is sucked up into the glass barrel of the wax eliminator. This usually takes about two to three minutes.

After the wax is eliminated, the crucible former is removed and the ring is put in a cold furnace with the crucible down. Approximately thirty minutes is allowed to reach the desired casting temperature of 900° F. After one hour at

*From Phillips, Ralph W.: Relative merits of vacuum investing of small castings as compared to conventional methods, J. Dent. Res. **26**:343-352, 1947.

this temperature, the casting is made immediately.

The flask should stand for three or four minutes before being plunged into water so that smoother castings with a better grain structure are produced.

Castings of good quality can be obtained by using this technique. The investment that I use in this technique is Beauty Cast.*

Modified hygroscopic investing

It is most interesting to note at this point Markley's[3] observation that distortion caused by resistance of the wax pattern to hygroscopic and setting expansion is excessive with the so-called hygroscopic expansion techniques. It is necessary to use investments and methods that produce the least possible combined setting and hygroscopic expansion. Hygroscopic expansion can be minimized by keeping the water level about ¼ inch below the top of the ring.

1. Attach a sprue pin to the finished wax pattern while it is still on the die. Coat the sprue with wax, which will allow it to fall from the invested mold as the wax is eliminated in the furnace, leaving a smooth canal free of debris through which the gold will flow uninhibited.

2. Thoroughly clean the wax pattern, line the ring with asbestos (Johns-Manville long fiber asbestos paper), and position the pattern in the ring as previously described. The casting ring must fit snugly into the crucible former so that no air is drawn into the pattern area when the investment is vibrated to place.

3. Miner's clean cast inlay investment and Denver investment* are excellent for this technique. A water-powder ratio of 50 grams of investment (Miner's Clean Cast) to 13 ml. of water is used for all full crowns, veneer crowns, reverse pin patterns, average or large M.O.D. inlays, and posterior three-quarter crowns. (That is, for all preparations having long and parallel walls). A water-powder ratio of 50 grams of investment (Miner's clean cast) to 13.5 ml. of water is used for small inlays, small M.O.D.'s, etc. (that is, for all preparations with conical or short walls).

4. Completely wet the investment by hand mixing and then finish the mix under vacuum. This mix is applied to the pattern with a small brush held lightly against a vibrator. As the

*Whip-Mix Corp., Louisville, Ky.

Fig. 8-40. In modified hygroscopic investing (Miner's clean cast investment) invested ring is placed in a water bath at 100° F. for thirty minutes. Water level must be kept ¼ inch below top of ring.

brush is vibrated, the bristles work their way into all corners and over all areas of the pattern thoroughly with investment, eliminating any air that might be entrapped in the investment. The lined ring, which fits snugly into the crucible former, is positioned and filled with investment. While filling is proceeding, the ring should be held in the hand and the hand rested on the plate of the vibrator so that the mild vibrations may cause the ring to fill evenly without entrapped air.

5. Place the ring immediately in the water bath at 100° F. for thirty minutes. Keep the water leved ¼ inch below the top of the ring so that the water-powder ratio is not affected. (See Fig. 8-40.)

6. On removing the ring from the water bath, trim excess investment and let the ring stand for ten to fifteen minutes more before removing the crucible former.

7. Place the ring in a furnace preheated to 600° F. with the sprue hole down. By having the furnace preheated, the wax is eliminated rapidly through the assistance of residual moisture in the investment, thereby flushing the wax from the mold. As the wax melts, the sprues, which were coated with wax, will fall out. Hold the temperature at 600° F. for thirty minutes; then turn ring-to-sprue hole up, and raise the temperature to 1100° F. (for "long" castings bring temperature to 1300° F.), letting the casting ring remain at this temperature for at least one hour.

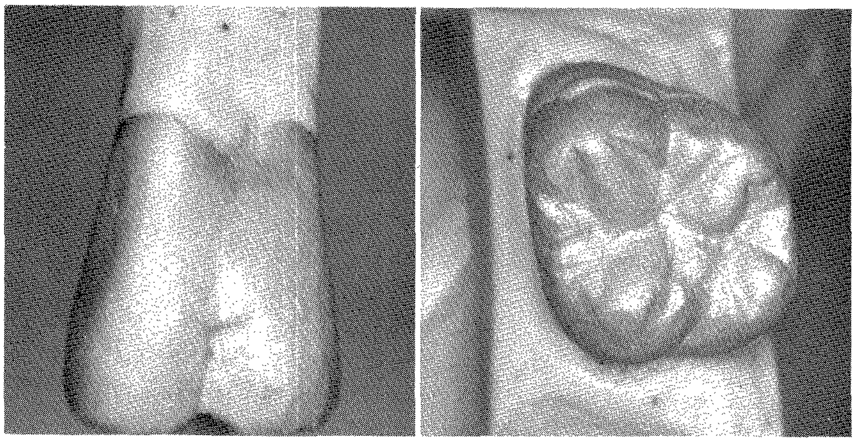


Fig. 8-41. A "long" casting made by using modified hygroscopic investing.

8. Remove the ring from the furnace, and cast immediately. (See Fig. 8-41.)

If it is spatulated with 15.5 ml. of water and raised to and held at 1100° F. for fifteen minutes in the burn-out furnace, Denver investment (composed of 17 grams of Cristobalite and 33 grams of Gray investment) will have very good properties. It sets slowly enough for water bath compensation even when spatulated mechanically.

Hygroscopic technique using controlled amount of added water

Technique

In this hygroscopic technique, worked out by Asgar, Mahler, and Peyton,[12] at the University of Michigan, controlled addition of water in varying amounts is used to influence the desired investment expansion. Their experiments showed more consistent results in obtaining well-fitting castings when the investment was allowed to come into contact with a specified amount of water rather than a maximum amount. They add a specified amount of water to the investment ring with a syringe, rather than placing the invested ring in a water bath and allowing the investment to absorb a maximum amount of water. In other words, in this method the investment is not allowed to absorb water and expand to its fullest capacity. The operator is allowed to control the exact amount of resulting expansion by adding a limited, or controlled, amount of water to the investment. The mechanism for this type of expansion is the same as that for normal setting expansion, the growth of gypsum crystals.

Although it was found that having warm water in contact with the invested ring was unnecessary, some clinicians feel that the technique is improved further if the ring is placed in a water bath at 110° F., keeping the water level below the top of the ring so that no additional water is supplied to the investment but allowing the pattern to be warmed, thereby letting the investment expand more evenly. To compensate for this wax expansion, less water is added at the reservoir. It also was shown that investments which expand hygroscopically have a limit to the absorption of water and subsequent expansion. This limit is affected by the water-powder ratio, conditions of spatulation, age of the investment, and differences from one manufactured batch to another.

Before using the controlled water addition technique, the manufacturer's instructions that accompany the investment and equipment purchased should be read carefully.

Hygrotrol* is the investment of choice in this technique. This investment gives high hygroscopic expansion, as well as high strength, to prevent mold fracture when casting into the unsupported investment mold.

After the sprued pattern is mounted on the sprue base, the pattern is treated with a 50-50 mixture of tincture of green soap and hydrogen peroxide, after which it is dried. Next the pattern

*Whip-Mix Corp., Louisville, Ky.

is painted with a wetting agent (Vacufilm) and allowed to dry.

Use is made of a flexible rubber ring rather than the solid ring lined with asbestos. The rubber ring eliminates the need of the asbestos liner, which would absorb the added water, thereby mitigating the accuracy of the water addition. The flexibility of the rubber ring substitutes for the cushioning effect of the asbestos liner in a solid ring.

The investment is mixed thoroughly, using a water-powder ratio of 0.32, and the pattern is painted with investment, using the brush-vibrator method or vacuum. If the brush vibrator method is used, the rubber ring now is placed carefully on the sprue base and the investment is poured around the painted pattern. This is done by pouring down the side of the ring and allowing the investment to rise around the painted pattern (a thin supporting metal ring can be placed around the rubber ring for convenience during hand investing, but it must be removed immediately after the rubber ring is filled). If a vacuum apparatus is used, a thin supporting metal ring must be placed around the rubber ring prior to investing to prevent its collapse during vacuum investing, but it must be removed immediately afterward. If this metal ring is allowed to remain around the flexible rubber ring, the hygroscopic expansion will be restricted and proper compensation will not be affected.

After the ring is filled, the level of investment is cut off flush with the top of the rubber ring. The metal collar, which acts as a reservoir, is placed into the top of the rubber ring, and the required amount of water is added with a 2 ml. capacity syringe.

Different wax pattern forms require different amounts of compensation. Parallel-walled patterns require more compensation than taper-walled patterns.

The syringe is filled with an amount of water needed for the type of wax pattern being invested, and the water then is dispensed carefully into the reservoir collar (see above schedules).

The investment is allowed to set for forty-five to sixty minutes before the reservoir, rubber ring, and sprue former are removed.

The cylinder of investment is placed into a furnace that is preheated to 900° F. and allowed

Schedule for controlled water addition as recommended by Mahler[13]

Type of pattern	*Water addition*
1. Thin three-quarter crown	1.0 ml.
2. Class I and class II, small M.O.D.	1.1 ml.
3. M.O.D., three-quarter crown	1.2 ml.
4. Bicuspid, full crown	1.4 ml.
5. Class V, full crown	1.5 ml.
6. Crown with facing	1.6 ml.

(For parallel-wall castings use 0.1 ml. more than listed here, and for sloping-wall castings use 0.1 ml. less than listed here.)

Schedule for controlled addition, with warm water bath

Type of pattern	*Water addition*
1. Class V, full crown	0.7 ml.
2. All other types	0.6 ml.

to burn out for one hour before it is removed from the furnace and cast.

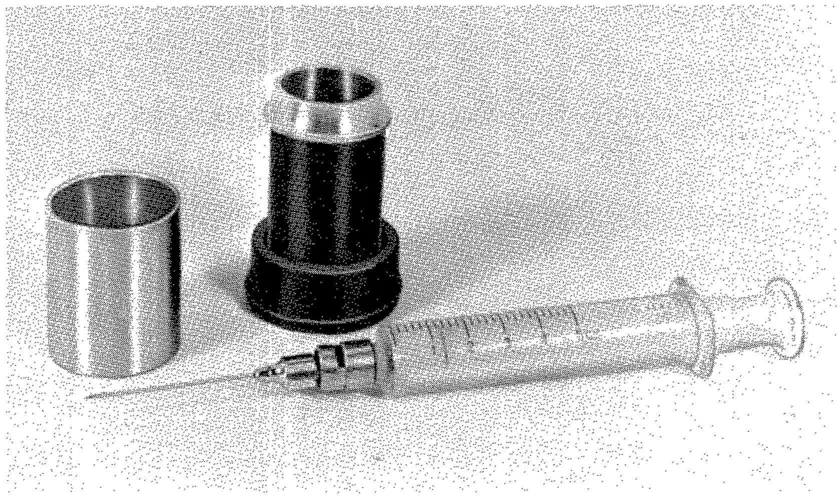
Because of the density of this investment (Hygrotrol) due to strength requirements, full-crown wax patterns (especially) should be sprued and vented properly, and the casting force should be sufficient to prevent back pressure porosity (see recommendations for the correction of back pressure porosity in discussion on spruing).

Because of the possibility of mold fracture, which results from thermal shock, Mahler[13] suggests having the gold alloy in a fluxed molten state almost ready for delivery into the mold before taking the mold from the furnace to the casting machine. Also enough metal should be used so that ample button to avoid shrinkage porosity is left.

The investments that are used in this technique obtain sufficient hygroscopic setting expansion by the addition of a specified amount of water after they are placed in a flexible rubber ring, which offers no resistance to the expansion of the investment. The asbestos liner is eliminated since it would absorb some of the added water. The casting ring is eliminated also since it, too, would restrict setting expansion. The investments should be, and are, strong enough to be handled and cast into without a protective casting ring.

This hygroscopic technique produces excel-

A



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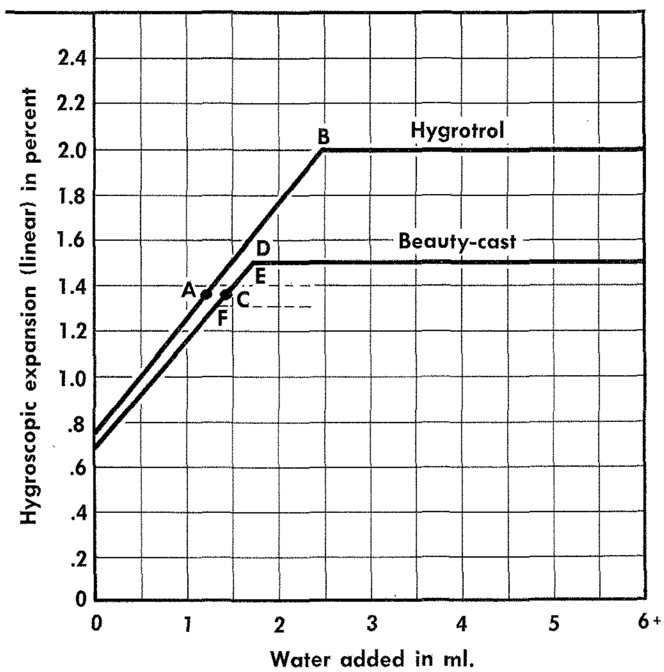


Fig. 8-42. A, Investing equipment used in hygroscopic technique, using controlled amount of added water. **B,** Graph of hygroscopic expansion of investments—water-added technique. (Courtesy Whip-Mix Corp., Louisville, Ky.)

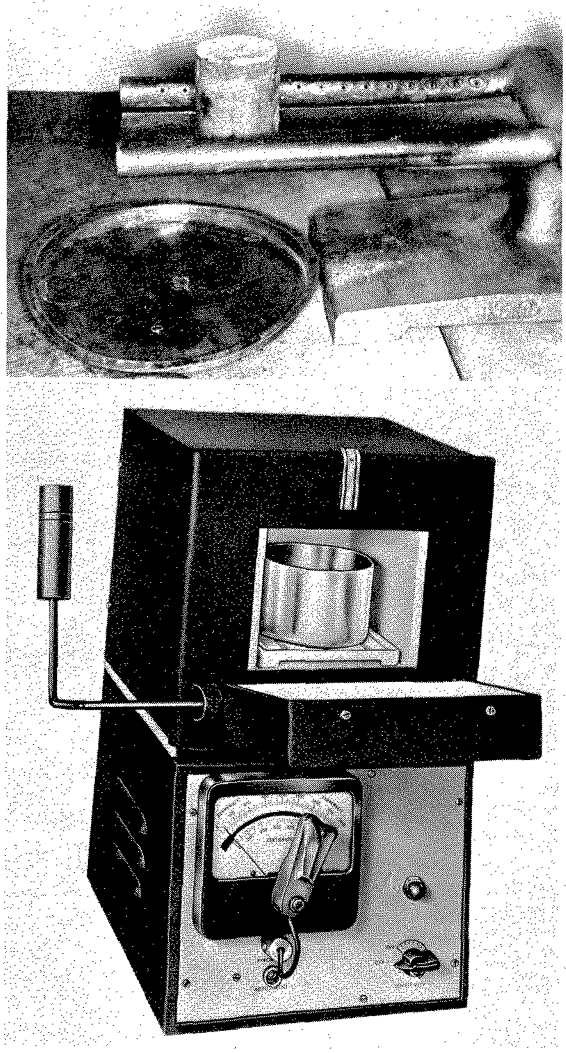
lent castings with a high percentage of reproducibility (Fig. 8-42).

BURNOUT: OBJECTIVE AND IMPORTANCE OF TIME PLUS TEMPERATURE

Burnout is one of the key steps to success or failure in the process of casting. The mold must be burned out for a sufficient period of time and at the correct temperature.

An electric burn-out furnace (Fig. 8-43) equipped with an accurate pyrometer should be used and the temperature indicators spot checked periodically for accurate calibrations. This can be done with Jelenko Tempils.

One must remember that the temperature of the mold is not necessarily the same as the pyrometer reading. The results of a research project showed that "the more water used in the



A

B

Fig. 8-43. A, Type of gas burner that I use for initial elimination of wax and water of crystallization (helps to preserve muffle of electric burn-out furnace). **B,** Electric burn-out furnace equipped with accurate pyrometer. (Courtesy J. F. Jelenko & Co., Inc., New Rochelle, N. Y.)

total amount of investment of all molds in the furnace, the more burnout time will be needed to eliminate all of the water and have the temperature of the molds the same as that registered on the pyrometer."[*]

It takes approximately twenty-five minutes to eliminate the water from the investment in one inlay ring. The temperature of the mold will not rise above 240° F. until all the water has been eliminated. Therefore the temperature of the mold is not above 240° F. for the first twenty-five to twenty-seven minutes of the burn-out period, even if the reading on the pyrometer is 1000° F. or more.

Approximately one hour ten minutes of time is required to burn out one inlay ring in an oven, and another ten minutes for each additional ring in the oven. If larger rings are used, extra time should be added to get a complete burnout.

The burnout is not started until the investment has set thoroughly, but, by the same token, the investment mold is not to be dried out completely. Cracking of the investment will occur in the oven if it has been allowed to dry out too much. This condition is remedied by moistening the investment for a few minutes before placing it in the oven.

The mold is heated slowly at first (preheat at 600° F. for at least thirty minutes) until the free water and water of crystallization of the plaster have been evaporated. If it is heated too fast or before the investment has set, rough castings will result. Rapid heating causes boiling of the wax and the generation of a large quantity of water vapor, which in turn roughens the surface of the mold and also loosens flakes of investment from the mold chamber, to appear later as inclusions within the casting or in the form of pits.

The mold is heated to a high enough temperature and for a long enough time to eliminate the wax completely (1200° to 1300° F.), being careful at the same time to avoid overheating. As the wax is being eliminated some of it is absorbed by the investment, and this portion requires more time for elimination to avoid occlusion of the pores of the investment by carbon, which would prevent proper venting for the escape of gases when the gold alloy is forced into the mold.

The objective of the burnout is to eliminate all the wax and residual carbon and to arrive at a pattern chamber whose surfaces are a replica of the wax pattern. The temperature to which the mold is heated must be high enough, and the mold must be soaked at that temperature long enough to eliminate the wax and also pro-

*From Windish, William, and Wetterstrom, E. T.: Importance of controlled burnout, Thermotrol Technician, p. 3, March-April, 1964.

vide the necessary thermal expansion to produce an accurately fitting small type casting. The length of time that the mold is held at the burnout temperature is important since time plus temperature can completely dissipate the carbon resulting from the burning of the wax.

It is necessary to avoid overheating the mold because the binder in most investments is plaster of Paris or some similar form of gypsum, which, chemically, is calcium sulfate. At high temperatures, above 1350° F., the calcium sulfate decomposes slowly and gives off sulfur or sulfur compounds. The sulfur combines with certain metals in the casting gold, especially copper and silver, forming a surface film of sulfides, which causes a discoloration that is difficult to remove from the casting. This sulfur also attacks the metal inlay rings, the heating element of electric furnaces, and other metal parts, causing rapid deterioration.

It is most important to establish a routine burnout cycle in your own laboratory to ensure routine success.

GOLD ALLOYS—PHYSICAL PROPERTIES

It is always necessary to consult the gold manufacturers' charts for the physical properties of their alloys before selection for use. Properties such as the following should be observed:

1. *Brinell hardness,* which is the resistance of an alloy to indentation. As hardness increases, resistance to wear increases
2. *Ultimate tensile strength,* which is the stress on a metal at the moment of breaking under tensile loading. For dental golds it is a measure of the maximum stress the gold restoration can take before breaking
3. Yield strength, which is the maximum stress that can be applied to a metal before permanent elongation takes place. Since structures must withstand loading without permanent dimensional changes, this value of yield strength rather than the ultimate tensile strength is used for design purposes.
4. *Burnishability,* which is the ability to extend a metal in length or area by "spreading" it with a hard, mildly pointed tool. It can be quantitatively evaluated as a combination of percentage elongation divided by hardness. The greater the elongation of the metal and the softer it is, the better is its burnishability,
5. *Percentage of elongation,* which is the percentage of permanent extension of a prescribed length of a metal specimen at the moment of breaking. It is the engineer's measure of ductility.
6. *Melting range,* which is the range of temperature within which an alloy is partly melted and partly solid. It begins to melt at the lower limit and becomes completely molten at the upper limit of the range. The upper limit serves as a guide in judging the ease with which the gold can be melted for casting, and the lower limit is useful in selecting a suitable solder.

Experimentation and clinical application has shown that a smaller grain size in gold alloys produces better physical properties in the metal; therefore it is desirable and advantageous in the casting process.

Grain refined castings show an increase in tensile strength and elongation without a corresponding increase in hardness, which allows the metal to be deformed more without fracture. This is most important in the burnishing of margins and in the adjustment of clasps.

An understanding of these physical properties makes it possible to use an alloy—one that can withstand considerable overloads, can reduce the danger of permanent distortion without rupture, and can resist flaking when the margins are drawn to a featheredge—with excellent castability.

CASTING AND MELTING GOLD ALLOY

Equipment

Casting equipment consists of a device for melting the gold and another for forcing it quickly into the mold cavity. Use should be made of modern equipment in this most important operation.

Equipment that is used generally for melting the gold is a blowpipe supplied with artificial or natural gas, and compressed air and a gas-oxygen flame. The gas-oxygen flame must be used with care so that the metal is not overheated.

A properly adjusted blowpipe flame is made up of (1) a blue cone one-third to one-fourth the length of the flame, a mixture of unburned gas and air, (2) a reducing area in the center of the flame, and (3) oxidizing areas at the edges of the flame (Fig. 8-44). Blowpipes that do not have these sections well defined are common causes of casting troubles through oxidation. The

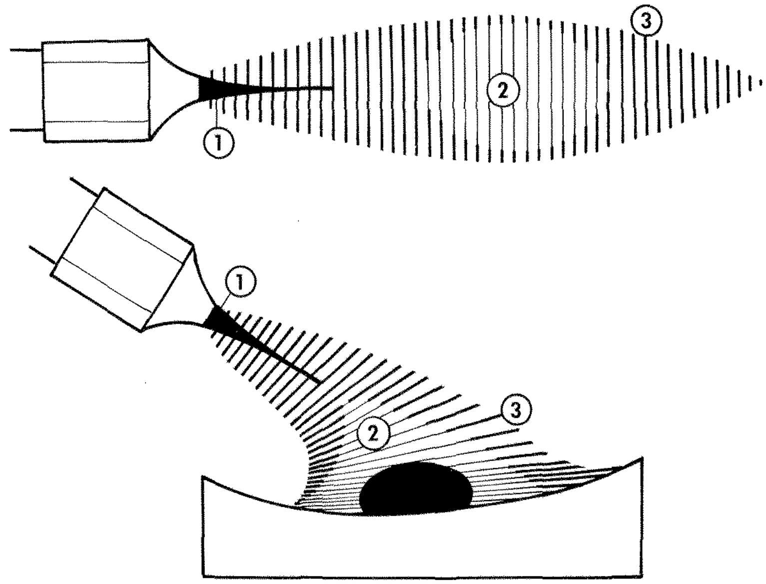


Fig. 8-44. Properly adjusted blowpipe flame is made up of *1*, a blue cone one third to one fourth the length of the flame, a mixture of unburned gas and air; *2*, reducing area in center of flame; *3*, oxidizing areas at edges of flame.

light blue center cone is the area of almost complete combustion and is therefore the hottest part of the flame and slightly reducing. This is the part of the flame that should contact the gold and cover it as completely as possible for rapid melting and protection from oxidation.

Melting and fluxing

Some oxidation will occur during melting regardless of how carefully the blowpipe is handled. It is important therefore that the metal be well protected from oxidation by the use of flux, preferably a reducing flux (such as Ney casting flux or Jelenko reducing flux), and also by keeping the metal covered at all times by the reducing portion of the flame. This type of flux forms a protective covering, and its effective reducing agent converts the oxides back to clean metal, thus retaining the original composition and properties of the alloy. This flux should be added just after the metal has started to liquefy, and another pinch of flux should be added just before casting.

It is essential not only to melt the gold completely before casting so that it will flow freely into the mold, but also, above all, to avoid overheating the metal because high temperatures promote excessive oxidation and absorption of gases. Overheating leads to rough castings, which are weaker and more brittle than normal. It produces a subsurface porosity with a pitting of the surface, which causes discoloration. The ideal range for the melting of the gold alloy should be approximately 100° to 150° F. above the melting range of the alloy.[15]

Cast when the metal is completely molten, and if in doubt as to the fluidity of the gold alloy, do not attempt to move the button by moving the flame, but vibrate or shake the casting machine, which will serve the purpose as well and at the same time will prevent oxidation of the metal. Keep the blowpipe adjusted properly—when the surface of the gold has a scum or film on it, it is being oxidized, and when the surface is bright, shiny, and clear or mirrorlike, the metal is being reduced. Sufficient metal should be used to fill the mold cavity and also to produce a dense sprue and a fair-sized button.

The types of casting machines in general use are centrifugal, air pressure, and vacuum (Fig. 8-45) I am familiar with the use of all these machines and prefer the Thermotrol and the Tri-caster.*

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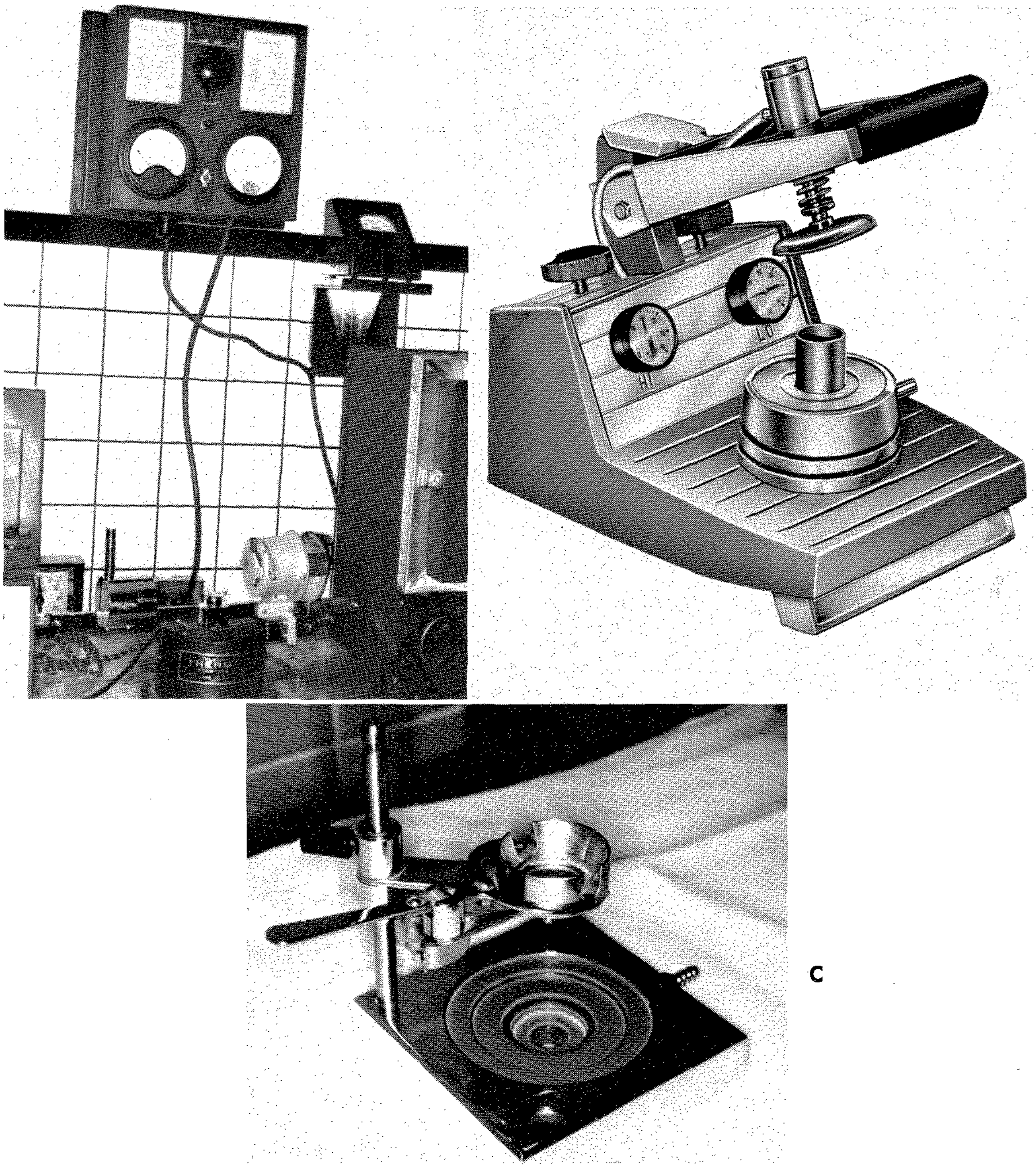
*Whip-Mix Corp., Louisville, Ky.



A

B

C

Fig. 8-45. Types of casting machines in general use. **A,** Jelenko Thermotrol. **B,** Whip-Mix Tri-caster. **C,** Schmitz Vac-O-Cast.

The Thermotrol minimizes the human element and also combines the melting and casting functions into one machine. The metal is melted (by induction) within a carbon crucible in a platinum wound muffle, and the force, used to throw the metal into the mold cavity is centrifugal. Another important factor that was previously pointed out in the discussion of the melting process is that it is equipped with a pyrometer to measure the casting temperature of the alloy used.

Users of Thermotrol casting machines should check the pyrometer readings periodically with the actual temperature inside the muffle by, employing a Therm-O-Check*. A Thermo-O-Check (which melts at 1760° F.) is placed in the muffle and the current turned on. When the Thermo-O-Check draws into a molten globule, the pyrometer should read 1760° F.

Excellent results are obtainable with the Thermotrol casting machine, even when thin sections or intricate patterns are involved. The density and soundness of the castings are very high.

The Tri-caster has three stages of pressure: (1) vacuum—to remove residual gases and air from the mold, (2) low pressure—to initiate flow of molten metal, and (3) high pressure—to complete filling of the mold.

As the handle is closed the base gives and vacuum is actuated; in the same motion of the handle the low pressure is applied to start the metal through the sprue, and then in pretimed split-second sequence the high pressure takes over to push the metal into the far recesses of the mold.

The Tri-caster can be used not only for the casting of regulation gold alloys, but also for the high-fusing ceramic golds and the aluminum alloys, for trays, bases, and clutches. The results are excellent—the castings are dense with sharp margins and complete in the thinnest of sections.

Regardless of the type of casting machine used, when the mold in the furnace has attained the desired temperature, it should be removed from the oven, and the casting should be made rapidly to prevent cooling, which will cause a dimensional change. In other words, a volumetric shrinkage of the mold can take place.

The casting ring should be allowed to stand two or three minutes before quenching it in water.

*J. F. Jelenko & Co., New Rochelle, N. Y.

Pickling solution

Use should be made of the new proprietary pickling solutions to clean castings. The one of choice is Jel-Pac*. (See Fig. 8-46.) It is a harmless, nonirritating, granulated powder, which, when mixed with tap water, makes a strong nonvaporous pickling acid. Since it is nonfuming and produces no corrosive vapors, it does not ruin laboratory equipment.

As Jel-Pac liquid becomes dissipated or contaminated with copper, its color turns from clear to green. This built-in efficiency indicator minimizes the hazard of copper plating of the restorations.

In solution Jel-Pac pickles at its most rapid rate when heated to approximately 140° F. Within approximately one minute oxides disappear and pickling is thorough. Jel-Pac will do a complete pickling job when cold, but the action is not as fast. Clean bright surfaces are produced.

Saf-T-Forceps are used to remove the castings from the pickling solution. Because of the

*J. F. Jelenko & Co., New Rochelle, N. Y.

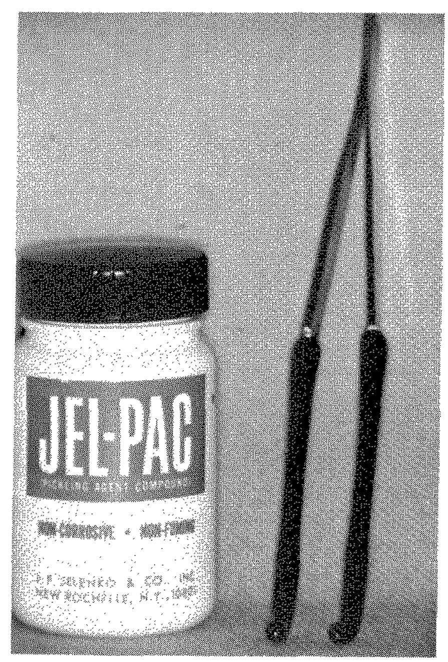


Fig. 8-46. Good pickling solution and Saf-T-Forceps. Contamination is not a problem with these special forceps.

forceps specially treated tips, contamination is not a problem as it is with metal tweezers. The possibility of flash copperplating of pickled restorations thereby is eliminated.

Treatment of residue buttons

Thoroughly clean residue buttons of investment and surface oxidation. Melt the button down on a clean charcoal block, using reducing flame, and with the addition of liberal applications of reducing flux remove any slag with a clean slate pencil; then plunge the hot button into an acid pickle. Never use an asbestos block for this procedure—only a charcoal block because it can be kept clean and thereby avoid contamination of the melted alloy. It also has a reducing action, which, in combination with reducing flux, breaks up metallic oxides and converts them back to clean metal.

Phillips[16] calls attention to the important fact that, when the button has been melted and treated with reducing flux, the flame is removed from the metal and allowed to freeze. This is a mistake because when exposed to the air, the congealing metal will absorb gases, which is exactly what we do not want. His method is to turn off the air and allow only the gas flame to play on the surface of the metal until it congeals. The gas flame will protect the alloy from occluded gases, but it will not prevent solidification from taking place.

Some dentists think that hydrofluoric acid is a very efficient agent for the removal of adhering investment from both the casting and button, since hydrofluoric acid cuts the silica. The casting and button should be soaked overnight in cold hydrofluoric acid to remove adhering investment. This acid should be used carefully and should be kept in tightly covered polyethylene bottles since it attacks glass.

It is good practice to add at least 50% new metal to all melts.

Castings never should be made from gold alloys that have not been cleaned thoroughly.

Precautions in casting gold alloys

Attention must be paid to all details so that castings with the best possible physical properties are produced. Avoid contamination of the gold alloy in any form, such as the following.

1. *From metal dies.* If metal dies are used, place castings in a pickling dish containing a 50% solution of nitric acid, and warm slightly. The base metal will disintegrate.
2. *From rust in the compressed air line.*
3. *From the overheating of the gypsum-bonded investment* (above 1300° F). Sulfur compounds are formed which enter the molten metal to produce a brittle alloy, and tarnishing of the alloy is also possible.
4. *From oxidation.* If the melt is not made in a reducing atmosphere from the beginning to the completion of the casting, oxidation will take place, which may be the cause of pits or discoloration of the metal. Fluxes help prevent oxidation, but are not the complete answer. A reducing atmosphere is the answer to this problem.

Stripping

Stripping is a method that is used to relieve the inside surfaces of small type castings so that they can be fitted to their respective dies and seated properly during cementation. By electrochemical action this stripper uniformly removes a microscopic layer of gold from the surface of the casting.

The Lektro-Dip* stripping outfit is used (Fig. 8-47). This type of equipment uses an acid that removes metal from the surfaces of an inlay or crown. It differs from aqua regia in that its action is fast (about one minute), and the gold surface inside the casting has a polished, etched appearance rather than the dull appearance produced by aqua regia.

This equipment is somewhat the reverse of copperplating equipment. In copperplating, copper is removed from the anode and is deposited on the cathode. With this stripper the gold inlay or crown becomes the anode, and the gold is removed and deposited on the cathode, which, in this case, is the metal container holding the acid. Gold can be recovered by wiping it off the sides of this receptacle. Because the acid is heated in this method, wax cannot be used to protect the margins as in the etching method of aqua regia. To prevent damage to the margins, they are painted with nail polish, which can be removed with a solvent such as acetone or chloroform after stripping.

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*J. F. Jelenko & Co., Inc., New Rochelle, N. Y.

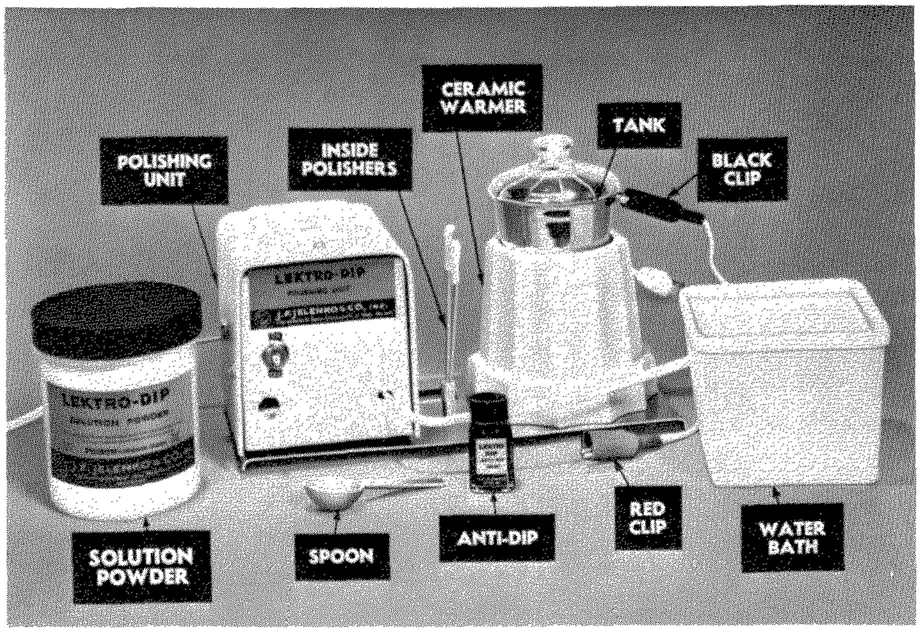


Fig. 8-47. Lektro-Dip stripping outfit. (Courtesy J. F. Jelenko & Co., Inc., New Rochelle, N. Y.)

Heat treatment

Soft and medium hard inlay golds (types A and B) are not affected by heat treatment, but the hard and extrahard golds (types C and D)—the platinum, palladium, gold, and copper alloys—can be hardened appreciably by slow cooling or left in a softened condition, by rapid cooling.

It must be remembered that heating type C and D gold alloys to soldering temperatures will destroy any previous hardening treatment and that securing maximum hardness and strength is not always desirable since this process reduces ductility. A moderate hardening treatment is preferable. If a hardening heat treatment is contemplated, it is important that the clinician or technician follow the manufacturer's recommendations as to the proper heat-treating schedules for their alloys.

Rapid cooling of the golds by quenching them in water followed by a heat treatment at a controlled temperature produces the most satisfactory physical properties.[18] Methods available for this type of treatment are as follows:

1. The gold alloys may be heated at some constant temperature between 480° and 840° F. for a definite period of time. Some castings can be heat soaked for fifteen minutes in a stabilized oven at between 600° and 700° F., and then they can be air cooled.

2. They may be cooled slowly from 840° to 480° F. in a definite time interval. It generally is agreed that each alloy not only has an optimum heat-treating temperature, which means it has reached its maximum strength, but also exhibits a minimum corresponding brittleness. Again the importance of obtaining these temperature and timing schedules from the gold manufacturer is emphasized. Heat-treating furnaces and baths that operate at a constant temperature are available, and the manufacturer's treating schedules for their alloys must be used (Fig. 8-48).

Softening or hardening heat treatment also can be carried out effectively by regulating the time the casting is allowed to cool in the investment after casting. For softening, the inlay ring is plunged into water one to two minutes after casting. For hardening, the ring is allowed to cool three to six minutes before quenching. If a larger flask than an inlay ring is used, it will take longer for the gold to cool through the hardening range; therefore, a longer period should be allowed before quenching—six to ten minutes for a medium-sized flask and eight to twelve minutes for a large flask.[19]

Heat hardening for fixed bridges or splints

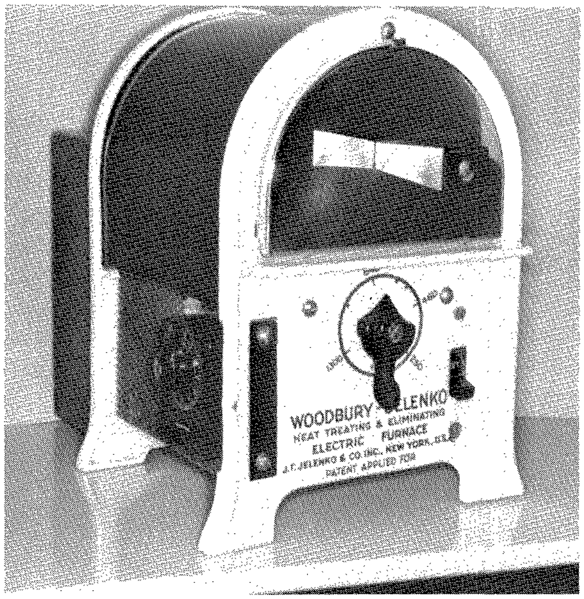


Fig. 8-48. Heat-treating furnace that I use.

must take place after the bridge is soldered into a unit. Selection of the various materials for constructing a bridge must be done carefully so that everything is compatible for heat hardening by the same operation. Consultation with the manufacturer of the gold alloys and solders will elicit the information.

My preferred procedure for an assemblage after soldering is to allow the work to bench cool for about five minutes and then slowly submerge the case in water to help break away the investment. This leaves the metal in a moderately heat-treated condition for maximum strength and toughness and appears to minimize warpape.

Gold alloys that are susceptible to heat treatment will show an increase in hardness and a decrease in ductility. Charts, issued by gold alloy manufacturers, will list the Brinell hardness when heat treated or quenched. It is felt, in general, that most dentists or technicians do not heat treat alloys; therefore, it is important to choose those alloys that are satisfactory when quenched.

CASTING GOLD TO GOLD

General considerations

When casting to a coping or wire embedded in the investment, the base metals in the gold coping or wire have to be prevented from becoming contaminated (oxides and sulfides) by using an investment with modifiers or one of the regularly used gypsum-bonded investments in conjunction with a suitable burn-out cycle.

Gypsum-bonded investments are used generally in this particular casting operation, and the decomposition of the calcium sulfate at temperatures higher than 1300° F. during wax elimination gives off sulfur gases—sulfur dioxide and sulfur trioxide—which contaminate the embedded metal and the alloy being cast to this metal.

O'Brien and Nielsen[20] have shown that the rate of decomposition of calcium sulfate in the investment is increased in the presence of carbon (created in the process of wax elimination), but decreases considerably in the presence of carbon dioxide gases. Therefore, modifiers must be added to the investment, which will produce carbon dioxide on decomposition, thereby protecting the embedded alloy from contamination. It also allows for a good bond of the superstructure metal to the coping.

Even in these modified investments care must be taken not to prolong the heating of the investment mold because most of the carbon dioxide gases will be released and terminated and not enough carbon dioxide gases will remain to protect the embedded metal from contamination.

Therefore, besides the use of a proper investment, a suitable burn-out cycle is of the utmost importance. The temperature of the mold plus the time during which the embedded metal is exposed to this temperature are important factors in contamination, and to avoid this possibility keep the mold temperature at 1300° F. for a short period of time.[21]

Construction of coping

The coping should be made as thin as possible, having incorporated in its design the proper cervical third anatomic form and a shoulder, which is placed subgingivally and is narrow and limited in its thickness to the width of the space created by the preparation of the tooth.

The coping should be cast in a gold alloy that contains a minimum amount of copper since alloys with low copper content will not oxidize readily in the burn-out procedure and will form a better bond with the new metal.[22]

Casting to coping

1. Wax the crown over the coping to a desired anatomic form.

2. Use multiple sprues so that this gold is allowed to enter the mold rapidly, to flow over coping, and also to provide for proper venting to allow for escape of hot gases, thereby avoiding back pressure porosity. A thin wax sprue attached to the side of the pattern will provide an air-escape channel.

3. Clean the wax pattern; then use a wetting agent.

4. Invest the waxed crown–coping combination, using Luster Cast investment* or Steele's Super investment.† These investments contain a deoxidizing agent such as graphite or powdered copper. Follow the manufacturer's instructions as to the water-powder ratio.

5. *Burnout.* The main purpose of the burnout is to eliminate the wax at lower temperatures without causing any decomposition of the investment material.

With the sprue hole down, place the ring in a furnace preheated to 900° F. By having the furnace preheated, the wax is eliminated rapidly through the assistance of residual moisture in the investment, thereby flushing the wax from the mold. As the wax melts, the metal sprue, which was coated with wax, will fall out. Hold the temperature at 900° F. for one hour to allow the temperature of the center of the mold to reach 900° F. and to eliminate as much of the residual wax as possible. At the end of this time, turn ring-to-sprue hole up and raise temperature to 1300° F., and let the casting ring remain at this temperature for sixty minutes. It requires about forty-five minutes for the center of the mold to reach the oven temperature of 1300° F.[21] Therefore, the center of the mold will remain at 1300° F. for a short period of time before casting—fifteen minutes. This will minimize the chance of contamination of embedded metal and give a good union.

Temperatures above 1300° F. will eliminate the deoxidizer in the investment in many instances, allow the coping to oxidize, and prevent the gold alloy from flowing freely and alloying with the coping surface. A welding result must be obtained between the liquid and solid metals, and therefore the surface of the embedded metal must be free of oxides and sulfides.[22]

6. *Casting.* The gold that is cast over the coping should be heated an extra 100° F. to allow it to flow better over the coping and to avoid premature cooling (the Thermotrol casting machine is excellent for this operation). If all precautions have been taken, an excellent welding result will ensue—a slight alloying of the gold alloy being cast and the coping surface.

Some dentists feel that a metal union, which requires no solder, is possible with this technique, but I always solder the butt joint between the overlay casting and the coping. The butt joint between the two is grooved, fluxed properly (antiflux and soldering paste flux), and soldered carefully and precisely.

CERAMIC GOLD ALLOYS

Investing

1. Wax pattern
   a. Design the wax pattern so that excessive porcelain bulk is avoided—never more than approximately 1.5 mm. labially or buccally.
   b. The thickness of the labial or buccal surface of casting is equivalent to that of a piece of 28-gauge wax.
   c. Keep the labial and buccal areas convex. Avoid boxings and concavities.
   d. By having even-flowing curves sharp points, corners or angles on the porcelain bearing surfaces are eliminated, as well as the possibility of stress concentration.
   e. Convex curves may assist in creating a prestressing effect, which could increase the apparent strength of the porcelain when subjected to tension.[23]
   f. Mechanical retention is contraindicated.

2. Sprue and mount pattern on a crucible former. A 10- or 12-gauge sprue and a 10- or 12-gauge vent can be used.

Ceramic high-fusing gold alloys have a short melting range, and, since it solidifies rapidly in the mold, a 10-gauge sprue should be used, if possible, to avoid shrink-spot porosity. For thinner patterns or copings use a 12-gauge sprue. Some pontics may require an 8-gauge sprue.

The sprue should be attached to the thickest

*Kerr Mfg. Co., Detroit, Mich.
†The Ransom & Randolph Co., Toledo, Ohio.

part of the wax pattern and a reservoir added to the sprue, regardless of the size of sprue. The reservoir must be attached to the sprue not more than $\frac{1}{16}$ inch from the pattern and must be thicker than the thickest part of the casting. Thicken the sprue slightly between the reservoir and wax pattern. (See Fig. 8-49.)

A length of 10-gauge round wax rod is used (*instead of a thinner gauge if possible*) for the "blind" vent since the heavier wax usually will

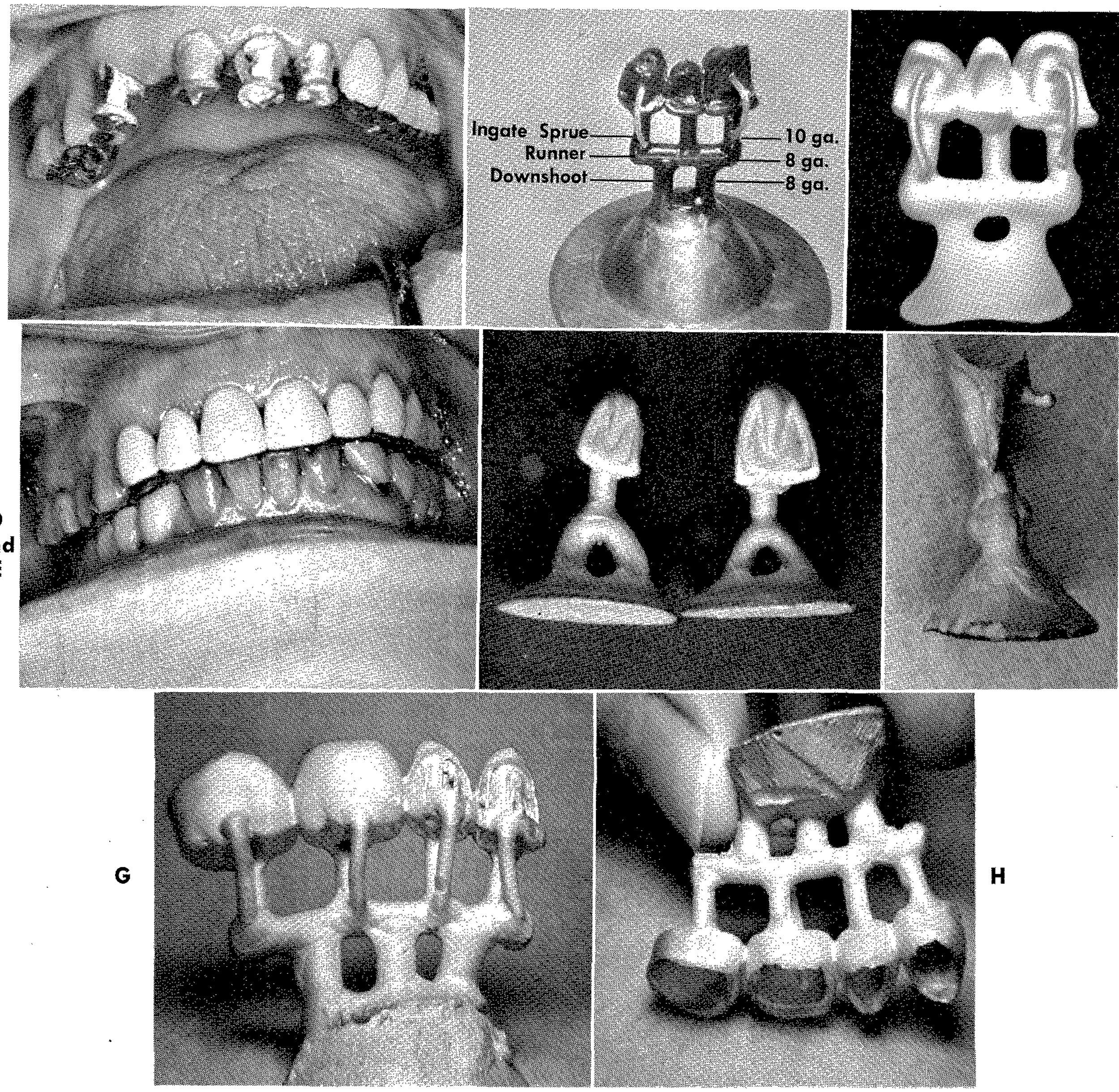


Fig. 8-49. A, Cast copings in position for impression to seat dies correctly in construction of working cast. **B,** *Proper spruing for casting one-piece bridge.* **C,** One-piece bridge casting. **D,** Completed one-piece, three-tooth ceramic bridge (extending from upper right central incisor to upper right cuspid) and two ceramic crowns (upper left central and lateral incisors). **E,** Excellent method of spruing for construction of a ceramic crown. **F,** Another good method of spruing. **G,** One-piece casting illustrating method of spruing. **H,** Lingual view of casting.

not be displaced by the investment entering the ring and a thinner gauge wax might be.

Remove a small section of the asbestos liner for the attachment of the wax form (blind vent) to the inlay ring proper with sticky wax. Do not extend wax beyond the edge of inlay ring. After the long fiber asbestos paper liner has been moistened by capillarity, the inlay ring is positioned over the wax pattern. The wax form for vent is bent into position in relation to the pattern. In full-crown patterns this vent form is extended into the cavity side of the wax pattern to within 2 mm. of the occlusal section of the pattern.

After burnout this "blind" vent forms an opening for the escape of gases from the mold cavity, thereby allowing a complete filling of the mold with metal without entrapment of gases. Back pressure porosity is thereby avoided.

3. Line inlay ring with one layer (butt joint) of long fiber asbestos paper. It must be flush with the end of the ring, except that at the crucible end it must be shortened sufficiently to accommodate the slight step on the crucible former. The liner may be moistened by placing the lined ring in a shallow vessel containing about ¼ inch of water. In a few seconds capillarity will moisten the liner from end to end.

4. Clean wax pattern. Apply a surface tension reducing agent.

5. The following are types of investment used in the casting of ceramic gold alloys:

   a. Use a phosphate-bonded investment (magnesium phosphate type) if the alloy to be used is essentially of a gold composition. Phosphate type investments are not as permeable as regular crown and bridge casting investments. The investment of choice is Ceramigold.*

   b. Use a silica-bonded investment (ethyl silicate type) if the alloy is essentially of a palladium composition.

The phosphate and silicate bonded investments are known for their stability at elevated temperatures. The casting temperature of the alloys that are cast into phosphate or silicate bonded investments are usually in the area of 2300° F., as compared to the gypsum-bonded investments, which are used mainly for casting gold alloys that melt below 1900° F.

It is hazardous to use a gypsum-bonded investment for the casting of ceramic gold alloys because of the possibility of contamination of the alloy. It is necessary to melt high-fusing gold alloys with an oxygen-gas flame, which is very hot. If the temperature of the gypsum investment goes past 1300° F., sulfur gases are given off, which are absorbed by the molten alloy. This can lead to a lowering of the bond strength of the porcelain to the metal, surface roughness, and poor fit.

To date the phosphate-bonded investments are the best for accuracy of fit and surface smoothness in the casting of high-fusing ceramic gold alloys.

Phosphate-bonded investment uses a special liquid. This liquid controls not only setting and thermal expansion, but also surface roughness. This necessitates accuracy in the measurement of the powder-liquid ratios.

If the liquid, as supplied, gives more expansion than wanted, it may be diluted with water to decrease the expansion of the investment. In other words, the ratio of special liquid to water used in the mix allows for variations in casting dimension. It is possible to obtain a frictional fit for pinledges, three-quarter crowns, etc. or a loose, or passive, fit for full crowns.

A loose, or passive, fit is necessary for full crowns to avoid fracture of the porcelain because of metal deformation during fitting or cementing of the restoration.

6. For average full crowns and lower anterior teeth, the following special liquid-water-powder ratios have been found to give good results.

   a. For the average full crown (upper anterior teeth, upper and lower bicuspids and molars) it has been found, by trial and error, that 5.5 ml. special liquid and 3 ml. water to 60 grams of Ceramigold powder will attain the desired results (must always have 8.5 ml. liquid to 60 grams powder).

   b. For lower anterior teeth—long, thin, or narrow preparations—use 7 to 7.5 ml. special liquid and 1.5 to 1 ml. water. The longer the preparation, combined with or without a small diameter, the more special liquid is needed for greater expansion. A

*Whip-Mix Corp., Louisville, Ky.

Fig. 8-50. Mixing bowl (marked with an X) to be used exclusively for ceramic type investment.

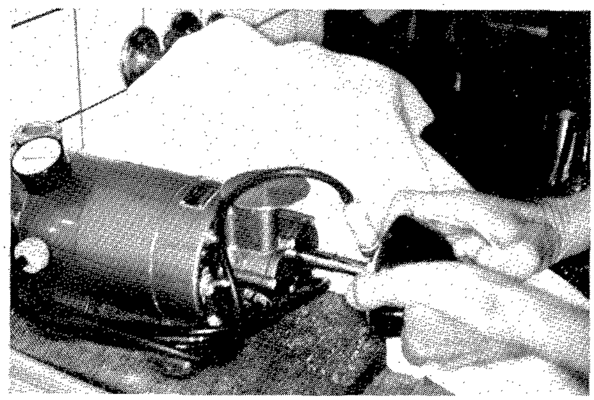
lot is dependent on the taper of the preparation and size of the tooth.

7. A mixing bowl for the exclusive use of this investment is a "must" (Fig. 8-50). Because of the ingredients in this material, it is possible that other types of casting investments may be affected adversely.

8. A water bath is not used routinely. If a water bath is used, do no immerse the inlay ring completely. The water should be at least ¼ inch below investment level.

9. The phosphate-bonded investments do not mix as readily as gypsum-bonded investments and therefore should be spatulated more thoroughly. Spatulate rapidly to overcome shorter working time of this investment and to decrease risk of entrapped air bubbles.

Add 60 grams of Ceramigold investment to 8.5 ml. liquid (5.5 ml. special liquid to 3 ml. water) and incorporate thoroughly with a hand spatula. It is helpful to place the mixing bowl on a vibrator while spatulating by hand, which will encourage a more rapid incorporation of the powder and the liquid. Mixing can also be done by vacuum and applied to the wax pattern by hand—vibrator method—or the vacuum investing unit can be assembled and the mix spatulated rapidly for twenty-five seconds under vacuum. Next hold Vac-U-Spat for twenty to twenty-five seconds without spatulating while maintaining vacuum. This additional time thins the mix so that it will flow readily onto restricted surfaces. Fill the inlay ring. (See Fig. 8-51.)



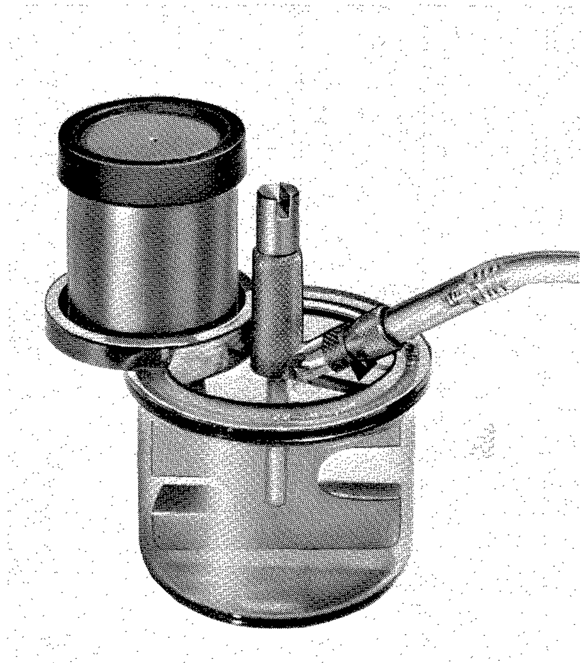


Fig. 8-51. Vacuum apparatus used to mix ceramic investment, which is applied to wax pattern by hand-vibrator method.

10. Let bench set for sixty minutes.

Casting

1. Remove sprue pin and crucible former. Scrape away enough investment to expose "blind" vent wax where it is attached to side of ring.

2. Maximum thermal expansion is obtained at 1300° F., and it will remain constant to 1800° F. If one goes past 1450° F. with Ceramigold investment, it is possible to burn out the protecting agents, but the "fit" will be satisfactory.

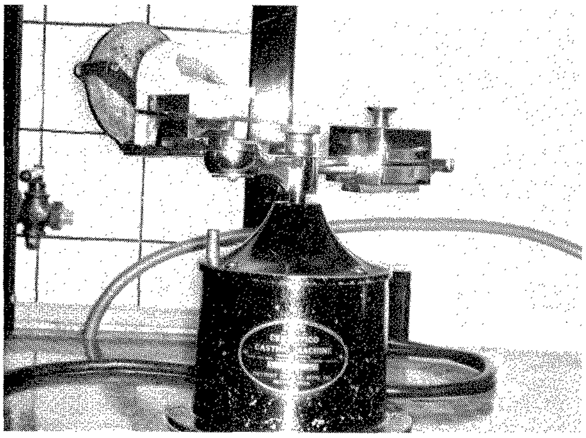


Fig. 8-52. Centrifugal casting machine used to cast high-fusing ceramic gold. Put an extra turn on spring to give a little more casting force because ceramic gold alloy is not quite as fluid as regular casting gold alloys and investment used is not as permeable as regular crown and bridge–casting investments.

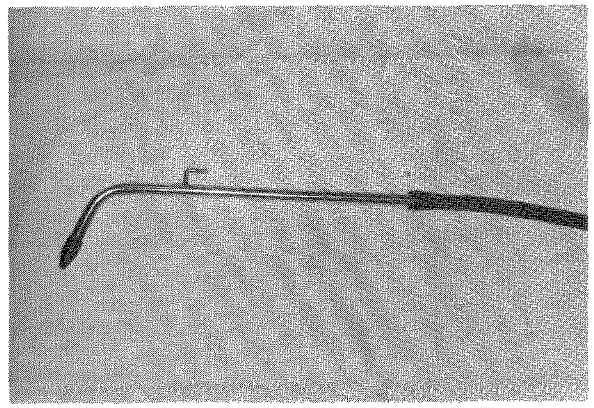


Fig. 8-53. Gas-oxygen torch used in melting high-fusing ceramic gold alloys.

Place the inlay ring in a furnace preheated to 600° F. with the sprue hole down. By having the furnace preheated, the wax is eliminated rapidly through the assistance of residual moisture in the investment, thereby flushing the wax from the mold. Hold the temperature at 600° F. for thirty minutes, then turn the ring to sprue hole up, raising the temperature to 1300° F., and let the mold remain at this temperature for one hour ten minutes.

Thin pinledges, three-quarter crowns, etc. should be cast at 1450° F. Higher temperatures increase the permeability of the investment and make it easier to cast thin sections. The metal can flow to all intricate areas. However, heating to higher temperatures will increase the tendency of the investment to adhere to the casting and will diminish the clean appearance of the casting.

3. Use the Tri-caster or centrifugal casting machine to make the casting. If the centrifugal machine is used, put an extra turn on the spring to give a little more casting force because the ceramic gold alloy is not quite as fluid as regular casting gold alloys and the investment used is not as permeable as regular crown and bridge casting investments (Fig. 8-52).

Use a clean crucible, a special high-heat ceramic crucible such as Wesgo* small type "A." It should not be used for any other type of gold alloy or lined with asbestos because of the possibility of contamination to the ceramic gold alloy.

To provide for a minimum of oxidation in the casting of ceramic gold alloys, it is recommended that a thin film of borax be melted into the discharge path and orifice of the Wesgo crucible prior to making the first melt. Subsequent treatment should be unnecessary.

4. A gas-oxygen torch is used for melting this type of gold alloy—use the reducing cone of the flame. A small gas-oxygen torch is recommended (Fig. 8-53), and this type of flame must be used with care so that the metal is not overheated. Metal should be held under the torch for a short period of time to heat it to the casting temperature of 2300° F. Surface roughness and porosity can be caused by overheating the alloy.

5. I do not use any flux during the melt. However, if one is desired, Steele's Flux Tabs* or calcined Borax† can be used.

6. Use more gold alloy of the ceramic type than would be used when casting regular gold alloys. Use half new gold when recasting with a button, and it is wise to treat buttons in hydrofluoric acid before recasting.

If new gold is being added to the button, put the new gold in the crucible first, the button on

*William Dixon, Inc., Newark, N. J.

*The Columbus Dental Mfg. Co., Columbus, Ohio.
†Williams Gold Refining Co., Inc., Buffalo, N. Y.

top of this, and make the melt as quickly as possible.

Use protective goggles with cobalt blue lenses during the casting operation.

When the melt is about finished, transfer the ring from the oven to the casting machine, complete the melt in a few seconds, and make the casting, thereby avoiding any possibility of dimensional change caused by any cooling effect of the mold.

The ideal time to release the casting machine is when the metal looks shiny and mercury-like. Let the casting machine come to a full stop before removing the ring.

7. Allow the ring to bench cool until you can pick it up with your fingers. By slowly cooling the casting in the ring to room temperature the heat treatment of the gold alloy is accomplished, and, if the porcelain baking procedures are carried out carefully, this added strength is not lost.

8. Quench in water. Remove casting from investment and brush it as clean as possible.

Treatment of the casting

1. After mechanical cleaning pickle the casting in hot 50% hydrochloric acid for five minutes or use Jel-Pac pickling solution. Keep a separate pickling acid and container for the exclusive use of ceramic gold alloys to eliminate any danger of copper ion contamination from other types of gold alloys. Use Saf-T-Forceps.

2. Neutralize the investment in baking soda and rinse in water.

3. Cut off sprues and do the necessary finishing, using stones and disks specifically allocated for working with ceramic golds, and keep these cutting tools in a marked separate container. Indiscriminate use of stones or disks used on other types of gold alloys can cause contamination by copper, silver, etc.

4. Some technicians lightly sandblast casting at low air pressure (Fig. 8-54). If this is done, use clean sand in the Handy Sandy for ceramic gold only.

5. The area to receive porcelain should be ground with medium or fine grit mounted stones.

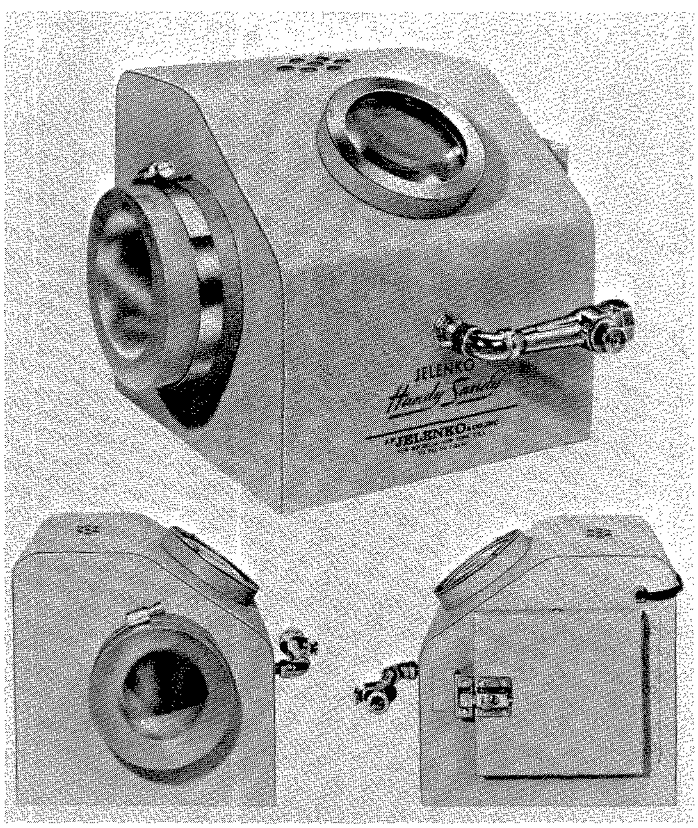


Fig. 8-54. Apparatus used for sandblasting of castings at low air pressures.

Fig. 8-55. Ultrasonic cleaning unit used for cleansing of castings.

Fig. 8-56. My acid chamber.

This procedure makes it easier to apply the opaque porcelain.

6. Rubber wheel all surfaces that are not to be covered with porcelain.

7. After these mechanical procedures are completed, the casting is cleaned thoroughly in an ultrasonic cleaning unit (Fig. 8-55).

8. The casting can be repickled at this stage of the operation, using 50% hydrochloric acid, or it can be pickled in hydrofluoric acid, using an overnight soak, or the casting can be put in a wide-mouthed, screw-capped polyethylene bottle containing hydrofluoric acid and the bottle put in the ultrasonic cleaner for twenty minutes. When using hydrofluoric acid, use extreme caution in its handling. (See Fig. 8-56.)

9. The gold manufacturers recommend inserting the casting into a porcelain furnace at 1200° F. for elimination of any chance of contamination and raising the temperature to 1925° F. Remove casting as soon as this temperature is reached or after a few minutes of heat soaking and cool under a glass. This gives some more heat treatment to the alloy.

10. After this treatment do not touch the area to receive porcelain with the fingers. Oil from the hands can affect the quality of the porcelain-gold alloy bond. If this has been done inadvertently, remove the fatty oils with methyl alcohol.[22]

• • •

If the previously mentioned technical procedures are carried out faithfully, castings exhibiting accurate fit, sharp margins, and smooth surfaces can be obtained (Fig. 8-57).

The success of porcelain-gold restorations are dependent on a number of factors. A few of the important ones are (1) matched coefficients of expansion, (2) chemical bond, (3) a good Brinell hardness of the alloy, and (4) sag resistance.

1. Coefficient of expansion or coefficient of thermal expansion is the most important property for both the gold and the porcelain. The coefficient of expansion is the percentage change in length when a material is heated from room temperature to higher temperatures. Therefore it is the most critical property in designing a ceramic-to-metal combination and must be adjusted as close as possible between gold and porcelain, with a slight edge being given to the gold. Gold, therefore, should have a slightly higher coefficient of expansion.

To reduce interfacial stresses between the porcelain and metal, their coefficients of expansion should be matched or compatible.

The bond between these two materials is dependent upon this important factor of matched coefficients of expansion. The greater the disparity is between the coefficients of expansion

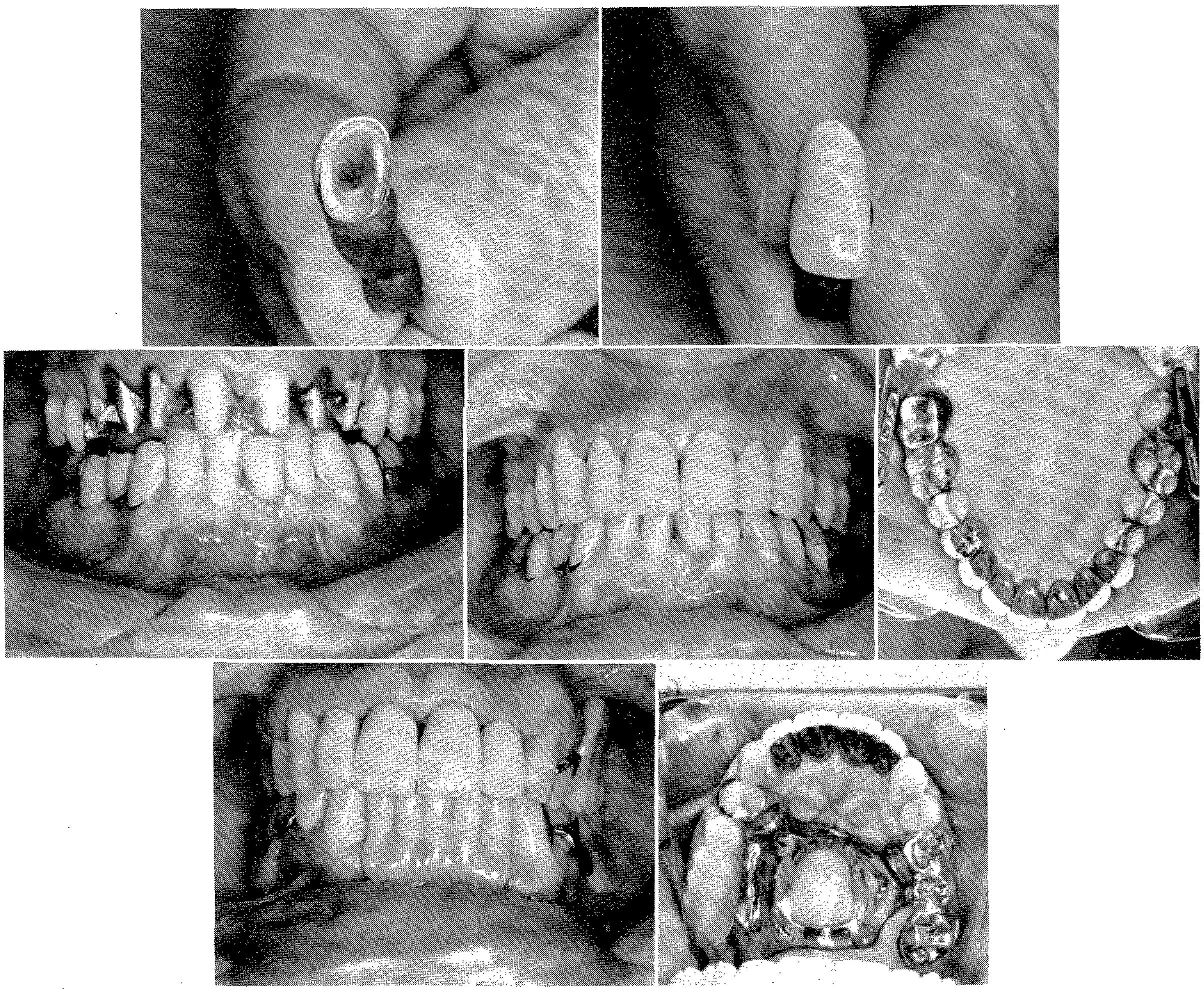


Fig. 8-57. Few cases of porcelain-gold restorations.

of the two materials, the greater the interfacial stress will be; hence, the greater the probability of bond rupture.

As the porcelain-metal combination cools, the metal contracts faster than the porcelain and pulls it together. This leaves the porcelain in compression where it is strongest. If the gold alloy shrinks less on cooling, after firing the porcelain, the porcelain will be in tension, where it is weakest, and resulting in crazing of the porcelain surface. Ceramics are strong in resistance to forces that try to shorten their length and otherwise compress them.

Accurate control checks must be made by the manufacturers of these materials to maintain them in a precise ratio to each other.

2. Also it is necessary to have a chemical bonding. Oxides contribute to a chemical bond between the alloy and the porcelain. The oxide formation must not affect the color of the porcelain. The main bond is chemical and only slightly mechanical. The mechanical bond results from the gripping of the many grooves in the surface of the metal by the porcelain.

If either of these two all-important factors—matched coefficients of expansion and chemical bonding—is not present in the porcelain-gold pair, then the full strength of the bond will not be developed.

The porcelain and gold must be made for each other to expand and contract compatibly and provide an inseparable bond.

3. It has been found that the ceramic gold alloy actually becomes stronger during the porcelain bake. The full-strength potential of the gold is developed.

4. Sag resistance is the ability to withstand sag, creep, or deformation at high temperatures. The importance of sag resistance is primarily its effect on accurate fit of the restoration, not before but after baking on the porcelain. This development also has resulted in higher hardness and greater strength.[25]

Salient facts

1. The physical properties of the materials entering into the casting process, that is, waxes, investments, and gold alloys, must be understood thoroughly and applied intelligently.
2. When the pattern wax is manipulated intelligently, it has a high degree of stability.
3. It is necessary that the cast be run very soon after the impression is taken.
4. Rapid cooling of the casting by quenching it in water, which is followed by heat treatment at a controlled temperature, produces the most satisfactory physical properties.
5. The manufacturer's directions should be followed as to the correct water-powder ratio for their product.
6. When vibrating the investment, it should not be vibrated violently.
7. The inlay ring is lined with one layer (butt joint) of long fiber asbestos paper. It must be flush with the end of the ring, except that at the crucible end it must be shortened sufficiently to accommodate the slight step on the crucible former. The liner may be moistened by placing the lined ring in a shallow vessel containing about ¼ inch of water. In a few seconds capillarity will moisten the liner from end to end.
8. Fresh acid pickles should be prepared frequently. All castings should be dipped in sodium bicarbonate solution after pickling, to neutralize the acid.
9. One part nitric acid to two parts water should be used to remove fusible metal from inside castings. The metal can be boiled in this acid. A fume chamber is used.
10. All gold alloys do not have the same shrinkage. The degree of shrinkage varies with the alloy used, and this point must be remembered when determining the water-powder ratio for investing patterns. By slightly changing the water-powder ratio metals and their alloys of different coefficients of expansion can be cast to dimension.
11. An electric furnace with a pyrometer, which is checked frequently, should be used for the burnout.
12. An intelligent selection of gold alloys for the case at hand should be made, taking into consideration such physical properties as ultimate tensile strength, yield strength, proportional limit, elongation, Brinell hardness, melting range, and burnishability.
13. In melting gold use the central flame at the point just below the blue cone—the reducing zone. Use reducing flux.
14. Rapid cooling (quenching just below red heat) after casting makes gold alloys as soft and malleable as possible. Slow cooling (in invested ring or in a furnace) after casting increases the hardness, strength, and brittleness of the harder alloys.
15. Pits in casting may be caused by improper spruing, improper melting of the metal, inclusions of detached particles of investment or other foreign material, or too little or too much flux.
16. Rough castings may be caused by the following: (1) too rapid of a burn-out, (2) heating the investment to too high a temperature, (3) heating the gold to an excessively high temperature, (4) too heavy vibration during investing, and (5) the investment mixed improperly.
17. The development of mechanical spatulation and use of certain wetting agents have aided tremendously in the elimination of surface irregularities.
18. Absolute adherence to a very careful and standardized technique cannot be over emphasized.
19. Smooth castings are produced by the proper water-powder ratio, mechanical spatulation, a thin coating of a wetting agent, a careful painting of the investment on the pattern, proper burnout and melting of the gold.
20. Permeability in casting investments is a very important factor. It can affect the completeness and fine definition of a casting as well as its soundness, finish, and physical properties.
21. Bubbles on the surface of a casting may be caused by entrapment of air during investing or the use of too much wetting agent.

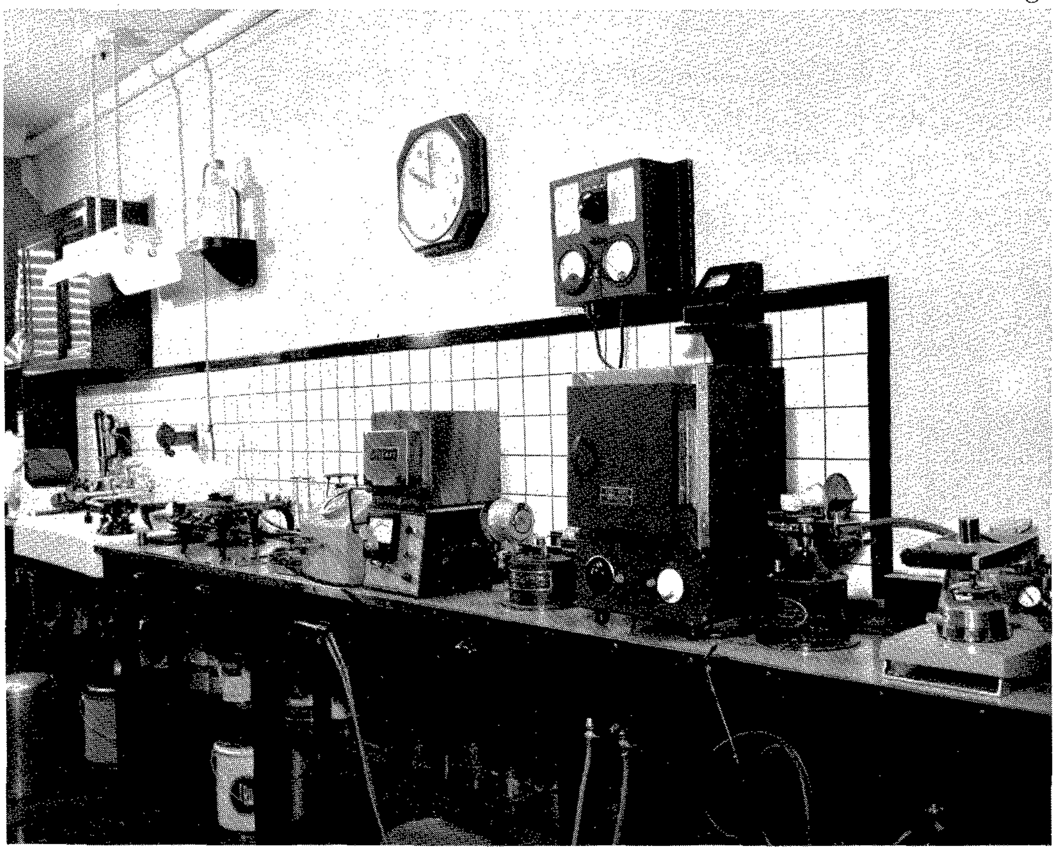


Fig. 8-58. Picture of casting and soldering section of my laboratory.

22. The pickling agent that I use is Jel-Pac, which is a harmless, nonirritating compound and is mixed with tap water to make a strong pickling solution that is nonfuming and produces no corrosive vapors. It does not ruin the laboratory equipment. It produces clean bright surfaces quickly. Saf-T-Forceps are used to remove the castings from the pickling solution. Because of the forceps' specially treated tips, contamination is not a problem as with metal tweezers. The possibility of flash copper plating of pickled restorations has been eliminated.

23. It has been recommended that after acid treatment, because of retention of acid in casting surfaces, the casting should be reheated to a cherry red and then quenched in 70% alcohol. This brightens the casting and dissipates retained acid.[24] (See Fig. 8-58.)

REFERENCES

1. Hollenback, George M., and Rhoads, J. E.: A study of the behavior of pattern wax, J. S. Calif. Dent. Ass. **27**:432-434, 1959.
2. Baum, Lloyd: Wax pattern by direct and indirect methods. In Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co., pp. 127, 128.
3. Markley, Miles R.: The wax pattern, D. Clin. N. Amer., pp. 615-623, Nov., 1958.
4. O'Brien, William J.: Practical application of current casting research, J. Prosth. Dent. **10**:558-560, 1960.
5. Strickland, W. D., and Sturdevant, C. M.: Porosity in the full cast crown, J.A.D.A. **58**:69-78, 1959.
6. Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co., pp. 171-185.
7. Hollenback, George M.: The control of erratic behaviors of casting investments, J. S. Calif. Dent. Ass. **30**:159-162, 1962.
8. Hollenback, George M.: Precision gold inlays made by a simple technic, J.A.D.A. **30**:99, 1943.
9. Coy, Herbert D., and Hall, S. Guy: Hygroscopic investment expansion for small castings, D. Clin. N. Amer., pp. 625-636, Nov., 1958.
10. Hollenback, George M.: Simple technic for accurate castings; new and original method of vacuum investing, J.A.D.A. **36**:391-397, 1948.
11. Phillips, Ralph W.: Relative merits of vacuum in-

vesting of small castings as compared to conventional methods, J. Dent. Res. **26**:343-352, 1947.
12. Asgar, K., Mahler, D. B., and Peyton, F. A.: Hygroscopic technique for inlay casting using controlled water additions, J. Prosth. Dent. **5**:711-724, 1955.
13. Mahler, David B.: Controlled hygroscopic expansion of the investing material. In Hollenback, George M.: Science and technic of the cast restoration, St. Louis, 1964, The C. V. Mosby Co., pp. 156-170.
14. Windish, William, and Wetterstrom, E. T.: Importance of controlled burnout, Thermotrol Technician, p. 3, March-April, 1964.
15. O'Brien, William J.: A digest of current casting research, Thermotrol Technician, pp. 1-2, Jan.-Feb., 1960.
16. Phillips, Ralph W.: Casting. In Johnston, J. F., Phillips, R. W., and Dykema, R. W.: Modern practice in crown and bridge prosthodontics, Philadelphia, 1960, W. B. Saunders Co., p. 164.
17. Kovaleski, Theodore: How to relieve crowns and inlays to correctly fit the die, Thermotrol Technician, p. 3, Nov.-Dec., 1958.
18. Shell, John S.: Fundamentals of metallurgy as applied to dental technical procedures (reprint), Dent. Students Mag., pp. 3-15.
19. Coleman, Richard L.: Casting procedures. In Ney bridge and inlay book, Hartford, Conn., 1958, The J. M. Ney Co., pp. 133-159.
20. O'Brien, W. J., and Nielsen, J. P.: Decomposition of gypsum investment in the presence of carbon, J. Dent. Res. **38**:541-547, 1959.
21. Asgar, K., and Peyton, F. A.: Casting dental alloys to embeded wires, J. Prosth. Dent. **15**:312-321, 1965.
22. Jelenko, J. F.: Making the coping, crown and bridge construction, ed. 5, New Rochelle, N. Y., 1965, J. F. Jelenko & Co., Inc. p. 67.
23. Mumford, George: The porcelain fused to metal restoration, Dent. Clin. N. Amer., pp. 241-249, March, 1965.
24. Henschel, C. J.: Acid retention in gold castings; a preliminary report, J. Dent. Res. **30**:599, 1951 (abst.).
25. Tuccillo, Joseph J.: Why a porcelain-gold "matched pair"? Thermotrol Technician, pp. 1,4, Nov.-Dec., 1964.

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