Volume two

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.

Harold R. Schreiber, a teacher and very able practitioner of periodontics, who performed the periodontal surgery in a number of cases presented in this book.

James W. Bynum, an excellent endodontist, teacher, and research man, whose skill as an endodontist is vividly supported by roentgenographic evidence in this text.

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.

John Marré, a most capable oral surgeon, whose judgment I value and whose friendship and encouragement have been mainstays of my career.

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."

I also wish to express my appreciation to the following:

Arnold S. Block, M.D., and *Michael Karl,* M.D., for reading Chapter 15 on emotional aspects of extended restorative procedures and suggesting a few additions and deletions to it.

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My deep appreciation and thanks to the individuals who participated in the development and quality of the art and photographic illustrative material, Reba Cohea, Bill Briggs, Reinhart Stiegemeier, Kramer Lewis, Marilyn Mesi, Alvin Taylor of New York, and James R. Schmidt, D.D.S., M.S.D.; to Harriet Stuernagel, librarian at Washington University School of Dentistry, who was always willing to assist me in obtaining references; to my daughters, Frances and Rosalind, for proofreading; to Lorraine Holzborn for her untiring and excellent efforts in typing the manuscript.

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.

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Chapter 9

Soldering

General considerations

Soldering is defined as the flowing of metal onto another metal to produce a joint, where the solder has a lower fusing point than the parent metal.

The assembly of several units into one fixed unit depends upon the strength of the soldered joints for its mechanical success. Since the soldered joint is the weak link in the appliance, the fewer the soldering spots the less chance of error from the standpoint of joint fracture and torsional inaccuracy.

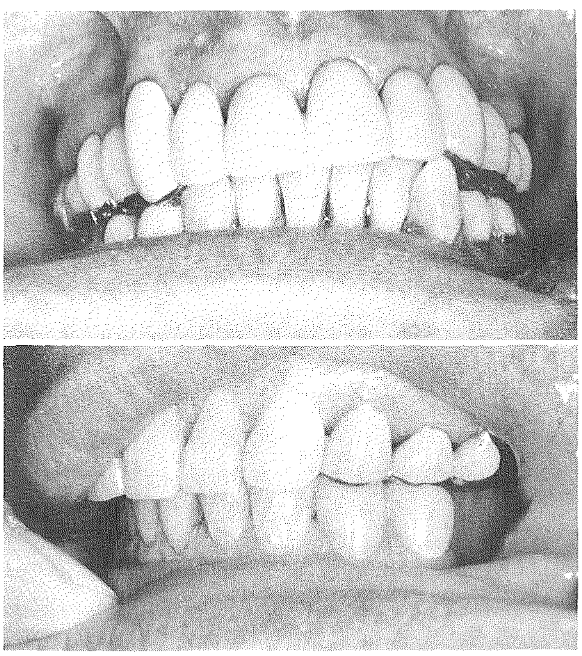


Fig. 9-1. Solder joints must be of sufficient size vertically and positioned correctly anatomically so as not to impinge on interdental papillae or to allow lateral packing of food.

Besides a mechanical success we also must have a biologic success, that is, a solder joint of sufficient size vertically and positioned correctly anatomically so as not to impinge or "choke out" the interdental papilla or to allow lateral packing of food (Fig. 9-1). A combination of the two successes, mechanical and biologic, will avoid joint fracture, gingival tissue inflammation, and torsional inaccuracy.

Selection of gold solder

The gold solder selected should have the following properties:

1. It should approximate, in mechanical properties and color, the alloy with which it is to be used.

2. It must melt at a temperature low enough to permit flowing without injury to the alloy being soldered (at least 100° to 150° F. below the temperature at which the gold alloy being soldered begins to melt).

3. It must not ball up and stay in one spot but must flow smoothly into the joint. Solder should flow freely and evenly and "wet" the metal, causing a good union. The "wetting" quality of solders is important as an aid in the spreadability of the solder on the surface of the parent metal. For the best wetting action the surface of

the metal must be clean, and the metal to be soldered should be in a reducing atmosphere during the entire operation.

4. It should be high-karat solder because high-karat solders flow better and resist tarnish more than those of low karat. A lower fusing solder tends to ball up and must be heated considerably above its melting point before it will flow readily.

5. It must be strong enough to withstand stresses.

It is known now that the smaller the grain size of metals, the better will be their physical properties. That is why the use of microfine solders result in stronger soldered joints—the chance of producing a brittle solder joint caused by excessively large grains is reduced greatly.

Select the solder by fineness and not by karat. The karat (solder) refers to the fact that this is to be used in soldering, for example 18-karat gold alloys, but gives no information as to fineness. Solder designed 18K does not contain 18/24 gold. Fineness, melting range, physical properties, and color are the criteria for selection of the solder.

Solder gap

Besides cleanliness, controlled heating, proper fluxing, proper selection of solder, proper relation of joints, and access to joints, which are essential requirements for successful soldering, maintaining a solder gap of 0.01 inch, which is the equivalent of three sheets of writing paper or one sheet of 30-gauge wax, is necessary. (See Fig. 9-2.)

It is desirable to make the solder gap as small as is consistent with good end results, while at the same time avoiding contact of the parts to be soldered during burn-out and blowpipe heating. If the parts to be soldered are in tight contact before heating, warpage will occur.

If the solder gap distance is too small, porosity of the solder joint may occur. Also, the expansion of the gold parts during burn-out and flame heating will close the gap and will exclude the solder from the parts in contact. Only the periphery of the solder joint area will be soldered.

If the solder gap distance is too wide, a weak joint will result. In many instances it is difficult to bridge the joint with the molten solder, and, if this operation is completed, distortion occurs because of greater shrinkage during solidification.

The factors that affect the width of the solder gap are as follows:

1. The setting expansion of the soldering investment
2. The thermal expansion of the investment during burnout
3. The expansion of the gold of the retainers and pontics during burnout
4. Expansion of the gold of the retainers and pontics when exposed to the soldering flame

"Both the setting expansion of the soldering investment and its thermal expansion tend to increase the center-to-center distances of pontics, and so will increase the solder gap over that established on the model. On the other hand, the thermal expansion of the gold parts will cause them to move from their own centers toward each other and, thus, tend to close the gap."*

Therefore, the proper solder gap distance (0.01 inch) is provided to prevent warpage or distortion. The solder gap closes approximately 0.01 inch during soldering, and, if there is compensation for this, the solder will flow into these contacts by capillary action without distortion.

Soldering investments

At this point attention should be called to the necessity of selecting the proper soldering investment, a controlled one. If an unsuitable investment is used, the assembly will be distorted inevitably. An invested joint will have less distortion than one of similar shape that is not invested.

Soldering investments contain quartz and a calcium hemihydrate binder. In general, they are designed to have lower setting and thermal expansions than do casting investments. The particle size may not be as fine as casting investment because smoothness of mass is of less importance. The possibility of hygroscopic expan-

*From A handbook of dental laboratory procedures—crown and bridge construction, ed. 5, New Rochelle, N. Y., J. F. Jelenko & Co., Inc., p. 58.

A

B

C

D

E

F

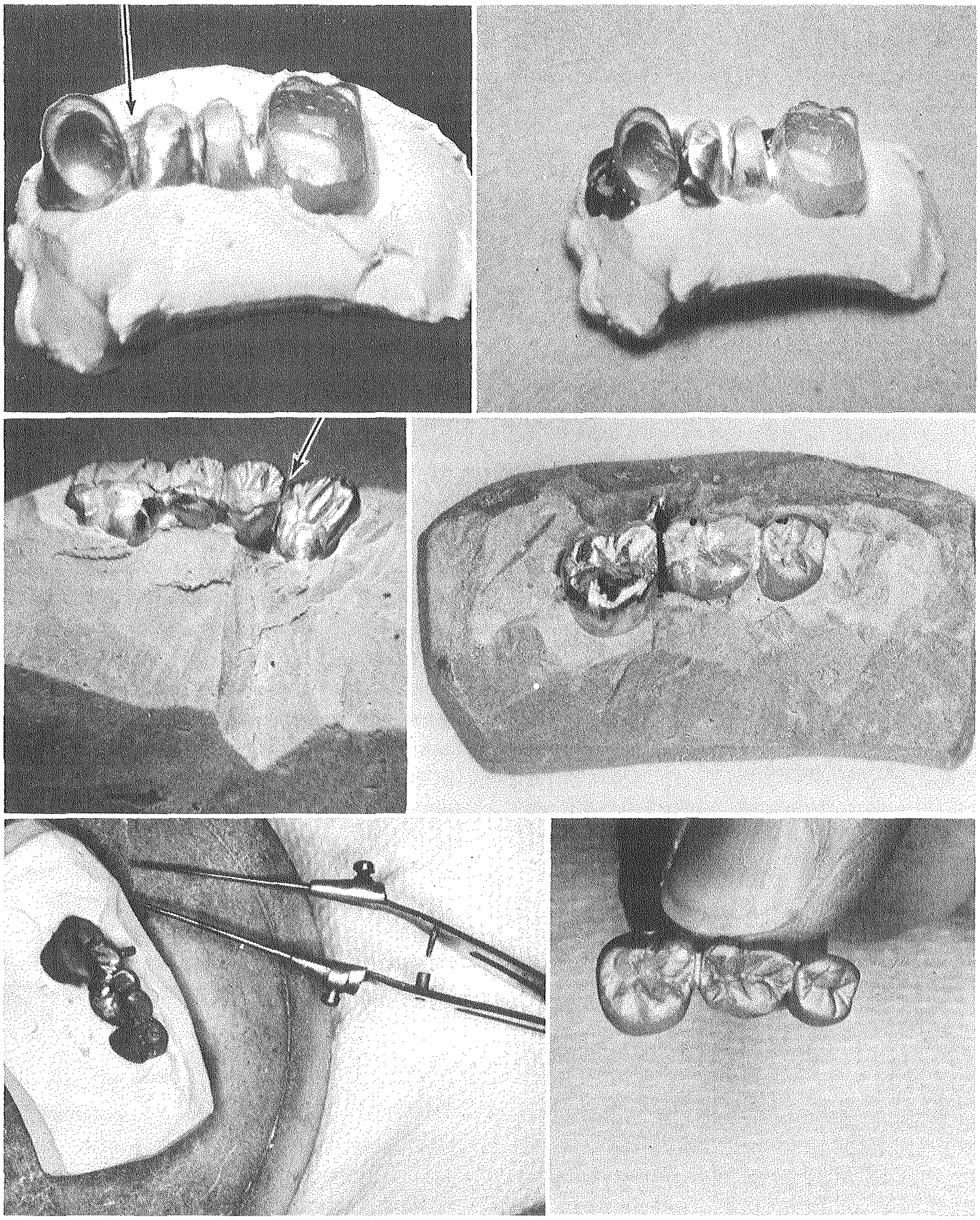


Fig. 9-2. A, Proper solder gap between cuspid retainer and pontic—cavity and ridge view. **B,** Sticky wax placed in gap before pouring up with soldering investment. **C,** Occlusal view of gap in soldering investment block. **D,** Solder gap too large. A piece of casting gold alloy is placed in a joint of this size before soldering. **E,** Joint soldered following above instructions. **F,** After finishing of solder joints and "sanding."

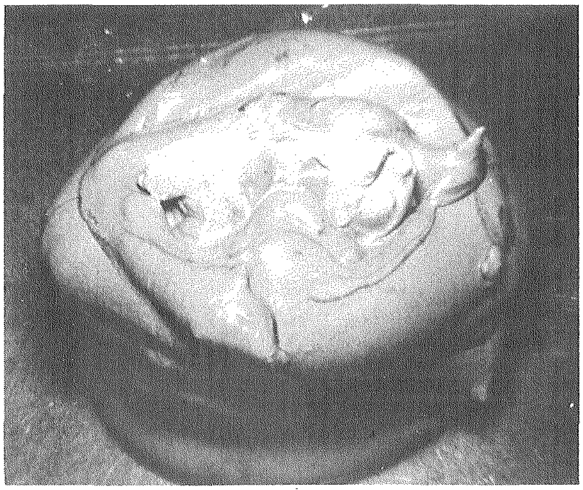


Fig. 9-3. Invest assembled parts heavily to prevent distortion during soldering—do not bury piece (plaster core index and contained assembled parts) in investment.

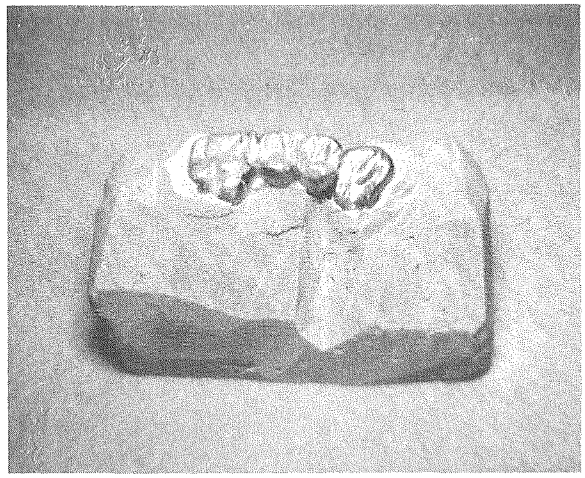


Fig. 9-4. After investment has reached its initial set, cut a V-shaped groove with a sharp knife at area to be soldered. This allows for joint to be accessible to soldering flame since it is bad for open flame of blowpipe to play directly upon invested mass, thereby releasing sulfur gas, which contaminates the alloy.

sion by contact of the soldered assembly with water during the setting of the investment must be avoided. The contraction of the solder (which contracts upon solidification practically the same amount as the other gold alloys, 1.25%) must be balanced with the setting and thermal expansion of the investment.

The manufacturer's directions for water-powder ratio and setting time must be followed. Invest the assembled parts heavily to help prevent distortion during soldering—do not bury the piece in the investment (Fig. 9-3). After the investment has reached its initial set, cut a V-shaped groove at each contact area with a sharp knife. This will make joints accessible to the flame—free access to the solder joint areas by the flame of the blowpipe is a "must" (Fig. 9-4).

The invested assembly must be allowed to bench cool after the soldering operation is completed to reduce distortion, etc. Observance of this point in the soldering operation helps in the production of a strong joint that is free from warpage. "Uniform physical properties of soldered bridgework are best obtained by leaving the soldered piece to cool slowly in the soldering investment for about five minutes before quenching. This procedure will allow gold alloys and solders which respond to a hardening heat treatment to gain some strength and hardness, and it will also reduce the elongation values. Slow cooling to room temperature is not advisable, because this procedure causes excessive recrystallization and grain growth and results in poor mechanical properties."* Some authorities in the art of soldering feel that the plunging of an invested assembly immediately after soldering tends to produce almost as much change as would occur if no investment was used.

A suitable soldering investment† combined with an accurate technique allows bridges or extensive fixed splints possessing a high degree of accuracy to be assembled.

Handling of the invested assembly

A factor that observation has shown to be taken lightly is the careless handling of the invested assembly during burnout and soldering. As was pointed out in the burn-out technique for casting, the investment must not be heated

*From Ryge, Gunnar: Dental soldering procedures, Dent. Clin. N. Amer., pp. 747-757, Nov., 1958.

†Modern Materials Mfg. Co., St. Louis, Mo., or Whip-Mix Corp., Louisville, Ky.

above 1350° F., to avoid the decomposition of the calcium sulfate, which gives off sulfur or sulfur compounds. If it happens during the soldering operation, this sulfur compound will contaminate the surface of the gold castings and prevent a good bond. This necessitates liberally cutting the soldering investment away from the areas of the joints to be soldered. It is bad for the open flame of the blowpipe to play directly upon the invested mass because this may cause the release of sulfur gas, which, being in close proximity to the gold, has the opportunity to penetrate it.

Burn-out technique

The purpose of the burnout is to eliminate the water from the investment so that its presence does not hold down the desired temperature of the investment and gold alloys during the soldering operation. The moisture makes it difficult to raise the temperature of the metal to the fusing point of the solder.

It also is necessary to produce enough thermal expansion of the investment to offset the tendency of the expansion of the retainers and pontics to close the solder gaps during heating.

Common methods of burnout of the invested soldering assembly is (1) the open gas flame in contact with the invested mass, which is on a stand of some kind, (2) the placing of a sheet of asbestos between the open flame and the invested mass, and (3) the controlled temperature furnace method.

In method 1, which allows the open gas flame to play directly upon the investment, the temperatures at the tip of an open gas flame are around 2000° F. The calcium sulfate of the soldering investment breaks down rapidly at temperatures above 1350° F., resulting in the production of sulfur gases and its by-product, contamination. These gases in contact with the gold alloys or the solder will cause detrimental effects through embrittlement and the production of sluggishness in the solder.

In method 2, in which a sheet of asbestos separates the open flame and the invested mass, problems are created also. Experiments performed by the research staff of J. F. Jelenko & Co. found that "the temperatures at the top of the assembly attained an approximately constant

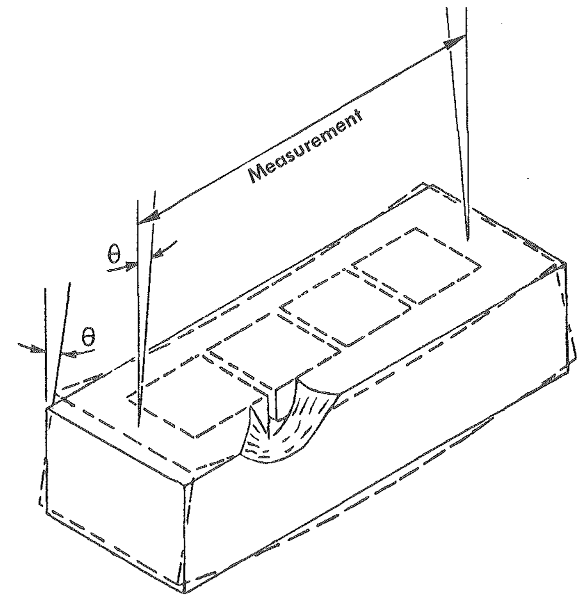


Fig. 9-5. Schematic drawing showing uncertainties of burnout over an open flame. (Courtesy J. F. Jelenko & Co., Inc., New Rochelle, N. Y.)

value of 550° F. in about twenty-five minutes. At the same time temperatures at the bottom of the half-inch thick block of investment became fairly constant at 1100° F. The micrometer readings on the projecting rods indicated an angular change of about .25° at each end of the assembly. This angular change resulted from the greater expansion of the investment at the bottom of the block because of its twice-as-high temperature, thus forcing the block into a curve as shown in Fig. 9-5.

"A quarter of a degree is not an impossibly excessive rotation of the abutment casting and in many cases would be tolerated in fitting the casting over the abutment preparation. Nevertheless, for a longer bridge (or splint), this rotation could be expected to be more."*

Because solder joint fracture and torsional inaccuracies can be the by-products of the previously mentioned methods, neither of them can be recommended as the burn-out technique of choice.

In method 3, the method of choice, the burnout is accomplished properly in a temperature-controlled furnace. The soldering assembly is

*From A handbook of dental laboratory procedures—crown and bridge construction, ed. 5, New Rochelle, N. Y., J. F. Jelenko & Co., Inc., pp. 59, 60.

put in a preheated burn-out furnace at 800° F. and is allowed to remain in this uniform atmosphere for thirty minutes or longer. This type of burnout produces a uniform temperature throughout the mass of the assembly and therefore makes it possible to avoid distortion in the assembly block.

Fluxing

It is necessary to avoid oxidation of the castings that are being soldered because the solder will ball up and not flow as the heat is applied, and, if some kind of attachment is accomplished, the result is a poor bond. To avoid this type of oxidation the proper handling of the blowpipe and the use of a good flux are of great assistance. The solder must flow easily, and the operation must be completed very quickly. If this does not occur, stop and start from scratch. Cleanliness is another factor to be taken seriously; a clean joint, free of investment particles, wax, rouge, etc., makes the best union. Therefore the cleaner the surfaces to be soldered, the more easily the solder will flow.

This all means that joints to be soldered must be free of oxides or contamination (dirt, grease, sticky wax, traces of die metal, polishing agents, etc.) created by the casting procedure, the waxing for assemblage of the various parts, the investing, and burn-out procedures.

After the assemblage for soldering has been invested properly and provided sticky wax has been used for positioning of the parts, the sticky wax must be eliminated completely by the liberal application of boiling water followed by the application of chloroform through the joints by means of a glass dropper. This step is very important because any wax remaining on the metal would be carbonized during the burnout. This carbon would act as an antiflux and make it difficult for the solder to flow.

Paste flux should be applied immediately after flushing with boiling water and applying chloroform, while the metal is still warm from this procedure. This allows the flux to flow over all exposed surfaces, protecting them from oxidation during the preheating and soldering procedures. A good flux is a vital adjunct to the soldering operation.

The parts to be soldered not only should be protected by flux, before heating and again after preheating before the solder is applied, but also the solder should be fluxed by dipping it into the jar of paste flux. Best control for fluxing is obtained if a paste flux is used. This type of flux is composed principally of borax glass and boric acid powder with the addition of small amounts of other materials to impart various desirable properties. Paste flux contains also a jelly base, which makes the flux easy to apply to the desired area and which melts when warmed, thereby flowing the flux into the joint to be soldered.[3] A good paste flux* has a gentle fluxing action and during use will melt down evenly and smoothly. No froth is formed (as with ordinary borax, which contains water of crystallization) to displace pieces of solder, and a good paste flux melts and fluxes the metal without discoloring the fluxed area so that the metal is left with a clean appearance.

Antiflux

Antiflux is useful to block off areas where solder is not wanted. It should be applied sparingly with a small camel's-hair brush before the application of the soldering paste flux. For the antiflux to stay in place as applied, slow and gentle heating is required. If this requirement is carried out carefully, a powder will adhere to the part or parts so treated, and solder will not flow over these protected surfaces.

Besides the antiflux supplied by dental manufacturers (which I prefer), use also can be made of rouge moistened with chloroform, white shoe polish, or lead pencil markings on gold surfaces not highly polished, since solder will not flow onto an area that is contaminated with graphite.

Use of the blowpipe

In the soldering operation the solder is melted in most instances with a conventional air and gas blowpipe (Fig. 9-6).

In general, the case to be soldered should be preheated in a temperature-controlled furnace, followed by heating of the whole assembly by a rather large moving flame before the blowpipe

*J. F. Jelenko & Co., Inc., New Rochelle, N. Y., or The J. M. Ney Co., Hartford Conn.

is adjusted to a more localized, pointed cone to be directed toward the individual solder joints when the solder is applied. Always use the hottest part of the reducing area of the flame, close to the inner, light blue center cone. (See Fig. 9-7.) This pointed hot reducing flame must be just large enough to cover the joint to ensure a deoxidizing atmosphere and not to impinge unduly on the adjacent investment, which would increase the danger of releasing contaminating sulfur compounds. Heat the parts to a dull red heat. Focus the flame on the metal, not on the solder. The heat of the metal should melt the solder. A minimum of solder should be used, and the operation must be completed rapidly once the solder begins to flow. Solder should flow freely and "wet" the metal, causing a good union. A thin strip of solder can be touched to the hot metal, or small pieces of solder that were clipped previously from a strip of solder can be used if preferred. If the solder does not flow readily, discontinue heating, and after the assemblage has cooled sufficiently for handling reclean and reflux before soldering is attempted again. Overheating is best avoided by adherence to the general principles of cleanliness and fluxing in conjunction with proper heat application.

Many breakages at soldered joints are caused by the weakening action of the molten solder on the soldered parts. When solder is melted and flowed on solid metal, the solid metal tends to be dissolved in the molten solder. Such diffusion requires heating to temperatures close to the melting range of the parent alloy. A strong solder junction can be obtained without very much diffusion between the solder and the parent alloy, remembering that an extremely small amount of such solution of the soldered parts may not be injurious and might even be considered beneficial in producing a closer bond with the solder. (See Fig. 9-8.)

Uniform properties of soldered bridgework are obtained best by allowing the soldered piece

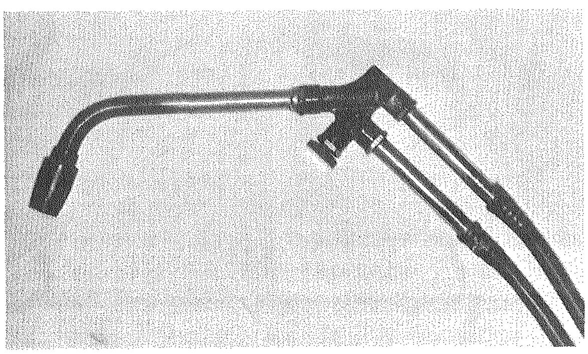
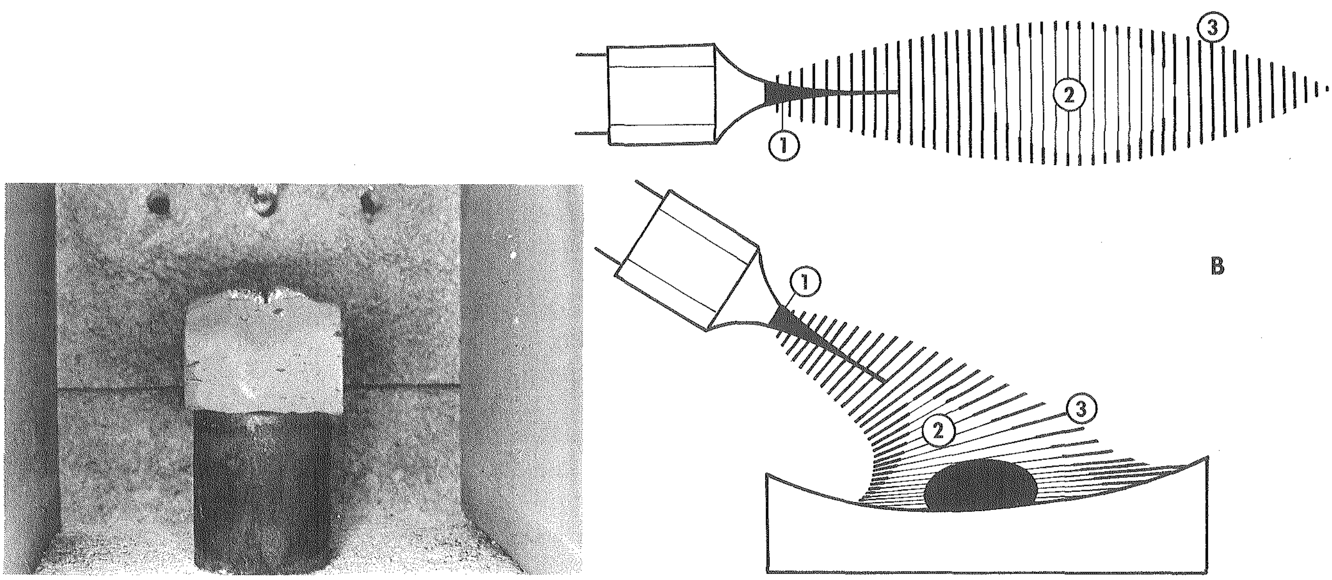


Fig. 9-6. Conventional air and gas blowpipe.

A



B

Fig. 9-7. A, Invested assembly placed on inlay ring in burn-out oven. This permits air to circulate freely around the case and heat it uniformly. **B,** Use hottest part of reducing area of flame, close to inner, light blue center cone.

A

B

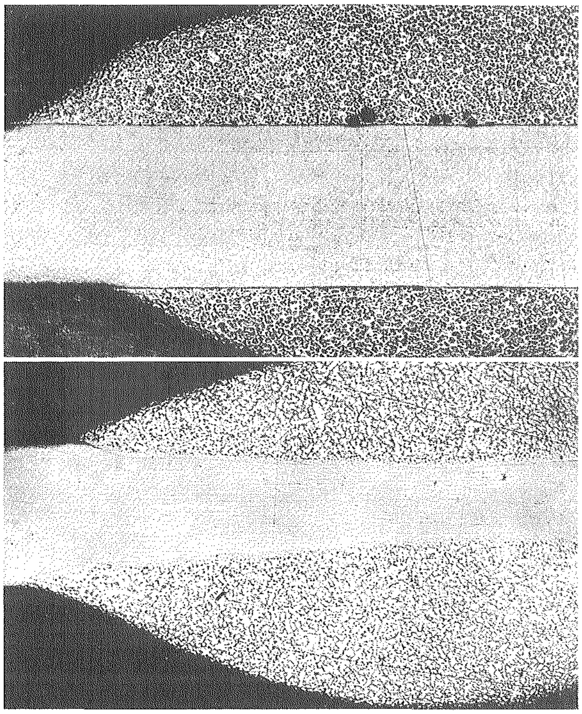


Fig. 9-8. A, Section through a soldered wire. As soon as solder flowed, flame was removed. There was no overheating and no solution of wire in solder. B, Same wire and same solder flowed in same way, except that solder was kept molten for forty-five seconds. Solution of wire was very marked; weakening of wire at edge of solder is obvious. (From Gold handbook, Hartford, Conn., 1956, The J. M. Ney Co.)

to cool slowly in the soldering investment for five minutes before slowly dunking the case in water to help break away the investment. This leaves the metal (gold alloys and solders) in a moderately heat-treated condition for maximum strength and toughness and appears to minimize warpage. Elongation values are reduced.

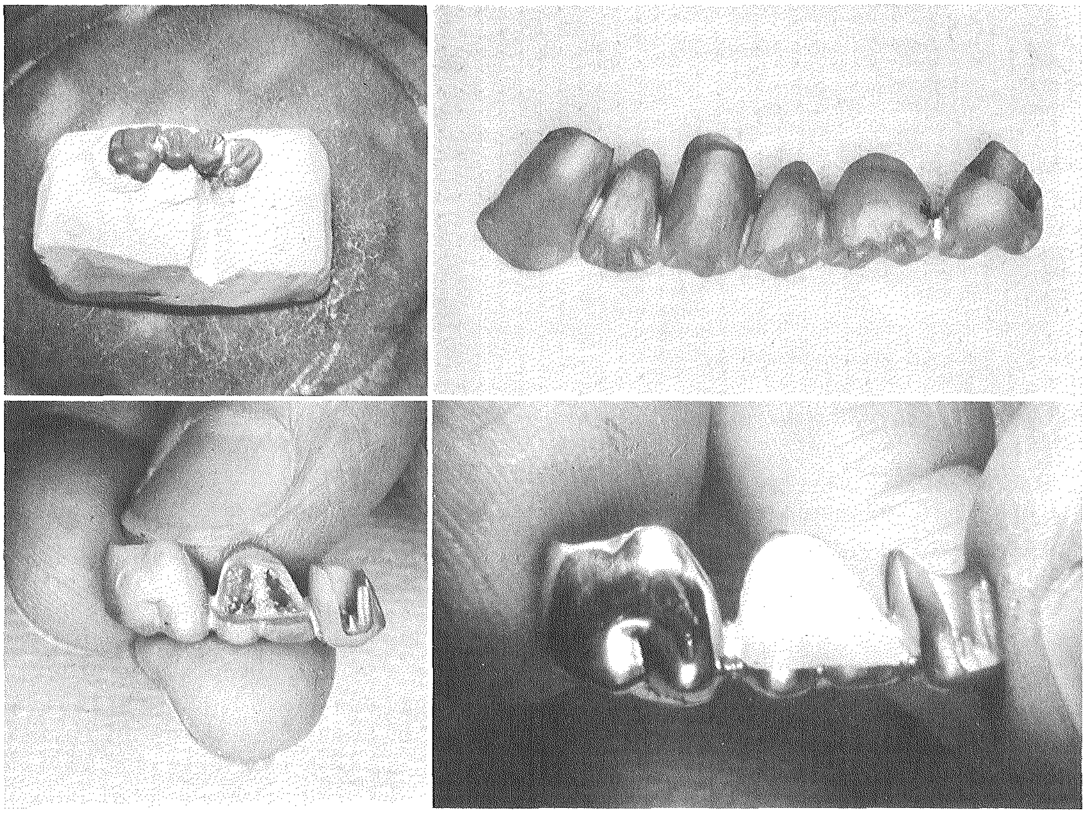
Slow cooling of the soldered assemblage to room temperature is not advisable since this procedure causes excessive recrystallization and grain growth and results in poor mechanical properties.

Some clinicians have advocated reheating the soldered case to a dull red and quenching to relieve internal stresses and warpage, but experience has shown that the sudden and nonuniform cooling caused by quenching is more likely to cause warpage than to correct it.

Requisites for good soldering

1. Cleanliness is the first prerequisite for successful soldering. The parts to be soldered should be cleaned thoroughly; that is removal of all oxides, dirt, grease, wax, and traces of die metal (if a metal die is used). The work and solder should be kept clean and well fluxed.
2. Provision should be made by a sufficient solder gap distance to prevent warpage during heating.
3. The piece to be soldered should be invested in a properly formulated soldering investment—one having a lower setting and thermal expansion than casting investment. Contraction of the solder must be balanced with the setting and thermal expansion of the soldering investment.
4. The proper application of antiflux and soldering paste flux is necessary to avoid oxidation of the castings being soldered because solder will ball up and not flow.
5. The invested assemblage should be preheated in a temperature-controlled furnace at 800° F. for thirty minutes.
6. Proper selection of the solder to be used is important; that is, one whose upper limit of melting range is 100° to 150° F. below the lower limit of the melting range of the parts to be soldered. The solder should approximate, in mechanical properties and color, the alloy with which it is to be used.
7. Correct use of the blowpipe is necessary.
8. One of the requisites for a good, strong, soldered joint is a low surface tension between the molten solder and the retainer or pontic. Careful heating to a dull red heat of the metal in the area of soldering helps reduce this surface tension.
9. The number of heatings of a joint must be reduced to a minimum. If this is not done, nonuniform changes will be produced.
10. The solder should be heated just enough above its melting point to flow freely and completely to the limits of the desired joint and no further. Solder will pull through the joints rapidly, and excellent union will result, and grain growth will be avoided. This operation requires the intelligent use of both antiflux and soldering flux as well as the blowpipe. (See Fig. 9-9.)

A



B

C

D

Fig. 9-9. A, Solder is heated just enough above its melting point to flow freely and completely to limits of desired joint. B, Showing solder pulled through joints correctly, allowing for an excellent union and avoidance of grain growth. C, Correctly positioned solder joints. D, Case ready for insertion in patient's mouth.

11. The depth of the solder joint occluso-gingivally should be as deep as possible.

12. A thick solder joint is undesirable because it is weak. The less solder used to produce the union, the less the distortion will be.

13. In soldering prolonged heating with the blowpipe should be avoided. Solder in a few seconds with the solder flowing by capillarity.

14. The soldered assemblage should be allowed to bench cool for five minutes before quenching it in water.

15. The soldered bridge should be pickled in Jel-Pac* solution, the nonfuming acid. Do not heat the soldered bridge or splint in a bunsen flame and plunge it into the acid.

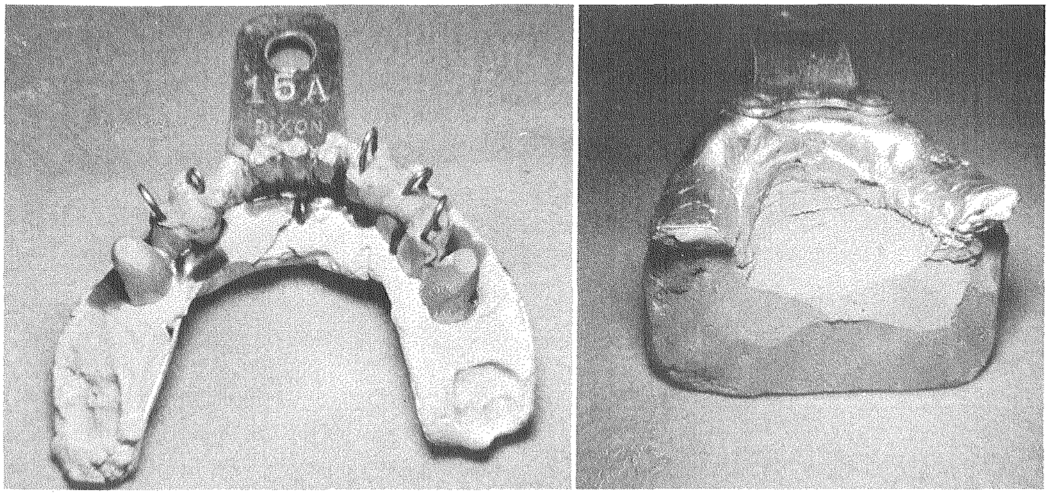
16. It is necessary to get sound, gas- and oxide-free joints between the parts. This also gives the joint strength to bear occlusal loads.

*J. F. Jelenko & Co., Inc., New Rochelle, N. Y.

Procedural steps in the soldering of a fixed appliance

After the abutment retainers have been fitted and adjusted accurately and the hinge-bow transfer and centric relation bite are taken, a plaster impression or a combination modeling compound–Kydac wash index core enveloped in an "overall" alginate impression—is taken for construction of the soldering cast (Fig. 9-10).

1. All castings being assembled on the model, the next step is the removal of the castings and grinding of spaces for solder gaps over areas designated for joints. Gaps should be 0.01 inch wide, the thickness of three thicknesses of letter paper or one sheet of 30-gauge wax. Always remember that a minimum amount of solder should be required, and, before the parts are united with sticky wax or a quick-setting

A


B

Fig. 9-10. A, Impression (in this case, plaster) taken for construction of soldering cast. B, Impression poured in stone or soldering investment.

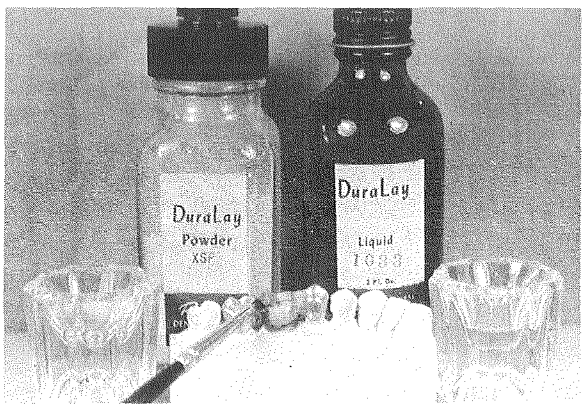


Fig. 9-11. DuraLay acrylic resin applied with brush-on technique. This material leaves no residue when burned out. (Courtesy J. F. Jelenko & Co., Inc., New Rochelle, N. Y.)

acrylic such as DuraLay,* they should be cleaned well. If DuraLay acrylic, which will leave no residue when burned out, is used, the following technique is used (Fig. 9-11). Wet the brush with monomer, pick up a small amount of powder from the dappen dish, and apply it to the area of the joint. Do not have the mix too wet. Dry under a light bulb for a fast set. When hardened, this material will neither distort like wax can under certain conditions nor break like sticky wax. If sticky wax is used, occlusal stone indexes are made so that the assembly is held together during investing. Invest the assembly, not too deeply, using a good soldering investment following the manufacturer's directions for water-powder ratio. Allow it to set hard, at least thirty minutes, before removing the index. A good interrelation of the castings must be maintained.

It is impossible to get precision fits of retainers if too many joints are soldered at one time because of the problem of expansions and contractions of the investment, gold alloys, and solder. Clinical judgment will dictate how many and what joints are to be soldered during each soldering operation, especially if a long span or a large fixed splint is under construction.

2. If sticky wax was used, thoroughly remove it by flushing with boiling water. Sticky wax must not remain on the metal because it would be carbonized during the burnout and because this carbon would act as an antiflux, making it hard for the solder to flow. (No boil-out is needed for DuraLay since it will burn out clean in the furnace.) The castings should be exposed so that there is free access to the solder joints; the joints must be left well exposed to the flame so that all parts may be heated evenly. Trim the investment liberally, cut a V-shaped groove at each contact area with a sharp knife, and again flush the joints with boiling water followed by chloroform.

3. The joints should be well covered with a

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

good soldering paste flux to prevent the formation of oxides while soldering. Do not use ordinary borax. Antiflux can be applied to all areas where solder is not wanted (around the periphery of all joints) and should be applied before application of soldering paste flux. Be careful in its use. Apply the soldering paste flux immediately after flushing while the metal parts are still warm so that it will be melted and flowed over all exposed surfaces.

4. Do not burn out the soldering assembly over an open gas flame, with or without an intervening sheet of asbestos. Sulfur gas from the calcium sulfate in the investment will be generated if the investment is heated to a high temperature, which in turn will embrittle the gold and make the solder sluggish. Also, since the assembly is hotter at the bottom than at the top, the greater expansion at the bottom will cause warpage of the assembly. Put the soldering assembly in a preheated burn-out furnace at 800° F. for approximately thirty minutes. Support the assembly on a tray, and raise it from the floor of the furnace by setting it on an inlay ring. This will permit the air to circulate freely around the case and heat the assembly uniformly.

5. After the soldering assembly is removed from the temperature-controlled furnace, place it on an asbestos soldering block. Apply a little more soldering paste flux to the joints, and heat the entire assembly for a while with a rather large blowpipe flame, which is kept moving before adjusting the flame to the pointed cone to be directed toward the joints involved. Apply the light blue tip of the blowpipe to the metal to be soldered. In other words, use the reducing area in the center of the flame. When applying the solder to the hot metal, be sure it is fluxed also. A thin strip of solder can be used, or small pieces of solder can be picked up in a pliers and placed in the joint. Focus the flame on the metal, not on the solder. The heat of the metal should melt the solder. The solder should flow freely and "wet" the metal, causing a good union. (See Fig. 9-12.)

6. Allow the soldered assembly to bench cool for five minutes before quenching it in water. This leaves the restoration in a moderately heat-treated condition for maximum strength and toughness and appears to minimize warpage.

7. Pickle the restoration in Jel-Pac solution, the nonfuming acid. Do not heat the soldered restoration in a bunsen flame and plunge it into acid.

If all precautions have been taken (cleanliness, proper preparation of the assembly block, fluxing, proper burnout, and adjustment of the flame) and if a good solder whose upper limit of the melting range is 100° to 150° F. below the lower limit of the melting range of the parts to be soldered is used, the soldering should be accomplished in a few seconds. The solid metal will not be dissolved to any injurious degree in the molten solder if this technique is followed. The solder will pull through the joints rapidly, an excellent union will result, and grain growth will be avoided. (See Fig. 9-13.)

The foregoing procedures lead to sound, gas- and oxide-free joints between the parts. It also gives the restoration strength to bear occlusal loads.

All remaining joints are to be soldered by the same procedures as those just outlined. Do not solder too many joints at any one time. Reassemble the units on the master cast or in the mouth for each successive soldering operation. I reassemble the parts for soldering the various joints in the mouth, keeping the patient in the office until all soldering operations are completed and the restoration is fitted. This is done by the use of plaster core index impressions. (See Fig. 9-14.)

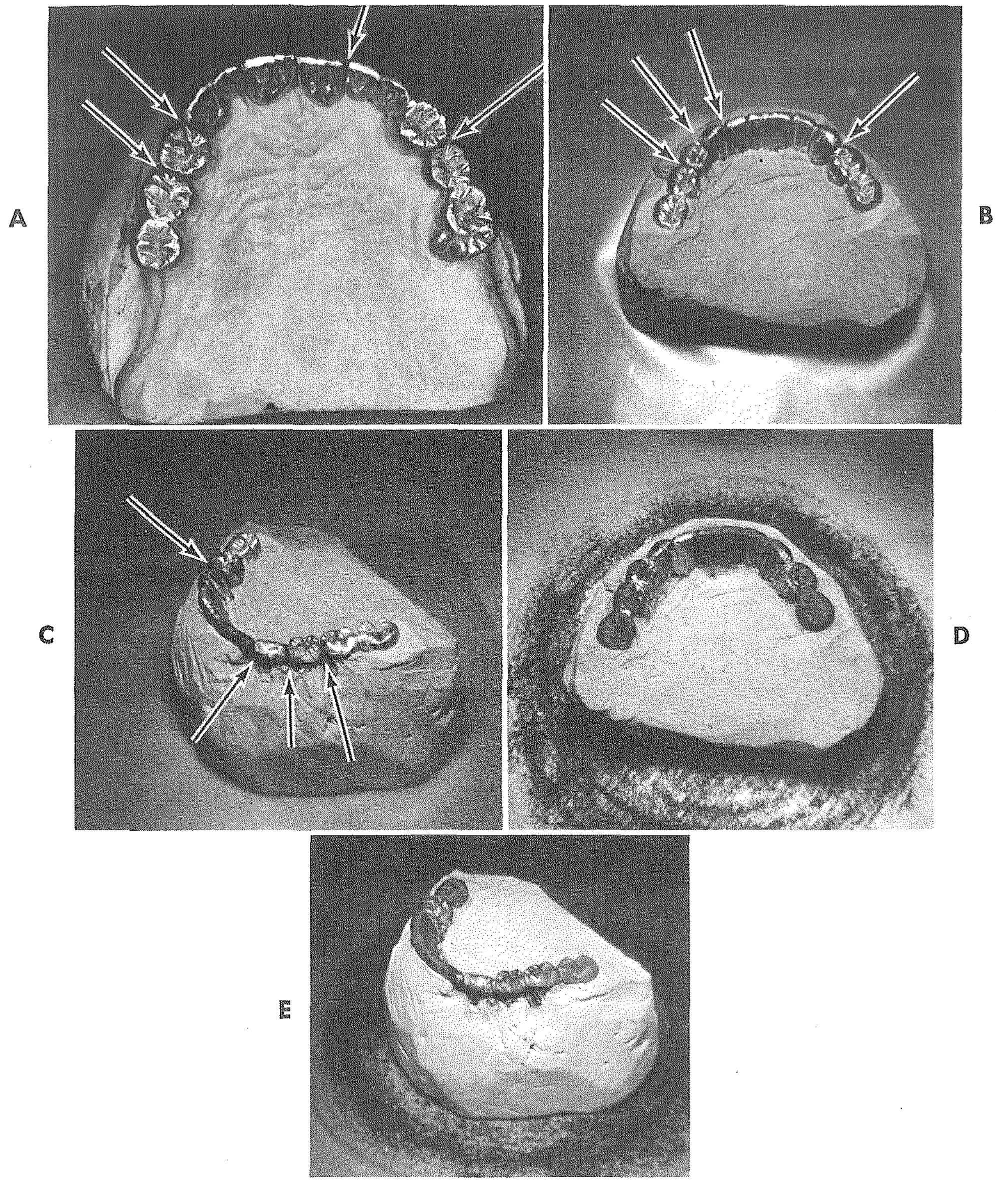
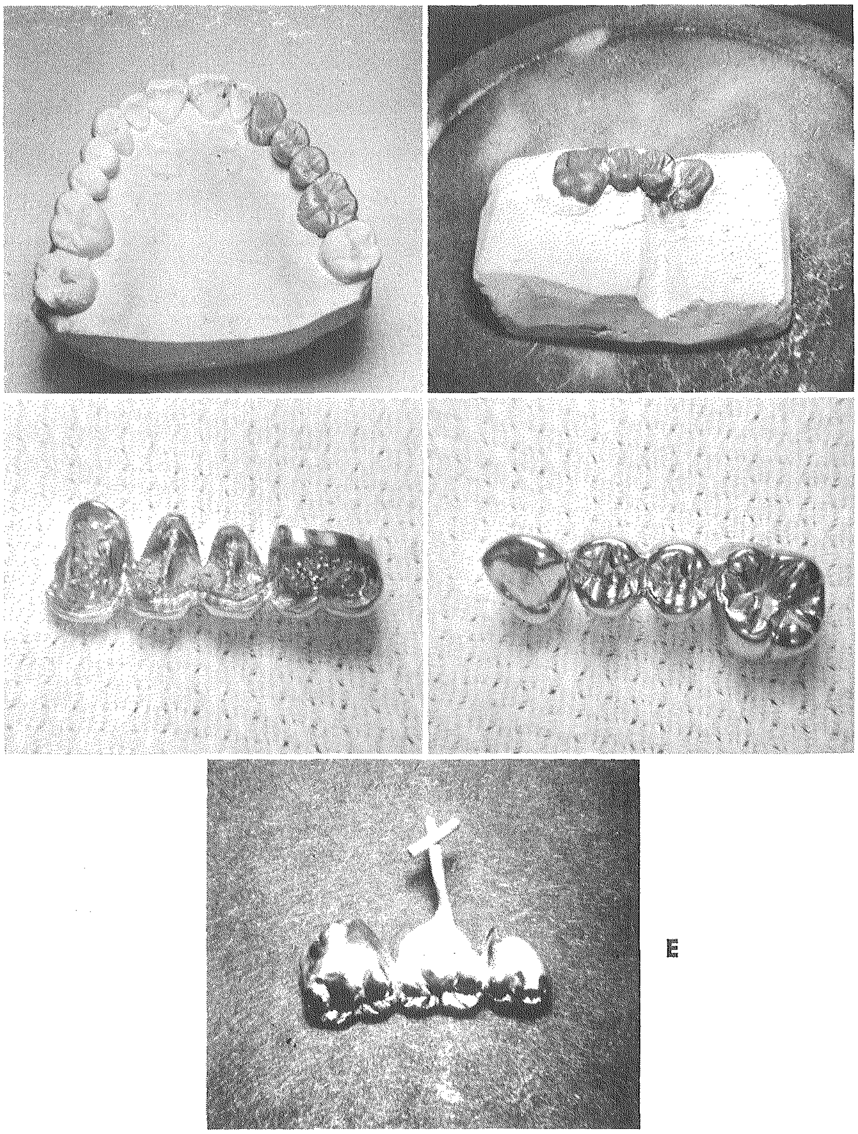
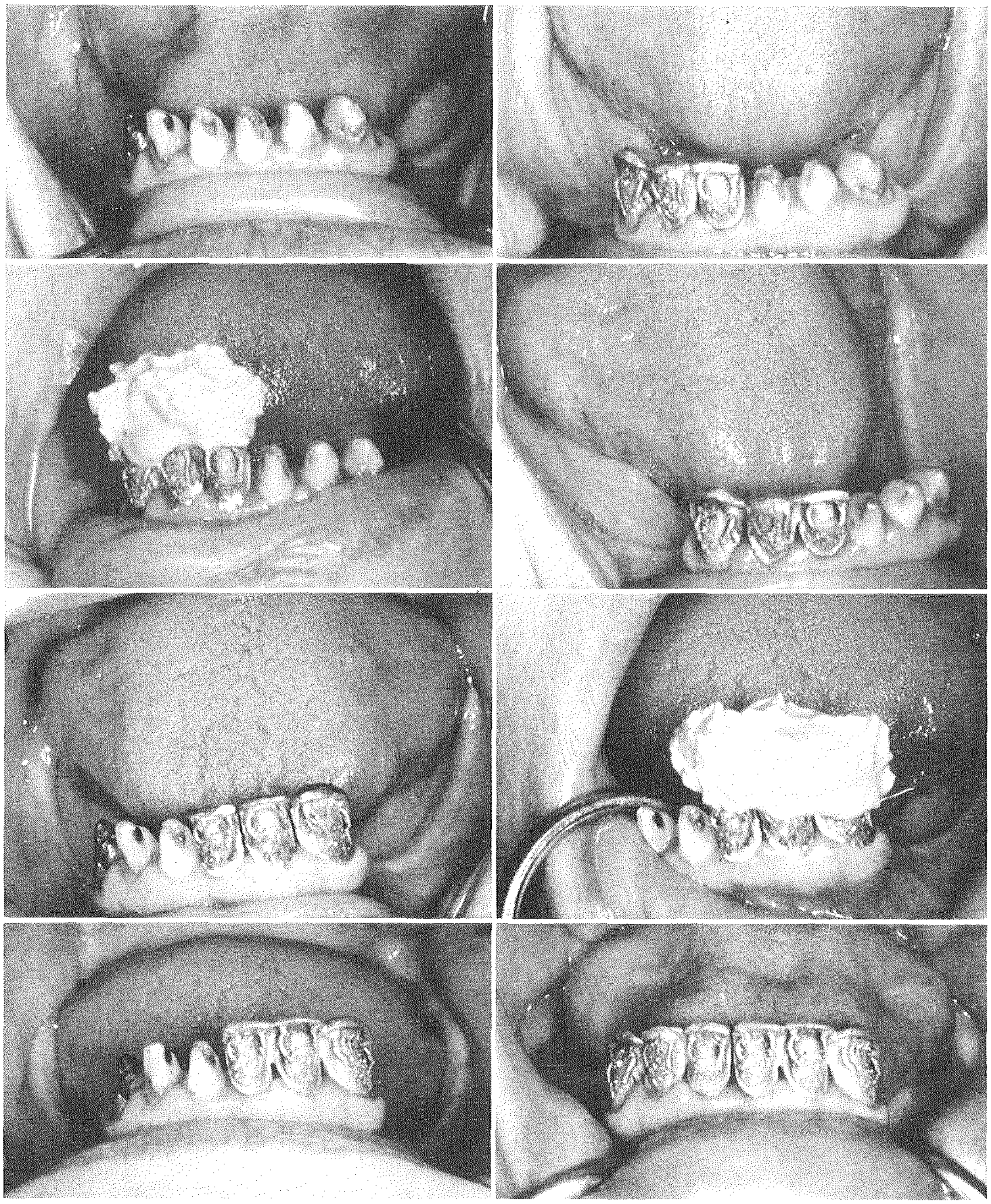


Fig. 9-12. I remove casting from impression (before pouring of stone or soldering investment) and grind spaces for solder gaps. **A,** Upper cast with prepared solder gaps (arrows). **B,** Lower cast with prepared solder gaps (arrows). **C,** Side view of prepared solder gaps (arrows). **D,** Lower case soldered. **E,** Side view of lower soldered case. In this case, after preparation of solder gaps, castings were replaced in impression and joints filled in with sticky wax and poured up with soldering investment.



A B C D E

Fig. 9-13. A, Assembled bridge ready for preparation of solder gaps to be joined to each other by DuraLay acrylic resin and invested for soldering. **B,** Bridge correctly soldered (see text). **C,** Buccal view of properly developed solder joints—correct vertical size and anatomic position. **D,** Occlusal view of same case. **E,** Added tail is attached to pontics to avoid possibility of pontic dislodgment after "wash-out" and preparation of assembly (V-shaped grooves) for soldering.



A B C D E F G H

Fig. 9-14. Series of illustrations showing assembling of various units in mouth for successive soldering operations. I use this method in periodontally involved mouths because of mobility pattern and span length of fixed splints. **A,** Prepared teeth. **B,** Castings seated on prepared teeth (right side). **C,** Plaster core index impression for soldering operation. **D,** Soldered section positioned on prepared teeth (right side). **E,** Castings seated on prepared teeth (left side). **F,** Plaster core index impression. **G,** Soldered section in place on prepared teeth (left side). **H,** Soldered sections (right and left) positioned on prepared teeth. **I,** Plaster core index impression for soldering joint between right and left central incisors. **J,** Enlarged view of the plaster index and castings. **K,** Case ready for last soldering operation. **L,** Joint between central incisors soldered. **M,** Finished splint in patient's mouth. **N,** Another case showing results of same procedures in a five-tooth fixed splint (lower right posterior teeth).

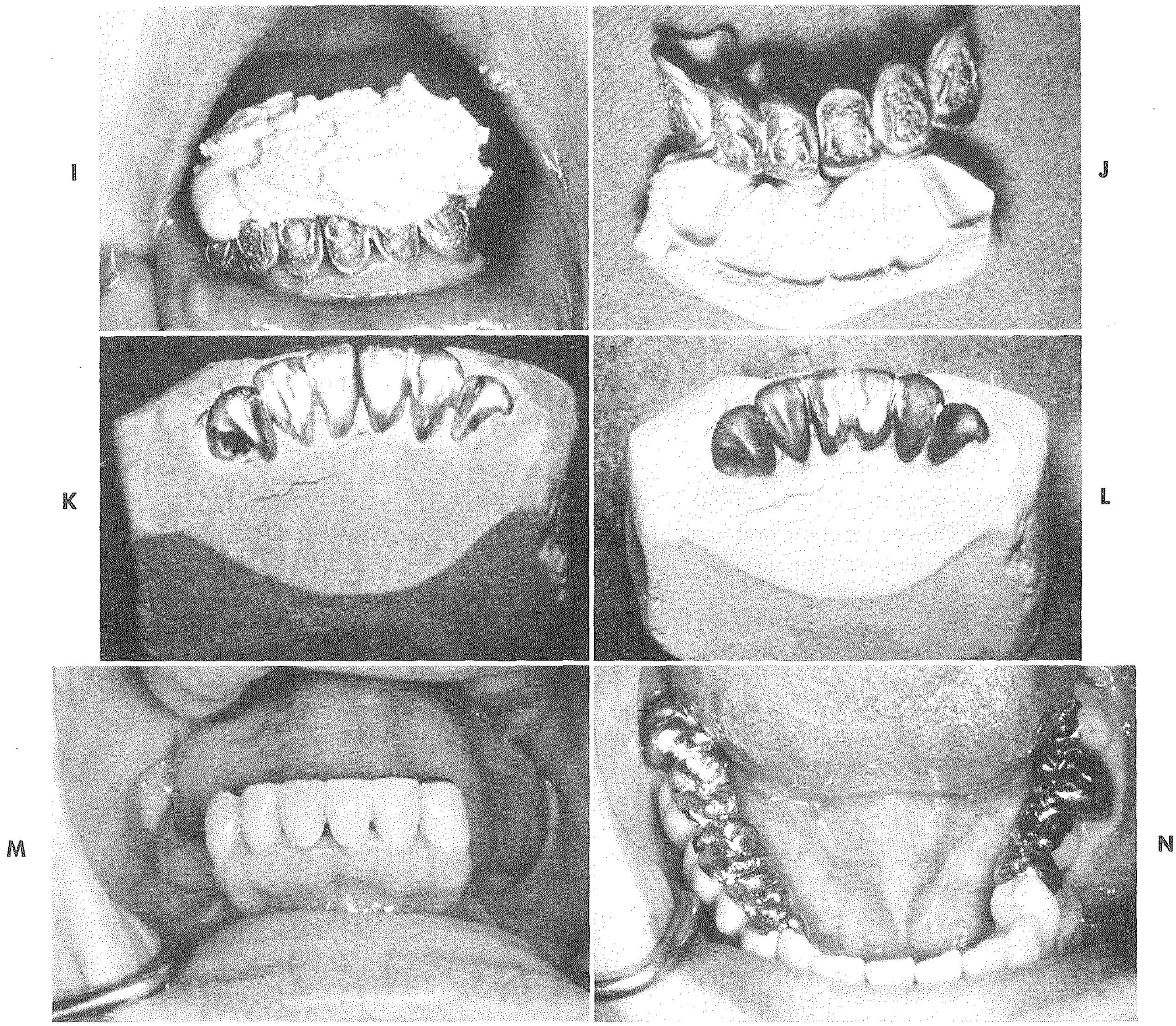


Fig. 9-14, cont'd. For legend see opposite page.

Soldering of high-fusing ceramic golds

The soldering of high-fusing ceramic golds requires the use of an oxygen-gas blowpipe and a high heat soldering investment such as Hi-Heat soldering investment.*

An investment that is used in these procedures should not only flow freely into the smallest crevice, but also must mold easily and stack firmly. It should set fairly fast, be able to be trimmed smoothly, and, if necessary, withstand rapid drying out. Some of these investments do not have the strength of conventional soldering investments; therefore care must be exercised in the handling of the invested case, that is, allowing at least twenty minutes after the investment becomes rigid before dewaxing it.

Technique

Method 1

1. Assemble gold castings (retainers and pontics) in the correct relation and tack them together, using a "quick-setting" acrylic such as DuraLay,† which is applied with the brush-on technique to unite the parts. Wet the No. 1 investment painting brush with monomer, pick up a small amount of DuraLay powder from the dappen dish, and apply it to the area to be joined. Use a generous amount of material when joining the parts. Do not have the mix too wet. Dry under a light bulb for a fast set. When hardened, this material will not distort like wax can under certain conditions or break like sticky wax.

2. Make a mix of the soldering investment (Hi-Heat) designed for high-fusing ceramic gold soldering, and follow the manufacturer's instructions as to its proper use. Fill the cast gold retainers with the mix, place the remainder of the mix in a towel, squeezing out the excess liquid, and seat the assembled gold parts on a patty of this thicker investment, being sure to allow for a thick base.

3. Allow the investment to set at least thirty minutes, preferably forty-five minutes.

4. Cut a V-shaped groove at each solder joint area with a sharp knife. The castings should be exposed so that there is free access to the solder joints by the flame. Flux is not used in the soldering of ceramic golds with high-fusing solder.

5. Place the assemblage in a room temperature furnace capable of attaining 1800° F. (Electric "Furn-A-Matic"* furnace), and raise the temperature to 1800° F. at the rate of about 50° to 100° F. per minute. Hold the temperature at 1800° F. for thirty minutes. The DuraLay acrylic, which has been used for assemblage of the gold parts, will volatilize during the preheating operation in the burn-out furnace.

6. At the end of this period (in furnace at 1800° F. for thirty minutes), remove the assembly from the furnace, place it on the soldering block, and apply the properly adjusted reducing part of the flame of the oxygen-gas blowpipe to the solder joint area, keeping it away from any investment to avoid sulfur contamination.

As soon as the gold starts to shine and seems to be oxide free, touch the solder to the joint (on the occlusal surface), and remove the flame as soon as the solder flows.

The solder that is used in this soldering operation, ceramic High-Fusing slim strip solder* or Ney-Oro P-16 solder,† has been designed with the proper physical properties, and porcelain will fuse to it satisfactorily. These types of solders do not have the free-flowing qualities found in conventional crown and bridge solders and frequently have to be coaxed or pushed into place.

7. Allow the soldered assembly to bench cool before quenching.

In my opinion soldered joints that are made prior to the application of the porcelain make the best joints.

It is felt that a greater number of these types of soldered joints fail than when conventional crown and bridge golds and solders are used. Manufacturer's contend that these failures are caused by the excessive use of flux, but Mumford[4] says "that examination shows a highly crystalline interface formed through the solder itself."‡

*Whip-Mix Corp., Louisville, Ky.
†Reliance Dental Mfg. Co., Chicago, Ill.

*J. F. Jelenko & Co., Inc., New Rochelle, N. Y.
†The J. M. Ney Co., Hartford, Conn.
‡From Mumford, George: The porcelain fused to metal restoration, Dent. Clin. N. Amer., pp. 241-249, March, 1965.

Method 2

In this method the finished porcelainized units are assembled for soldering. This can be accomplished because the coefficient of expansion of the Ceramco porcelain is well matched to that of the gold. The finished Ceramco units can be soldered together, making use of conventional crown and bridge solders, and no checking or crazing of the porcelain should occur if the procedures are carried out properly.

1. Prepare a small ditch or step just lingual to the finishing line of the porcelain.
2. Allow as much length as possible for solder joint incisogingivally or occlusogingivally.
3. Rubber wheel the area to be soldered.
4. The space between the parts to be soldered should be no more than 0.33 mm. wide.
5. Cover the porcelain with melted wax the equivalent of 30-gauge thickness.
6. Invest the assembly, using a good conventional crown and bridge soldering investment in an upright manner so that the molten solder will flow down between the parts due to gravity. A thick base is a "must." This method of investing, instead of laying porcelain down flat, prevents the possibility of crazing or discoloration of the porcelain by solder flowing on it.
7. After the invested assembly has set for thirty minutes, flush out the wax with boiling water. Place a small amount of soldering paste flux in each joint (be sure flux does not contact porcelain—may cause discoloration).
8. Place the assembly in burn-out furnace at room temperature, and raise the temperature to 1200° F. at maximum furnace speed. This takes about thirty minutes. Hold at this temperature (1200° F.) to heat soak for about fifteen to twenty minutes.
9. Remove case from the furnace and place it on soldering block. Apply a minimum of soldering paste flux to the solder junctions again, dip the solder strip or pieces into the flux jar (be sure and wipe off excess), and play the adjusted pointed flame of the gas-air torch (reducing area) on the gold, not on the investment, until the gold is heated to a dull red and is oxide free. Position pieces of solder or touch solder strip to heated gold surface, continuing to play the reducing area of the pointed flame on the solder joint until the solder flows. As soon as the solder flows, immediately remove the blowpipe flame.

Soldering in a porcelain furnace is not recommended since the furnace has an oxidizing atmosphere.

10. Allow the soldered assemblage to bench cool under a glass cover to room temperature.
11. Carefully remove the investment from the restorations.
12. Pickle the case in Jel-Pac solution (warmed to 140° F.) to remove oxides. *Precaution:* Do not pickle a ceramic gold case in a Jel-Pac solution that is used for conventional crown and bridge golds, since it could contaminate the ceramic gold with copper oxides.
13. Use running water, not neutralizing agents, to clean the case after using Jel-Pac.
14. Finish and polish the structure in the usual manner. As a final step, use tin oxide to polish the porcelain parts.[1]

I have joined crowns made of regular crown and bridge gold alloys to finished ceramic restorations by method 2.

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2. Ryge, Gunnar: Dental soldering procedures, Dent. Clin. N. Amer., pp. 747-757, Nov., 1958.
3. Bridge and inlay manual, Hartford, Conn., 1964, The J. M. Ney Co., pp. 94, 120, 121, 140, 141.
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Chapter 10

Cementation

Finishing and polishing of the casting

The finishing technique must be organized well, and the major part of this operation should be completed before cementation. The necessary armamentarium consists of an assortment of burs, mounted stones (carborundum and diamond), various types of disks (paper, cuttle, and crocus), rubber wheels, mounted brass wheel, felt cone and brush wheels, chamois wheel, tripoli, rouge, chalk, and other special polishing compounds (Fig. 10-1).

In the polishing phase use is made first of coarser abrasives followed by less abrasive, and then finer abrasives. The coarser marks that are left by the previous abrasive should be removed completely before using the next, finer abrasive. Progressively finer scratches are produced because of the systematic reduction in the magnitude of the surface scratches as one grade of abrasive and then another is used until surfaces possessing a smooth high luster are the end result (Fig. 10-2).

A primary rule to remember is that a good polishing job must be a thorough job. The importance of highly smooth surfaces on any restoration that is going into the mouth cannot be overemphasized. Rough, poorly polished areas of metal, acrylic, or porcelain tend to hold the salvia and debris and greatly accelerate the formation of deposits. Since such deposits become stained and unsightly, the cause is often attributed, although wrongly so, to tarnish of the metal rather than to inadequate polishing.[1]

After the sprues have been cut off and excess sprue metal has been removed with a heatless stone or carborundum disk, the casting is pickled and sandblasted and is ready for final fitting, finishing, and polishing (Figs. 10-3 and 10-4).

The castings are positioned on their respective dies (stone or metal), and, if any excess gold appears on the occlusal or gingival areas, it is reduced. Use is made of mounted stones or paper disks, rotating the stone or disk from the gold to the die. Areas that are accessible to stones and disks, for marginal finishing on the tooth itself, are left in very slight excess.

Some castings may require etching of the cavity side of the casting within 1 or 1.5 mm. of the margin, by the use of reverse electrolysis in the stripper, for proper seating on the die. This process of stripping also provides space for the cement. If this is not done, the principles of hydraulics will not permit the proper seating of the castings during cementation. (See Fig. 10-5.)

After the castings are fitted accurately on their respective dies, they (dies and castings) are placed into the working cast for adjustment of the contact areas. Adjust contact areas very carefully, using a cup-shaped carborundum disk followed with a sulci burlew wheel. Remember that when the castings are positioned on the teeth in the mouth, the contact areas must be correct anatomically both from a faciolingual and occlusogingival dimension and also that the proper proximal contours must be maintained. The contact areas must not be too tight or loose—they should allow the passage of dental floss with the proper amount of resistance. (See Fig. 10-6.)

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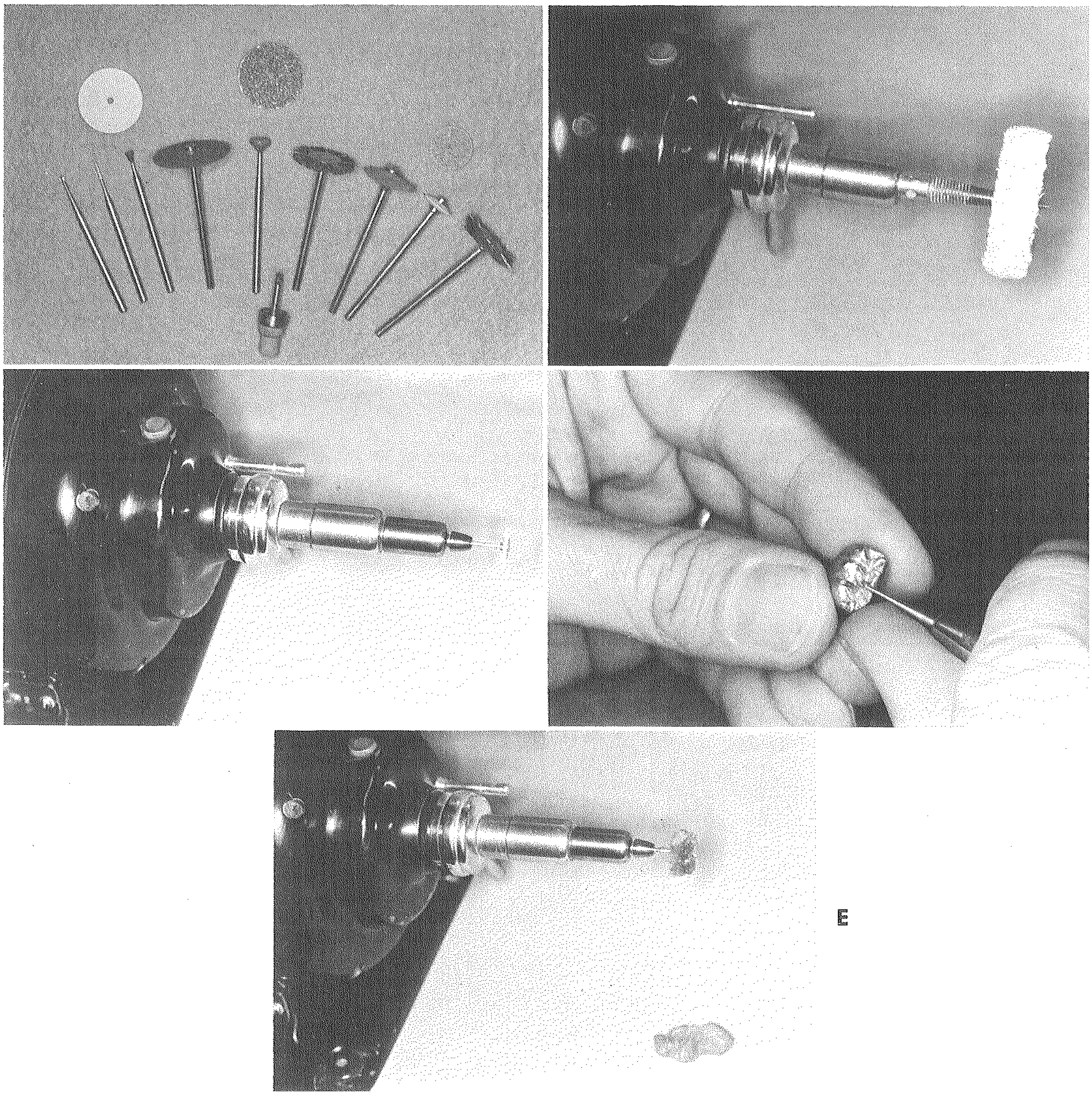


Fig. 10-1. Necessary armamentarium in the finishing and polishing of the casting. **A,** Burs, stones, carborundum disks, various grades of sandpaper disks, rubber wheels, brush wheels, and wire brass wheel. **B,** Rag wheel in a laboratory lathe. **C,** Brush wheel in a laboratory lathe. **D,** Burs (inverted cone, cross-cut fissure, gold finishing) used to develop or accentuate developmental and supplemental grooves and smooth occlusal surface. **E,** Chamois wheel for applying gold rouge as a final polish.

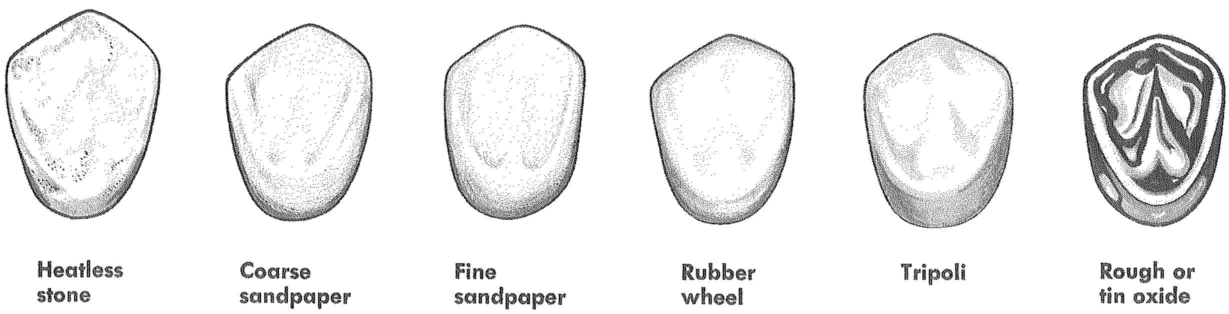


Fig. 10-2. These illustrations show each step in polishing technique and progressively finer scratches produced by various grades of abrasive. If technique is followed carefully, result will be a smooth, high-luster surface with a minimum tendency to acquire a deposit and become discolored. (From Bridge and inlay manual, Hartford, Conn., 1964, The J. M. Ney Co.)

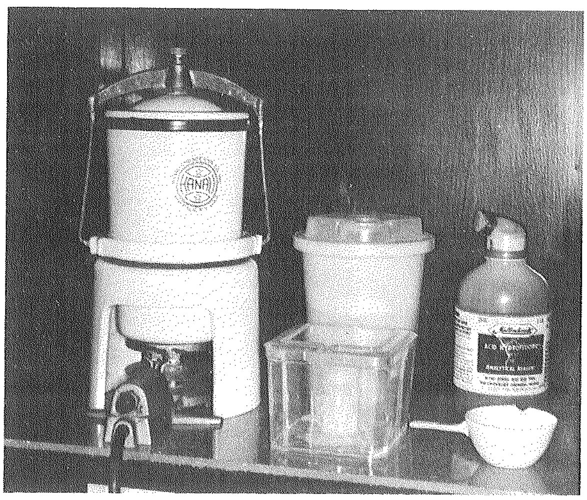


Fig. 10-3. My acid chamber.

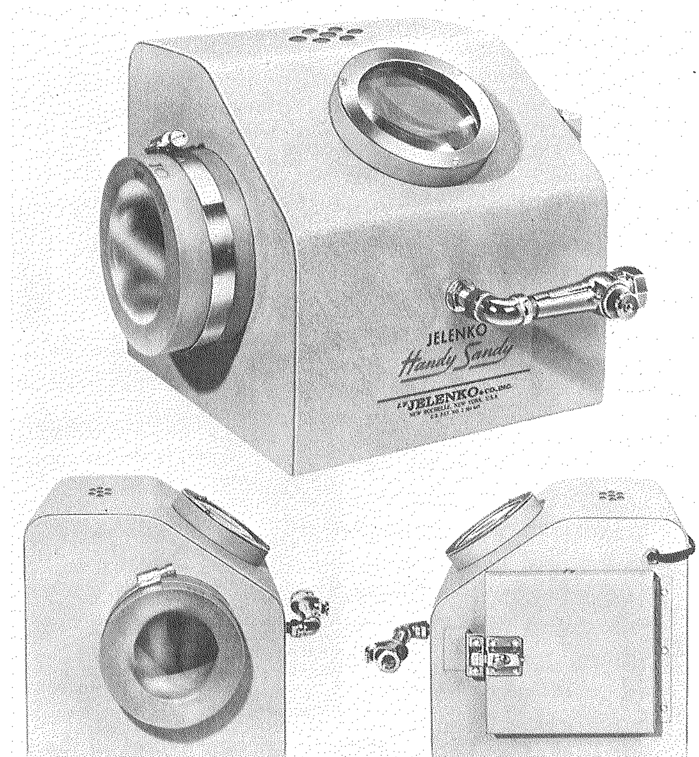


Fig. 10-4. Apparatus used for sandblasting of casting at low air pressures. (Courtesy J. F. Jelenko & Co., Inc., New Rochelle, N. Y.)

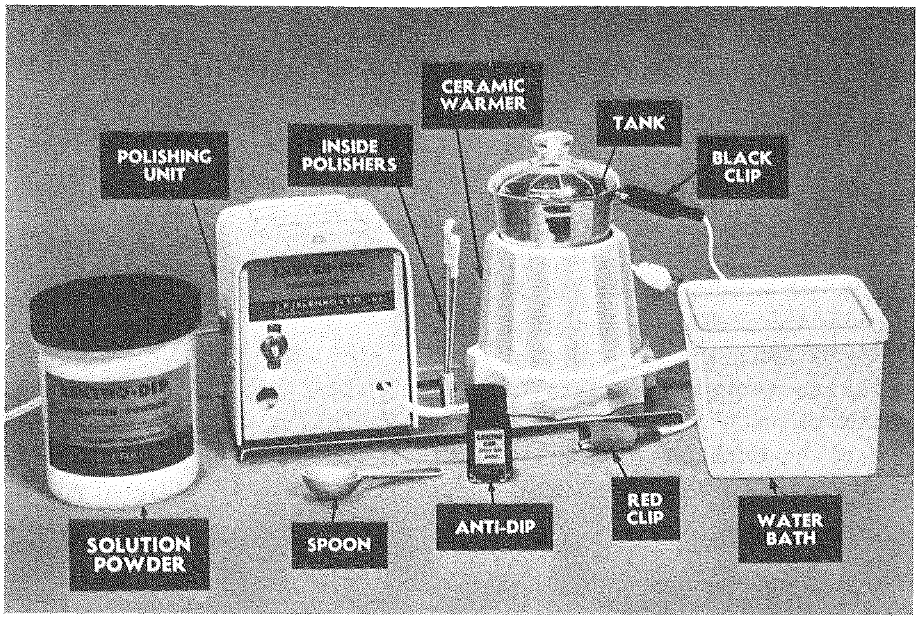
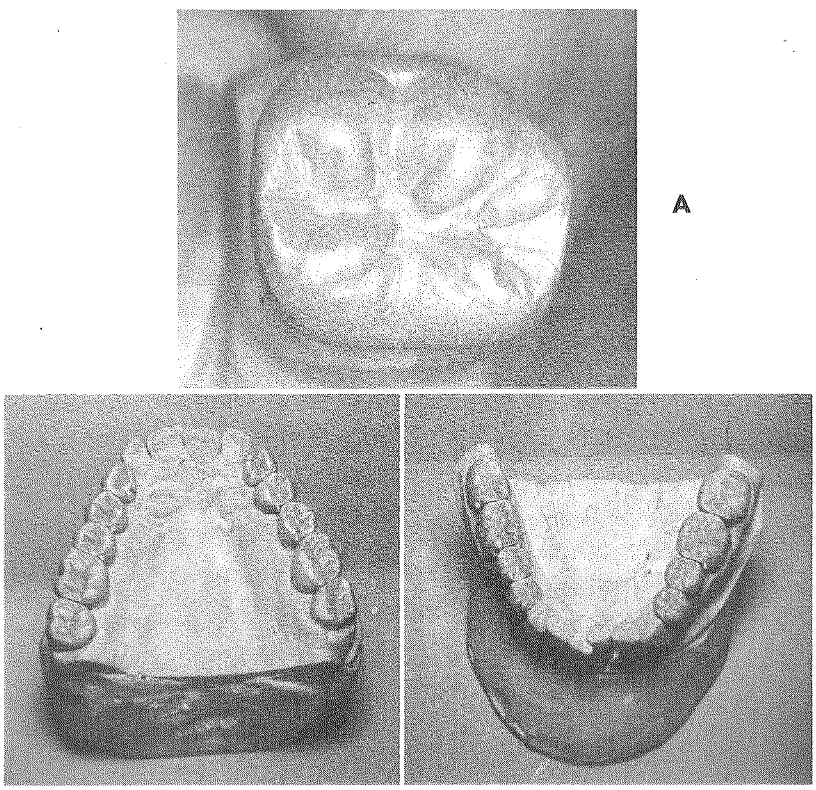


Fig. 10-5. Lektro-Dip stripping outfit. (Courtesy J. F. Jelenko & Co., Inc., New Rochelle N. Y.)



A

B

C

Fig. 10-6. A, Accurate fitting of castings on their respective dies is very necessary. **B,** Castings placed into working cast for adjustment of contact areas, etc. (upper). **C,** Castings placed into working cast for adjustment of contact areas, etc. (lower).

Next attention is directed to the correction of centric and eccentric relationships. Mounted stones, burs, and disks are used. Diamond stones are excellent for relieving of interferring areas and also for the preliminary smoothing of occlusal surfaces and grooves—they will not clog, and they hold their shape. When the carbon paper recordings show an even intensity of markings on all teeth, the restorations are ready for the final out-of-mouth polishing.

A smooth surface to accept a high polish must be accomplished. First, the occlusal surfaces may need some reshaping because of centric and eccentric adjustments. The occlusal anatomic form must be maintained. Diamond and carborundum stones and burs of the inverted cone type (No. 37 bur in straight handpiece is excellent), small round (Busch 1/4 round 4/0 or 5/0 best for supplemental grooves), "bud" and tapered No. 700 burs, and gold finishing burs are used for reshaping and smoothening of the occlusal surfaces. Light pressure and rapid movement are applied in the use of these burs and stones, unless developmental or supplemental grooves have to be reworked or accentuated, a condition that calls for the application of a little more pressure than ordinarily used. The remaining surfaces are smoothed by the use of various types of paper disks and rubber wheels. These disks (garnet, fine sandpaper, cuttle, and crocus) are used for semirough and fine finishing, and the rubber wheels remove scratches, smooth margins, and produce a dull satin finish. Be alert constantly so that the margins of the castings are not damaged.

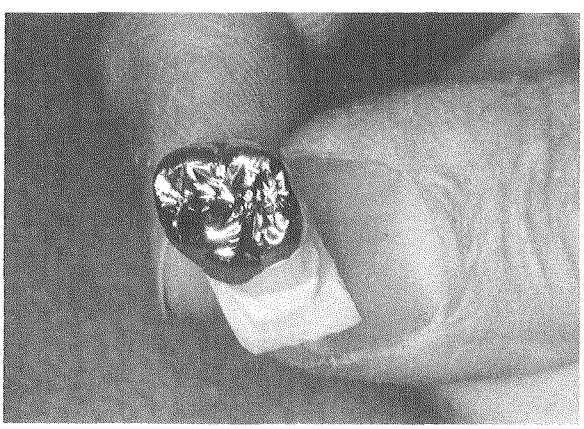


Fig. 10-7. Smooth finely polished casting with a minimum tendency to acquire deposit and become discolored.

The next step in the polishing procedure is the use of a mounted brass or steel wheel (a Dixon ¾-inch steel brush wheel run at high speed in the laboratory engine will not change occlusion if handled properly), which creates a nice smoothness, over the occlusal surfaces of the castings. Many operators feel that this should be the final finish of the occlusal surfaces, but I prefer a smooth, high-luster finish for reasons already mentioned.

The next step in the polishing procedure is the use of tripoli with a No. 11 Robinson soft bristle brush* (in the laboratory engine), controlling the amount of pressure applied on the castings with this polishing compound and keeping the gold surfaces covered with it at all times. This type of brush is excellent for polishing grooves and sulci. Running at low speed, the laboratory lathe also can be used, if desired, for this procedure.

Gold rouge is used next, either with a No. 11 Robinson soft bristle brush in the laboratory engine or on a chamois wheel (one that is used only for final polishing with rouge) on the lathe, running at No. 2 speed. Apply light pressure in the application of this material, "hitting" the casting frequently, but quickly, until a high luster is attained. A tin oxide compound can be used also.

All these procedures lead to a smooth, finely polished job with a minimum tendency to acquire deposit and become discolored (Fig. 10-7).

Now the castings are ready for cleaning to remove the polishing debris. It is felt that the rouge is one of the prime culprits responsible for rapid tarnishing of the gold alloy. The castings can be boiled in a washing powder (Spic and Span) solution and then scrubbed with this same solution to remove all traces of the tripoli, rouge, and other debris. Use can be made of PCR,† which was developed specifically to remove and solubilize iron compounds from polished surfaces. It is highly effective for removing tripoli, rouge, and all other buffing compound stains from gold, acrylic, and porcelain work. It is more effective when warmed. The restoration is immersed in PCR, and within a

*Buffalo Dental Mfg. Co., Brooklyn, N. Y.
†J. F. Jelenko Co., Inc., New Rochelle, N. Y.

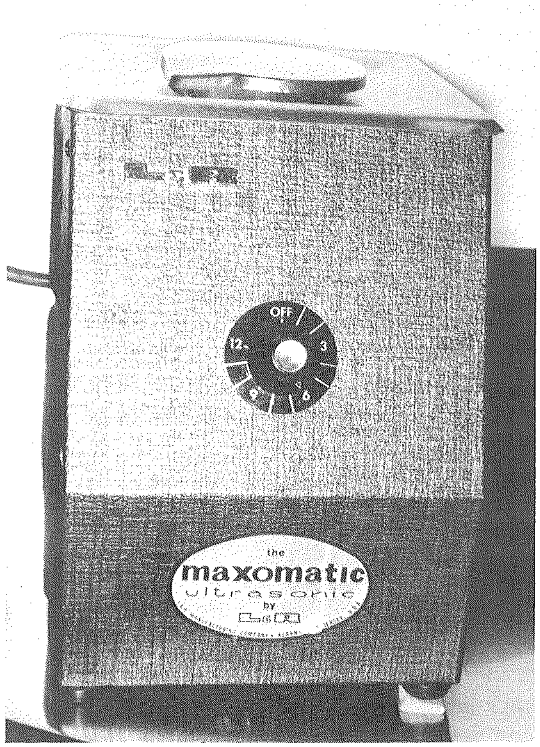


Fig. 10-8. Ultrasonic cleaner unit for cleansing of castings of polishing materials before cementation.

short period of time, usually ten minutes, stubborn stains can be rinsed or washed away. This material is completely water soluble and also is excellent for removing polishing compounds from the hands without harmful effects to the skin.

After the restorations have had the PCR treatment, I always put them in the ultrasonic cleaner unit for a final cleansing before cementation (Fig. 10-8).

Finishing and polishing of casting margins on prepared teeth

After the out-of-mouth finishing and polishing operations are completed and the restorations cleaned, they are ready for adaptation of the casting margins on the prepared teeth, which have been cleansed with fine wet pumice and peroxide applied with an end-brush or rubber cup to remove debris. If a zinc oxide–eugenol cement had been used for temporary cementation, all adherent remnants must be removed, using chemically pure benzine, carbon tetrachloride, or Cavidry.*

The castings are tried on the prepared teeth; and first consideration is given the contact areas. Do the contact areas accept dental floss with the proper amount of resistance? If adjustment is indicated in a plus or minus way, either by careful removal of excess contact or the addition of contact area by means of solder, extreme care must be exercised so that the contact areas are anatomically correct both from a faciolingual and occlusogingival dimension, and the proper proximal contours are maintained at the same time. A plus contact can be adjusted with a cup-shaped carborundum disk followed with a burlew wheel.

The proper adjustment of the contact areas will allow the castings to be seated firmly into position, using an orangewood stick and mallet, provided cavity preparation, impression, investing, and casting techniques have been carried out accurately. When the castings are seated firmly, all exposed margins should be examined with mouth mirror and a sharp explorer point, using binocular magnifying loupes. Margins that extend subgingivally will have to be evaluated by tactile sense, using an explorer point, or by means of a bite-wing roentgenogram. Slightly opened or flared margins are amenable to correction, but attempts to "spin" gold into voids in excess of slightly open margins end up in the loss of tooth structure and a tell-tale cement line.

Holding the casting firmly in place with a steel rod, burnish the margins with a beavertail burnisher. If the casting is not held firmly, it may become slightly dislodged, resulting in saw-tooth margins. All accessible margins are adapted perfectly to the tooth by means of a No. 39† mounted stone coated with petroleum jelly, in a contra-angle moving the stone with a circular or rotating motion, followed by abrasive disks such as extrafine garnet, fine sandpaper, and cuttle disks mounted on small-headed mandrels, rotating the stone or disk from the gold toward the tooth (Fig. 10-9). Only "true-running" stones should be used because, when stones become eccentric, damage to the casting margins and enamel rods ensue, resulting in

*Parkell Go, New York, N. Y.

†Chayes Dental Corp., Danbury, Conn.

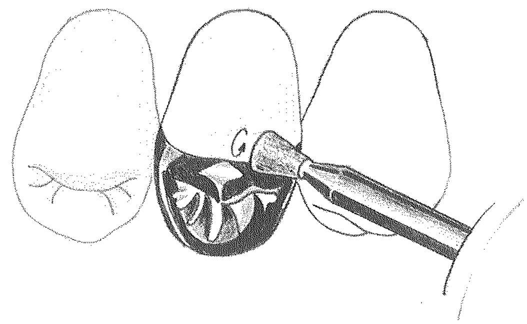


Fig. 10-9. "Spinning" of margins. All accessible margins are adapted by use of stones, garnet, and sandpaper disks, rotating stone or disk from gold toward tooth.

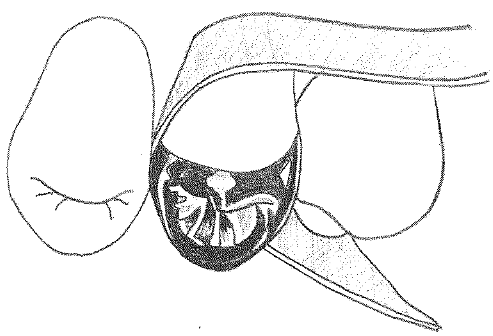


Fig. 10-10. Gingival margins of castings finished by burnishing and removal of excess with B4 Weidelstadt gold files, and gently stripped with fine sandpaper and cuttle finishing strips.

many instances in a chalky finish area adjacent to the casting.

If gingival margins show excess, they are finished by burnishing and removal of this excess with B4 Weidelstadt gold files. If gingival margins show excess, they are finished by burnishing and removal of this excess with B4 Weidelstadt gold files. Its curved face and angulation provide good access to the proximal surfaces and make it less injurious to the cementum. These areas should also be stripped gently with fine sandpaper and cuttle finishing strips. (See Fig. 10-10.)

Reexamine all margins visually with the explorer point and with a bite-wing roentgenogram. If everything is in order, remove castings and finish any roughness on gingival margins by disking with fine cuttle disks and rubber wheels. The major part of the finishing must be done before cementation because cement lines will result if extensive finishing is done subsequent to cementation.

The gold margins must be well tailored. By so doing, the castings will not be offensive from an esthetic viewpoint.

Cementation

Zinc phosphate cement

Both the selection and the proper manipulation of a satisfactory cement are most necessary. By its proper use in handling, the desirable physical and chemical properties can be brought out.

Zinc phosphate cement consists of a powder and a liquid, and its bacteriostatic properties appear to be very limited. The powders are essentially calcined zinc oxide and magnesium oxide, and the liquids are phosphoric acid, which is partially neutralized by the addition of metallic salts as buffers, and water. Setting time is controlled by the addition of definite concentrations of water. Precautions must be taken to protect both the powder and liquid from contamination.

It is necessary to remember, when working with these cements, that the water balance is critical and should be preserved. Since the liquid is hygroscopic, it is very susceptible to fluctuation in water content. The acid-water ratio of the liquid is balanced delicately for each particular product, and any alteration will effect the handling characteristics, setting time, and ultimately the physical properties of the material. Addition or loss of water, through exposure of the open bottle of liquid to room atmosphere, will alter the setting time—either accelerate or retard it.

An increase in the water content of the liquid accelerates the set of the cement and thus reduces the amount of powder that can be incorporated into the mix. Loss of water from the liquid greatly increases the setting time. Relative humidity percentage varies constantly and is hard to control in our offices.

This phenomenon, increase in the water content of the liquid or loss of water from the liquid, also will vary the consistency of the mix. Therefore, the bottle of liquid should be kept stoppered tightly, and the liquid should never be placed on the mixing slab until exactly ready for the mixing operation to avoid an overly long exposure to the atmosphere and a possible change in the acid-water ratio. Moisture from a chilled slab, unless carefully dried, gets incorporated into the mix, accelerating the set. A bottle of liquid that appears cloudy or shows a precipitation of crystals must be discarded. Also liquid should be discarded when it gets near the bottom of the bottle since there is the possibility that the water balance would be altered.

Since the setting reaction is an exothermic one, the cement should be mixed on a cool slab. A cool slab retards the setting reaction and permits the incorporation of more powder into the liquid. The powder-liquid ratio regulates the physical properties. The more powder added, within limits, the higher is the strength and the lower is the solubility of the mix of cement. It is essential, if possible, to get a mix of cement with low solubility and high resistance to abrasion.[2]

The best cement mix is obtained on the coldest mixing surface that is not below the dewpoint (does not sweat).

"(1) Cold slabs yield faster setting cements. The lower the mixing temperature, the quicker the final set in the mouth.

"(2) The use of a cold mixing surface (40°-60° F.) profoundly lengthens the safe working time of the mixed cement.

"(3) More powder can be safely incorporated on cold slabs.

"(4) It has been found that cement sets with more than 3 times the rapidity at oral temperature than it does at room temperature. The relatively high temperature of the mouth causes crystallization to begin almost immediately, but at room temperature, and especially on cold slabs, setting is greatly retarded.

"(5) Therefore, it is unwise to apply cement to the cavity before it is coated on the casting because of the disparity in their respective temperatures."*

The variables—liquid deterioration, relative humidity percentage, room temperature, slab temperature, dew point, and the fact that the powder is hygroscopic and will absorb moisture—must be controlled to the best of our ability because the weakest link in the casting process is the cement.

All these facts point to the importance of selecting the proper cement that fulfills all A.D.A. specifications and of correctly executing proper manipulative procedures in mixing this type of cement.

Preparation of the dentin for cementation

In mouth rehabilitation cases we deal in many instances with mutilated teeth, which have been prepared previously very deeply, have extensive restorations, and need only a little more trauma to arouse latent possibilities for extreme sensitivity or pulpal pathology. Also this condition can be caused by our carelessness in cavity preparation, impression taking, and cementation procedures—therefore the necessity of care in manipulative procedures and an understanding of the nature and use of the materials and tools used in our restorative methods.

Application of medicaments to the dentin for sterilization has its proponents and opponents. Both sides, however, agree that harsh medicaments should be avoided. Seltzer and Bender[4] say:

"(1) Sterilization of cavities with drugs prior to filling does more harm than good.

"(2) Bacteria tend to die out, once they are sealed into the dentinal tubules, unless there is seepage of saliva through the margins of the restoration.

"(3) The pulp will not be healthy if treated with germicides practically all of which are extremely irritating. A damaged pulp is receptive to the growth of microorganisms.

"(4) Desensitizing solutions are dangerous to the pulp.

"(5) Calcium hydroxide may be used as a liner to reduce the irritating action of zinc phosphate cement."*

I know that the research conducted by these able investigators on this particular subject and their vast clinical experience make the previously mentioned data authoritative. I am in agreement with them even though I use, when indicated, a protective varnish and a base of zinc oxide–

*From Henschel, Chester J.: The effect of mixing surface temperature upon dental cementation, J.A.D.A. **30**:1583-1589, 1943.

*From Seltzer, Samuel, and Bender, I. B.: Modification of operative procedures to avoid postoperative pulp inflammation, J.A.D.A. **66**:503-512, 1963.

eugenol cement or calcium hydroxide before cementation, which provides suitable thermal insulation and sedation, especially with zinc phosphate cements that contain orthophosphoric acid and affect the pulp adversely.

The protective varnish that is used consists of natural gums such as copal and rosin dissolved in a solvent such as ether or chloroform. The solvent evaporates rapidly, leaving a thin film on the tooth surface. Although the varnishes may not inhibit the passage of phosphoric acid completely, they greatly reduce it. They lessen the severity of pulpal irritation while proving to be fairly effective in blocking off pathways to temperature radiations. Phillips[5] advocates a continuous coating (three coats) for maximum protection.

Massler's[6] work with zinc oxide-eugenol cement demonstrated its superiority over all other preparations for deep caries. It shows excellent sealing qualities, is antiseptic, and is palliative to the pulp.

In the average or shallower cavities use is made of a nonirritating medicament such as Metimyd* ophthalmic suspension, which is followed by a preparation consisting of 25% parachlorophenol, 25% metacresyl acetate, and 50% U.S.P. camphor. Then a varnish such as copalite is applied. The objective of this procedure is to eliminate post-insertion thermal sensitivity. Many clinicians feel that the results with anti-inflammatory drugs have been encouraging and that further work in this field is justified and desirable.[7]

A point to always remember, especially in full-coverage and other extensive preparations, is to cement the temporary restorations with an antiseptic and sedative temporary cement to assist in pulp recovery from these operative procedures. Adequate time (in some instances as long as four weeks) must elapse between preparation and cementation of the restoration with a zinc phosphate cement so that the pulpal tissue can recover from trauma.

The addition of eugenol to orthophosphoric acid in "hard" cementation is to be discouraged because eugenol is incapable of neutralizing the acid and also causes a decrease in strength properties. The effect of the acid on the pulp would not be less, although sensitivity might be masked. To be effective, a desensitization procedure must, first of all, minimize pulpal injury.[8]

*Schering Corp., Bloomfield, N. J.

Berman[9] has this to say about cementation:

"(1) Cementation should seal a restoration permanently, preserve the health of the pulp tissue, and afford the patient comfort and freedom from sensitivity.

"(2) We haven't got the ideal cementing medium as yet, but oxyphosphate of zinc cement with its damaging potential of phosphoric acid, is still the most dependable medium.

"(3) With proper preparation of the dentin before cementation and correct handling of the cement mixture, it is possible to overcome the deterimental effects of this cement."*

Cement escapeways

Experimentation has shown that no dental cement will allow complete seating of the casting upon the preparation.[10] The end results are a disturbed occlusion, which needs adjustment for comfort, and the ruination of otherwise fine margins. We must make room for the cement. If this is not done, the principles of hydraulics will not permit us to closely approximate the seating of castings during cementation. The resistance to seating is greater when abutment walls are more nearly parallel. Often this pressure over thin remaining dentin may cause post insertion symptoms. Also a restoration that is left in supraocclusion results in a tooth (or teeth) that is sensitive to mastication and hypersensitive to thermal changes.

In a crown of close adaption the avenue of escape decreases progressively. Therefore there is the need for escapeways such as occlusal vents, machining of the inner surface of the casting to within 1 or 2 mm. from the margins or grooves, for ease of seating and for more complete seating of the restoration. In the final seating the cement escape channel assumes its greatest value by relieving compression from within. In unvented restorations with extreme frictional resistance on the preparation, trapped air or cement may form an incompressible lock and prevent full seating of the restoration. Selberg[10] has shown that without the cement escape channel the experimental discrepancy is 0.002

*From Berman, Martin H.: Preservation of pulp health during complete coverage procedures, J.A.D.A. 70:83-89, 1965.

inch, which means that the gingival margin is short by this amount. With the use of an escape channel the discrepancy is 0.0005 inch (minimum discrepancy possible of achievement), which shows that the value of a cement escapeway is equal to the difference between 0.002 and 0.0005 inch, or 0.0015 inch.

All this discussion vividly points up the fact that, unless we have extremely tapered preparations, passive fit of our castings, or stripped or machined out inner surfaces of castings within 1 mm. of the margins, a cement escape channel is a "must."

An occlusal vent can be prepared in a crown by drilling through the mesiobuccal cusp with a No. 59 twist drill, which creates an opening that will accept a piece of 18-gauge clasp wire with a snug fit (Fig. 10-11).

The clasp wire plug is almost severed at a predetermined point (0.5 mm. from crown) prior to cementation, which will allow (1) the use of an excess length of wire as a handle, facilitating its placement, (2) the bending of the wire to an angle for ease of placement, and (3) a fracture point after insertion.

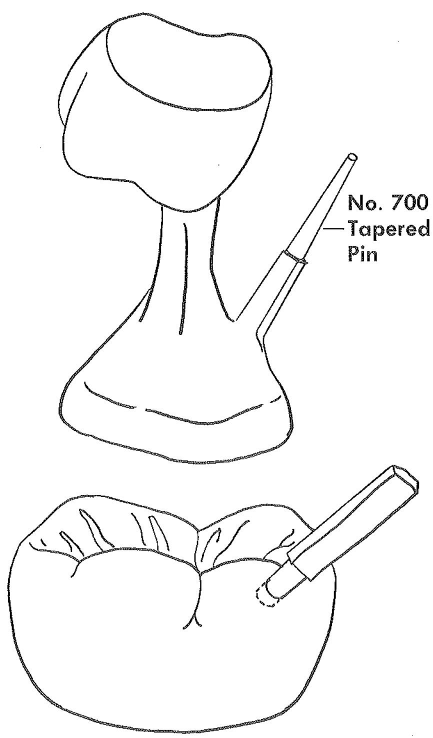


Fig. 10-11. An occlusal vent for a cement escape opening so that full cast restoration can be seated during cementation with minimum of discrepancy possible of achievement. Note tapered pin is cast with crown. (Suggested by Bassett, Russell W. [and used extensively by the author]: J. Prosth. Dent. 16:740-747, 1966.)

When the crown is ready for cementation, the vent must be corked with the 18-gauge clasp wire (or a No. 700 tapered pin cast of gold) so that a quantity of cement will not escape, thereby preventing the cement to flow ahead of the crown into the gingival area. After the crown is seated by finger pressure, the clasp wire stopper is removed and the restoration firmly seated into place with pressure by the use of an orangewood stick and mallet. A sustained pressure is maintained for five to seven minutes, but after about thirty seconds the clasp wire plug is replaced into the vent and seated to the full depth of the vent through the still soft cement. After the cement has set, the excess cement is removed carefully and the clasp wire plug, beyond the almost severed predetermined point, is broken off by bending it back and forth until it fractures. The part of the wire that extends beyond the crown surface (0.5 mm.) is stoned or riveted until it is even with the crown surface, after which it is smoothed and polished.

The patient will have a restoration that fits as well, and is as comfortable, after cementation as it was during the fitting stage.

Procedural steps in "hard" cementation

No dental cement is capable of true adhesion to tooth structure. It is an adjunct to retention, but not the sole source. A retentively shaped abutment preparation and a well-fitting casting in conjunction with the correct cement properly handled provides a long-lasting restoration.

1. If the patient manifests a copious flow of saliva, he should be given two 50 mg. Banthine tablets thirty minutes before the operation.
2. If teeth are overly sensitive, it is best for all concerned to use a local anesthetic.
3. Preparations are cleansed of debris and adherent remnants of zinc oxide–eugenol cement, using chemically pure benzine or carbon tetrachloride. Examine gingival crevices carefully for particles of temporary cement. Be sure the soft tissue is retracted enough so that the gingival edge of the crown does not impinge upon it when being cemented.

4. The gingival crevice is flooded with epinephrine solution (1:100) to eliminate seepage from the gingival tissues. The solution is allowed to remain three minutes, after which it is washed away with warm water.

5. Preparations should be isolated and maintained in complete dryness by means of cotton rolls or a rubber dam in conjunction with a saliva ejector. The presence of moisture interferes drastically with the crystallization of the cement. Excessive desiccation of the dentin with air blasting must be avoided.

6. Wash teeth again with chemically pure benzine and chloroform, and then swab teeth with Metimyd ophthalmic suspension. Leave the suspension for three minutes, after which apply a preparation, consisting of 25% parachlorophenol, 25% metacresyl acetate, and 50% U.S.P. camphor (with or without 1% prednisolone) allowing it to remain for two minutes. Then dry the teeth very carefully with warm air, after which use carbon tetrachloride to remove the oily film of medicament. Again dry very slowly and carefully.

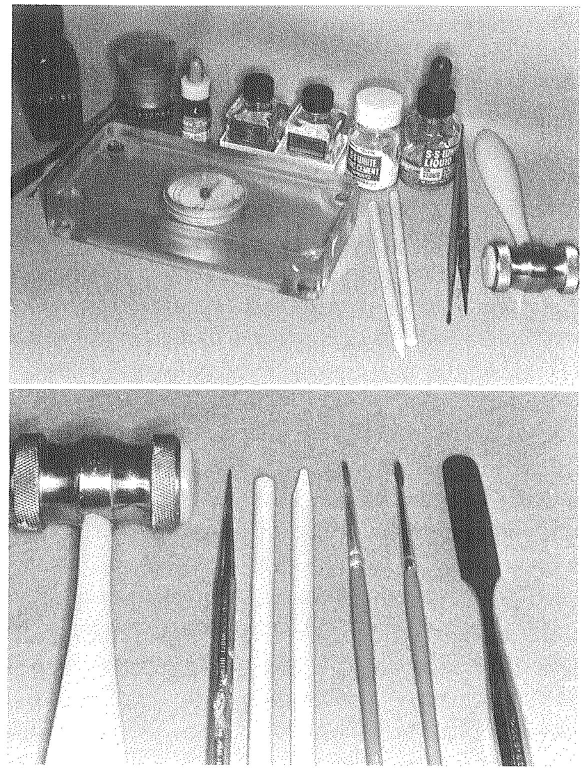
7. Coat the prepared teeth with a copal varnish (Copalite[*]) short of the finishing line or margin, and dry them carefully with a blast of warm air. A continuous coating (three coats) is essential for maximum protection.

8. Paint the teeth with a suspension of calcium hydroxide (Hydroxyline[†] or Dropsin[‡]), using a No. 1 contra-angle sable brush. Thin this suspension of calcium hydroxide slightly in a dappen dish to achieve a nice thin coating. Paint short of the marginal finishing line—it is self-drying and leaves a thin, insoluble film on the dentin. Logically, the calcium hydroxide should be applied first, but the Copalite varnish dissolves it. Many investigators feel that the use of calcium hydroxide is mandatory to protect the pulp from the damaging effects of the orthophosphoric acid of the cements and that varnishes alone are not effective for this purpose.[9]

9. Use a cement that meets A.D.A. specifications.

10. Before the mixing of the cement is started, prepare the internal surface of the castings for cementation. Slightly roughen the surfaces on the inside of the casting with a No. 33½ inverted cone bur just short of the margins; this procedure contributes to the efficacy of the cement bond.

*William Getz Corp., Chicago, Ill.
†George Taub, Inc., Jersey City, N. J.
‡Svedia, Enkoping, Sweden.



A

B

Fig. 10-12. A, Armamentarium used in cementation procedures. **B,** Close-up view of mallet, steel and orangewood seating and holding tools, brushes, and mixing spatula.

11. Make the cement mix on a thick glass or ceramic slab. The slab should be chilled to 60° to 70° F., being sure it is not below the dew point. (See Fig. 10-12.)

12. Place liquid on the slab just prior to starting the mix. To permit adequate working time in making multiple cementations, the setting time may be retarded by spatulating a small quantity of powder into the liquid and allowing this to stand for two or three minutes before adding the remainder of the powder. Four or five drops of cement liquid for each casting should be sufficient. (See Fig. 10-13.)

13. After two or three minutes have elapsed, add small increments of powder to the liquid, using a rotary motion to incorporate it thoroughly. Adding large amounts of powder will hasten the set and render the operator's working time unpredictable. Utilize as much of the slab

Fig. 10-13. Liquid must be placed on slab just prior to starting mix. Four or five drops of cement liquid for each casting should be sufficient.

Fig. 10-14. Maximum amount of powder must be incorporated into a given quantity of liquid and still the mass must be plastic enough to allow proper cementation of castings.

as possible, keeping the mass under control at all times.

14. When the mix of cement is at about the halfway mark, "the dentist should pause to wipe the spatula blade dry with a piece of lintless gauze. The spatula blade often has free acid along its sides and upper reaches. This may enter the completed mix when all the cement is gathered in, thereby inadvertently including free acid in the finished cement. Once the spatula blade is wiped dry, the dentist will see an immediate change in the character of the cement mix, because free acid no longer enters the mix from the spatula blade."*

15. The maximum amount of powder must be incorporated into a given quantity of liquid, and still the mass must be plastic enough to allow proper cementation of the castings (Fig. 10-14). For good consistency a strand of cement should follow to a height of ½ to ¾ inch. Also solubility is related directly to the amount of powder used. The mix should be very smooth.

16. The time of mixing should be approximately one and one-half to two minutes.

17. After the cement has been mixed properly (a thin mix with a maximum amount of powder in it), coat the casting (or castings) with a film of cement first (in the creamy consistency recommended) because of the disparity between mouth and room temperatures, and then fill or cover the preparations with the cement mix. Next, seat the restoration with finger pressure, which is followed immediately with heavy pressure, using an orangewood stick and mallet. A vibratory motion (with orangewood stick) is used to help express surplus cement, after which the seated restoration is kept under a sustained pressure with the orangewood stick or a Medart inlay pressure applicator until the cement has set, which is usually from five to seven minutes. (See Figs. 10-15 to 10-17.)

A good cement offers an excellent flow characteristic to assure positive and complete adaptation of locking cement to the opposing surfaces of the tooth and restoration. The locking film of cement is so thin that it is impossible to detect any lifting of the restoration.

In addition to low film thickness, other important characteristics or properties essential for complete placement of restorations are (1) smoothness of mix, (2) extra strength resulting from high powder-liquid ratio, (3) high resistance to solubility in mouth fluids, and (4) adjustable setting speed—fast, medium, or slow, as needed in each operation.

I use the camel's-hair brush technique as developed by McEwen[11] for applying the cement

*From Berman, Martin H.: Preservation of pulp health during complete coverage procedures, J.A.D.A. **70**:83-89, 1965.

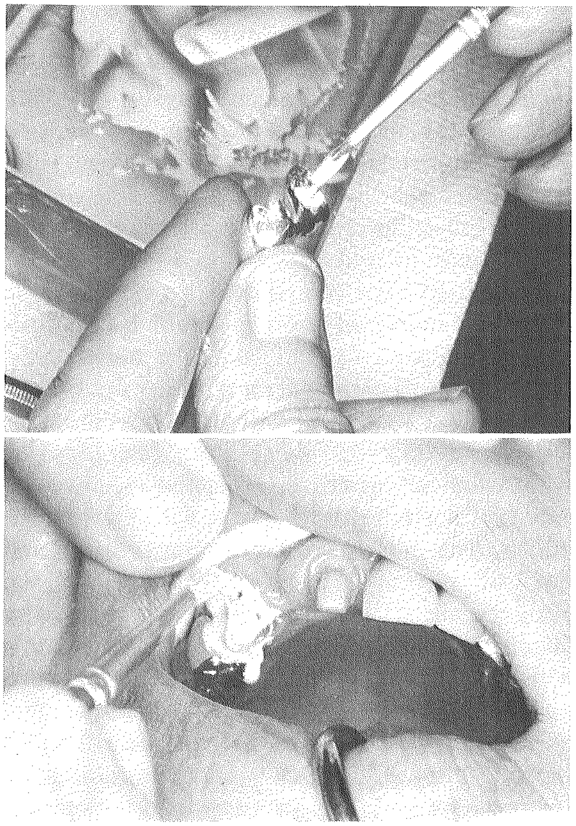


Fig. 10-15. After proper mix of cement is completed brush cement into crown and onto the preparation in a thin layer and seat restoration with finger pressure, followed with an orangewood stick, using a vibratory motion.

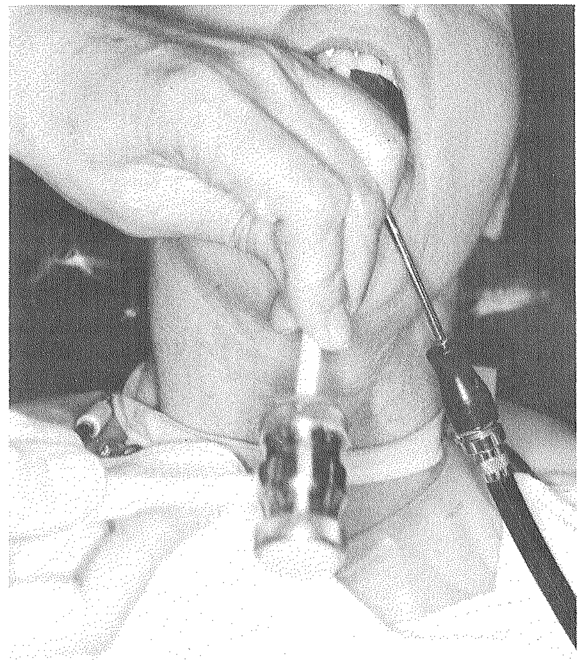


Fig. 10-16. Mallet pressure used to completely seat restoration.

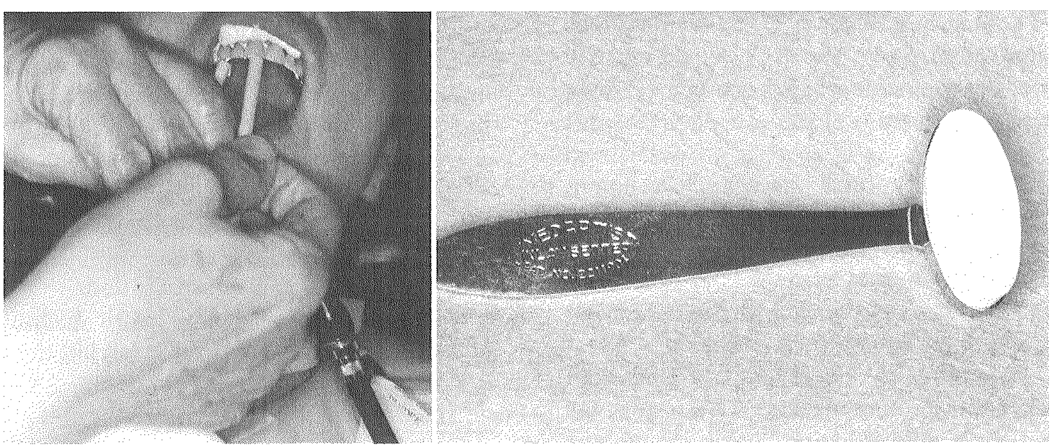


Fig. 10-17. Seated restoration is kept under a sustained pressure with orangewood stick or a Medart inlay pressure applicator.

to the casting and tooth preparation for the elimination of air bubbles, and for giving a constant and adequate cement coverage. The cement is brushed into the crown and onto the preparation in a thin layer, and, if several crowns are to be cemented at the same time, several brushes are used—one brush for two crowns is a good ratio.

Many times it is advisable to allow the assistant to hold the restoration with an orangewood stick or steel rod while the dentist burnishes the accessible margins before the initial set of the cement takes place, because excellent marginal adjustment can be obtained while the cement is in a plastic state. Slight disking of the restoration with fine cuttle disks is done immediately after all accessible margins have been burnished with a broad burnisher to force margins of gold castings, which may be displaced slightly by hydraulic pressure, against the tooth structure. This procedure can eliminate the finest cement lines.

18. When the cement has set thoroughly, remove excess cement, being very careful to do so subgingivally, in contact areas and under pontics. Bite-wing roentgenograms will be of great help in checking for vestiges of cement, the removal of which is so important for gingival health.

19. Check occlusion—centric and eccentric positions. Even though castings have been stripped or vented and cement mix made correctly, the gingival margin, at best, is scant 0.0005 inch. This could necessitate a slight occlusal adjustment.

20. Polish the restoration with a suitable moist polishing abrasive. The ones recommended by G. D. Stibbs,[12] Nos. 303 Centriforce abrasive* and 309 W Centriforce abrasive (a finer polishing abrasive) used with a soft rubber cup, are excellent.

21. Take postoperative roentgenograms of completed restorations (Fig. 10-18).

The entire finishing process must be executed with extreme care so that the abutment teeth are not overheated.

The gingival tissue will heal quickly from any mutilation incidental to the production of the complete restoration, provided tooth morphology

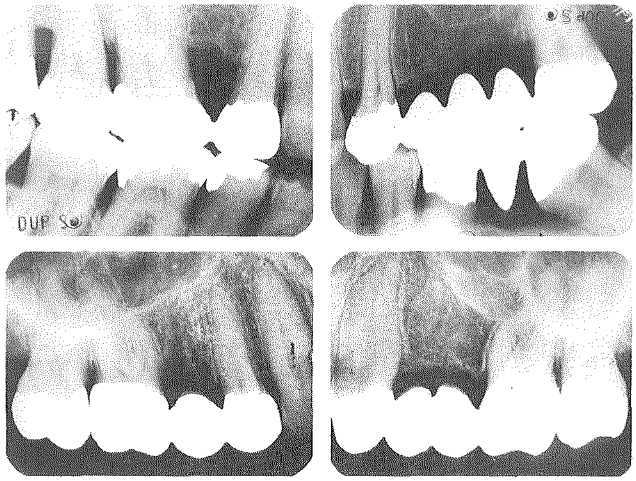


Fig. 10-18. Postoperative roentgenograms of completed restorations, showing gingival marginal fit and adaptation.

is correct, subgingival margins are accurate, and the gold surfaces are polished properly.

Temporary cementation

Requirements of a temporary cement

1. Temporary cement should handle easily on mixing and have adequate working time for seating of the restorations.
2. It should be nonirritating and sedative to pulpal tissues. It therefore is good for sensitive teeth, especially from the trauma of cavity preparation, impression taking, and construction of temporary acrylic crowns or splints.
3. It should stimulate the formation of secondary dentin.
4. It must have no deteriorating effect on acrylic resins.

These cements (temporary) consist of zinc oxide powder, eugenol and rosin liquid. Eugenol should not be used repeatedly on fully dried teeth, especially in deep preparations, since it is an irritant and can cause pulp involvement.

Temporary cementation offers unusual pulpal protection because it is nonirritating and sedative to the pulpal tissues. Therefore it not only reduces sensitivity by its palliative effect, thereby providing minimum patient discomfort, but also stimulates the formation of secondary dentin. Its mild effect on the pulp is related primarily to its ability to prevent ingress of fluids and organisms that might produce a pathologic con-

*American Optical Co., Southbridge, Mass.

dition in the pulp—caused by the fact that this type of cement adapts itself much better to the cavity walls. Also its solubility in organic acids is less than is that of zinc phosphate. It allows the pulp to heal.

The compressive strength of these cements is much lower than zinc phosphate cements, 2000 to 4000 psi as compared to a minimum of 12,000 psi.

Temporary cements also are inferior to zinc phosphate cements with respect to resistance to abrasion. The powder-liquid ratio has a negligible effect upon both strength and solubility, and its working time is less critical than that of zinc phosphate cements.[2]

Advantages of temporary cementation

1. Teeth with a doubtful prognosis can be retained provisionally in the splint. If a tooth has to be lost, the splint can be removed, the tooth extracted, and the crown converted into a pontic.
2. The gingival tissue can be observed, and, if irritation develops, the splint can be removed and adjusted. This is important especially if the margins of the castings are apical to the gingival margin should any overextensions of retainer margins be present.
3. Pontic adaptation can be observed and pontics can be recontoured, if the adjacent tissue becomes inflamed, to a more favorable pontic-to-tissue relationship.
4. Abutment teeth can be tested for vitality, and, when necessary, access for endodontic therapy is available without perforating the crown.
5. Worn or broken facings or veneers can be replaced.
6. If stabilization is inadequate, other teeth can be added to the splint.
7. Temporary cements protect the pulp and palliate the injury that is caused by abutment preparation, impression taking, and construction of temporary acrylic crowns or splints.
8. When indicated, restorations can be removed unhampered by the use of a back-action hammer, a steel rod and mallet, or a towel clip or Baade or Rubin crown remover, using an orangewood stick as a fulcrum. This is most valuable (a) if pain in an area of the prosthesis cannot be localized (removal of bridge or splint allows for clinical inspection and pulp testing), (b) if acrylic veneers have to be replaced, and (c) for caries inspection and periodontal observation.
9. Temporary cement permits an easier adjustment of the teeth and the restoration to a new physiologic relationship.
10. It allows prepared teeth to be sedated a number of times during treatment procedures. If abutment teeth are hypersensitive, the finished restoration should be cemented temporarily for at least three or four weeks. Under these conditions the prepared teeth become less sensitive and also more receptive to permanent cementation. Prepared teeth seem to tolerate the irritation from oxyphosphate of zinc cements better after temporary cementation. The need for sedation is greater than sterilization since sterilizing agents are injurious to pulps.[13]

Disadvantages of temporary cementation

1. Some of the abutment castings invariably become loose while others retain the splint securely.
2. Removal of the splint may be difficult and usually is painful. In some instances loose or mobile teeth can be removed with the splint.
3. The margins of the castings can be damaged by the force that is required to remove the splint.
4. Some abutment teeth gradually become desensitized, and the entire crown of an abutment tooth may be destroyed or "jellied out" by caries before subjective symptoms indicate loss of hermetic seal.

Criteria for temporary cementation for extended periods of time

Zinc oxide–eugenol cements should not be used for cementation purposes where unusual demands will be placed upon the cementing medium. The shearing strength of temporary cements are inferior to that of zinc phosphate cements. This type of cement is not indicated for three-quarter crowns, pinledges, and M.O.D. onlays for extended periods of time because susceptibility of the margins to abrasion and attrition could lead to failure, as could other stresses brought to bear upon the restorations.

This type of cement can be used for extended periods of time with properly constructed full-coverage retainers. The preparations for full coverage must not be too convergent, the walls of the preparation must have a taper of not more than 2 to 5 degrees, and all abutment teeth in the bridge or splint must be parallel to each other. Coupled with an accurate fit of castings, retentiveness is increased.

If preparations for full coverage are too convergent, by either operative overenthusiasm, previously prepared teeth, or caries, copings are necessary to create parallel and retentive walls to other preparations. Use is made of pin and groove retention on the convergent preparations. The completed gold copings, which are cemented on the more retentive preparations with zinc phosphate cement, should have the external form of an ideal tooth preparation.

By means of accuracy of fit of castings, correct parallelism of abutment teeth, and control of the occlusal factor, wash-outs of cement can be avoided to a great extent. However, in teeth exhibiting some degree of mobility, because of periodontal involvement and despite the fulfillment of the requirements just cited, the abutment retainer that is subjected to torque as a result of flexure will cause a break of the cement seal and a wash-out of the cement with its inevitable sequelae—sensitivity to thermal changes or biting pressures, a medicinal or bad taste, or a carious or "jellied out" tooth with pulpal involvement if it goes unobserved by the dentist or patient. Be observant of an oozing sound on biting pressure or the appearance of saliva bubbles at the gingival margin of the restoration on biting pressure or up and down movement of the retainer or appliance with the fingers. The careless use of the sticky or tacky foods and bad manipulation of stimulators also can break

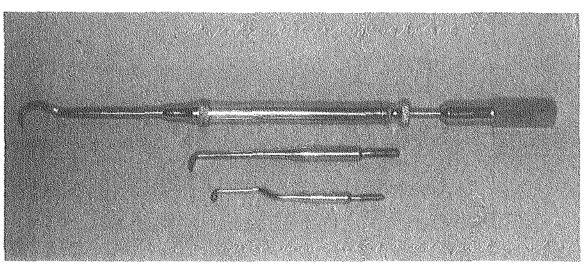


Fig. 10-19. Back-action crown remover with an interproximal sickle attachment and other shaped interchangeable points.

the cement seal. By all means remove the splint periodically, examine teeth and tissues to be sure that everything is in order, and then recement the splint with great care.[14]

The splint is removed by using either a steel rod and mallet, a back-action crown remover with an interproximal sickle attachment (Fig. 10-19), or a Baade or Rubin pliers or towel clip. The removal force must be gentle and well distributed, moving carefully and deliberately from one interproximal area to another. By so doing it is possible to avoid (1) fracture of the splint, (2) accidental removal of a mobile tooth, and (3) injury to the supporting structures.

After the splint is removed it is washed and then placed into an ultrasonic cleaner for removal of the cement. During this interim the teeth are cleansed of adhering particles of cement with chemically pure benzine or carbon tetrachloride. On removal of the splint from this unit it is washed in tap water, dried, and the acrylic parts coated with a slight amount of silicone grease, after which it is recemented.

Procedural steps in temporary or provisional cementation

1. Free the abutment teeth of debris by cleaning them with fine wet pumice and peroxide applied with a rubber cup, which is followed by washing with chemically pure benzine or carbon tetrachloride.
2. The splint is being readied by the chair assistant. The acrylic resin sections are dried and lubricated with a light coating of R.M. silicone grease.* This lubricant prevents an adverse chemical reaction between the acrylic resin and the eugenol and also makes it easier to remove excess temporary cement from the acrylic veneers.
3. Mix the zinc oxide–eugenol cement to a rich creamy consistency. Paint the inner surfaces of the retainers with the mix, using a small sable brush. This will break up the air bubbles, thereby avoiding entrapment of air in the castings.
4. Retract the cheeks and lips, position the splint, and seat firmly to place.
5. Instruct the patient to bite on a cottonwood stick, moving from one abutment tooth to

*Rocky Mountain Dental Products Co., Denver, Colo.

the next with a rapid motion, after which check centric closure and then have him close against cotton rolls until the cement hardens.

6. When the cement has hardened, remove excess by means of an explorer point or small dull curettes, especially subgingivally, so that an inflammatory reaction is avoided. Zinc oxide–eugenol cement does not set to a brittle hardness; therefore it is much harder to remove subgingivally than a zinc phosphate cement.

7. Use Orange solvent* to remove all vestiges of cement remaining on the acrylic resin parts of the restoration.[15]

EBA (o-ethoxybenzoic acid) cement

Advantages of EBA

The need for a permanent cementing medium that would eliminate the associated protection of the abutment teeth from chemical irritation caused by the oxyphosphate of zinc cements, and its sequelae, has been uppermost in the minds of dentists for many years. A zinc oxide–eugenol cement whose strength could be increased without increasing its solubility in the oral fluids seemed to be the answer to this problem.

Various additives have been utilized in attempts to improve the strength properties of zinc oxide–eugenol cements. The most recent one to accomplish this is o-ethoxybenzoic acid, or EBA. Brauer and co-workers[16,17] have announced EBA formulations that exhibited reduced solubility as well as improved compressive strength.

Substitution of EBA (o-ethoxybenzoic acid) for a portion of the eugenol produces a material with better physical properties than zinc oxide–eugenol cements. It produces a material that shows compressive, tensile, and shear strengths approaching those of zinc phosphate cements. A definite improvement in the abrasion resistance properties of the material also is achieved by the addition of this chemical. The problem of solubility is debatable—some[2] say that the solubility becomes greater in these zinc oxide–eugenol mixtures containing EBA while others[18] contend that it is less soluble. Clinical research by observation and evaluation from its use on a large scale is needed now in this vital area.

*Ackerman Dental Mfg. Co., Santa Monica, Calif.

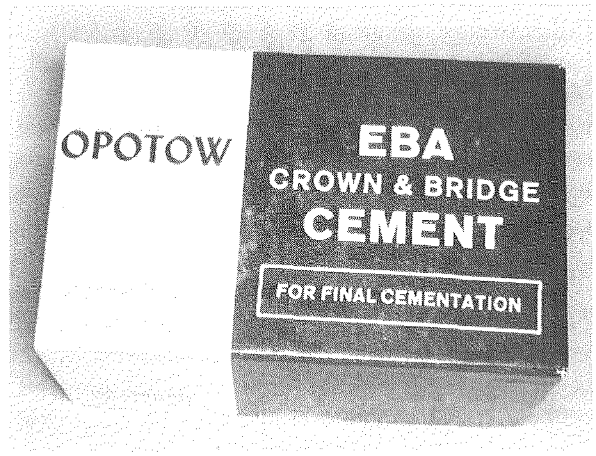


Fig. 10-20. EBA crown and bridge cement. A permanent cementing medium that does away with the associated protection of the abutment teeth from chemical irritation caused by oxyphosphate of zinc cements. It has better physical properties than regular zinc oxide–eugenol cements. More clinical research by use, observation, and evaluation of results is necessary with these materials.

Procedural steps in cementation with EBA crown and bridge cement*

1. Dry the crown, bridge, or splint.

2. Lubricate acrylic parts and interproximal spaces with a thin film of R.M. silicone grease.

3. Place the EBA cement powder and liquid on a cool glass slab (slightly more than one level scoop of powder and 3 drops of liquid). A glass mixing slab allows the application of greater pressure during spatulation. Pressure helps homogenize the mixture; after a few mixes the spatula and the glass surface become etched by the abrasive action of some of the components of the EBA powder. This improves the efficiency of subsequent mixtures. (See Fig. 10-20.)

4. Dry abutment teeth, control salvia, and, since this is an anodyne cement, do not apply chemical agents or Copalite varnish.

5. With a S. S. White No. 336 spatula incorporate the powder into the liquid and spatulate with pressure on the glass slab for thirty seconds to a minute or so. This manipulation is not critical and may be accomplished in any manner and at any speed. Spatulate well and thoroughly. The mix may seem rather thick at

*Opotow Dental Mfg. Corp., Brooklyn, N. Y.

first, but it will become more fluid as spatulation progresses.

6. After it remains on the slab approximately one minute, it begins to thin out so that you can pull a strand of 2 to 3 inches. There is plenty of working time—delayed set on the slab and quick set in the mouth.

7. Line the inside of the castings with this mix, using a small sable brush (do not fill the crowns), and seat the restoration with heavy pressure by means of an orangewood stick, using a vibratory motion to express excess cement, which is followed immediately with mallet pressure. Again, wipe away excess cement, and use a little more pressure with the orangewood stick and mallet, maintaining this pressure for two or three minutes.

8. While the cement is setting in the mouth, be sure that the spatula and glass slab are wiped with paper tissue before the set occurs, to avoid difficult scraping and washing.

9. Remove excess cement around and under restorations after set has occurred, which is usually five minutes. It sets very hard.

10. Caution the patient to avoid heavy pressure for three hours.

Cementation is the final step in fixed restorative dentistry. It can be a contributing factor either to the success or failure of the best fitting restoration. We always must consider the biophysical factors involved in this procedure, with progressive understanding of the manipulation required.[8]

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Chapter 11

Rehabilitation endodontics

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General considerations

A thorough knowledge of pulpal and periapical diseases, their clinical features, and pathological ramifications is essential for the dentist who wishes to practice rehabilitation dentistry. With this information the correct diagnosis can be made and the proper treatment given. Endodontic therapy often is indicated to retain these teeth in a state of health for the patient. These aspects will be considered in this chapter, with special emphasis on endodontics as it applies to rehabilitation dentistry.

Rehabilitation endodontics is basically the same as general endodontics, but a few phases deserve special consideration. The diagnosis of incipient pulp disease, including severe degenerative changes in the pulp, is of prime importance whenever extensive restorative procedures are to be carried out. If these conditions are detected or anticipated, endodontic treatment is indicated before reconstruction procedures are carried out. In contrast, if a minor restorative procedure involves a single tooth that has suspected but unconfirmed pulp disease, it may be done with delay of the endodontic treatment for later diagnostic confirmation. Diagnosis of early pulpitis is difficult whenever the involved tooth is part of a multiple restoration complex, and after diagnosis the endodontic treatment approach may lead to serious weakening of the restoration. If a single restoration is to be placed, a subsequent pulpitis may be detected more easily, and the endodontic treatment can be completed without jeopardizing the extensive restoration.

The technical phases of endodontics must be performed with the utmost care and skill. In rehabilitation endodontics this is of greater importance since in many cases an endodontic failure cannot be retreated after it has become part of a multiple restoration in which dowel retention has been used. It is possible to correct some such failures with the reverse obturation technique; however, most mandibular teeth and the palatal roots of maxillary teeth ordinarily are excluded from this technique.

Elective endodontics often is necessary in rehabilitation. There should be no hesitation to remove a healthy pulp and carry out endodontic therapy if intraradicular retention is necessary or if it is necessary for esthetics (Fig. 11-1). In elective endodontics strict adherence to the sterile procedure and all other basic techniques is just as important as if the procedure was not elective. A bacteriologic culture should be taken, and the root canal is filled only after a negative culture has been obtained. Some asymptomatic teeth with extensive carious lesions are infected, and this can be determined best by the use of cultures.

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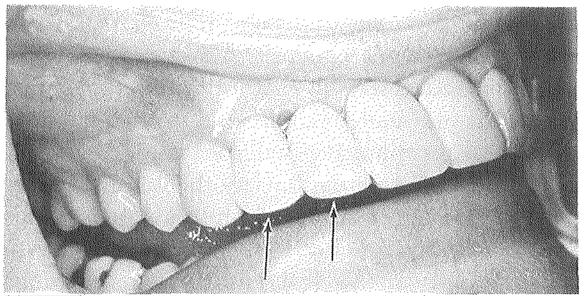

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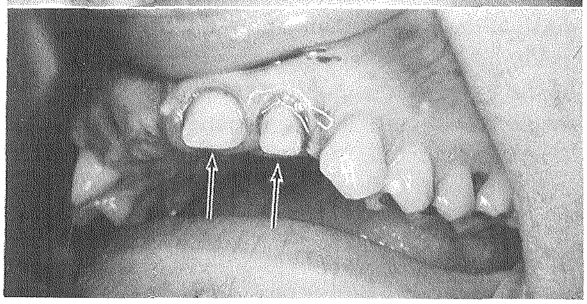

Fig. 11-1. Labial version of maxillary central and lateral incisors was such that the bridge that was constructed was esthetically unsatisfactory. **A,** Note the two lateral incisor pontics. **B,** To reconstruct bridge the pulps of these two teeth were electively removed so that labial surface could be sufficiently reduced.

Pulp disease

DEGENERATIVE PULP DISEASE

Pulp disease may be classified as degenerative or inflammatory. Degenerative pulp disease may take several forms, and it can be expected to occur in persons of advanced age or in much younger individuals if the involved tooth has had large or deep restorations of long standing. The following degenerative changes have been described[1,2] as occurring within the pulp.

1. Calcific degeneration
   a. Nodular
   b. Dystrophic
2. Fatty degeneration
3. Atrophy
4. Fibrosis

These conditions come about with aging and may be speeded up by chronic irritations such as deep carious lesions or large restorations. They are recognized histologically, but clinically they do not present definite diagnostic signs. The exception is calcific degeneration, in which changes may be detected roentgenographically in some teeth.

Malignant tumors rarely occur in the dental pulp.

INFLAMMATORY PULP DISEASE

Classification

Inflammatory pulp disease is caused by bacteria and physical or chemical injuries. Bacteria is most often the primary offender since it enters the pulp from a carious lesion or from an extensive periodontal lesion. Microorganisms may enter the pulp via a hematogenous route after a primary physical or chemical injury to the pulp. This is sometimes referred to as anachoretic pulpitis.[3,4] The following conditions of the pulp have been described[1,2,5]:

1. Pulp hyperemia
2. Acute pulpitis
   a. Serious
   b. Suppurative
3. Chronic pulpitis
   a. Ulcerative
   b. Hyperplastic
4. Pulp necrosis
   a. Caseation
   b. Liquefaction
5. Gangrene

This classification is based primarily on the histologic picture of the pulp at different stages of degradation. The clinical features are not always clear-cut and, clinically, the classification cannot be made accurately. It is not necessary then for the dentist to classify the pulpitis but only to determine which tooth has a pulp involvement of such a severe nature that it will not recover. This can be achieved most accurately if the dentist has a thorough understanding of the pathologic process involved.

A tooth in which a chronic pulpitis exists will sometimes give a normal response to all vitalometric tests while it remains asymptomatic for an indefinite period of time. Other teeth may be normal histologically throughout 90% of the pulp, but the 10% pulp involvement can result in definite pain symptoms. The pain symptoms result from an exacerbation of the chronic pulpitis in the tooth that had been asymptomatic. Some asymptomatic multirooted teeth give radiographic evidence of a periapical lesion at the apex of one root, while the remaining pulp tissue can be intact to a degree that the tooth will respond as vital to some vitalometric tests. Teeth with gangrenous pulps sometimes give a positive response to electric vitalometric tests. Liquid, which is present in certain such conditions, acts as a conductor.

To the clinician acute pulpitis is painful and requires immediate treatment. Microscopically the acute pulpitis will be recognized by dilated blood vessels, polymorphonuclear leukocytes, thrombosis, and serous or purulent exudate. All these features are not necessarily present at the same time. Clinically, the tooth will be hypersensitive to cold and later to heat. It may respond early to the electric vitalometer, or in later stages it may respond late or not at all. As the process advances and more of the pulp becomes necrotic, the pain can be elicited by heat and relieved temporarily by cold. The differential diagnosis often can be made by applying ice to the buccal surface of a tooth in which pain exists, to relieve the suffering temporarily. Pain from a pulpitis is often referred to other regions of trigeminal nerve distribution on the side of the face that the offending tooth is located. The use of a local anesthetic will exclude certain teeth or regions if the pain persists after the anesthetic or will confirm involvement of the same teeth or regions if the pain is eliminated following anesthesia. Some teeth will become hypersensitive to percussion in the late stages of acute pulpitis. Pain is the common characteristic that determines a clinical diagnosis of acute pulpitis, and the prefix of serous or suppurative will not alter the treatment once the offending tooth has been confirmed. In the early stages the patient is aware of pain that is elicited when cold contacts the tooth; however, the first pain may be spontaneous and often occurs upon reclining.

The first pain may be experienced with heat in the case of an exacerbation of a chronic pulpitis in which necrosis is extensive. The patient may indicate that a specific tooth is involved, but more often they can indicate only a region in the early stages. The initial pain may be referred to the ear, neck, temporal region, or teeth in the opposing arch.

Differential diagnosis

Acute pulpitis must be differentiated from pulp hyperemia and pulp hyperemia must be differentiated as to etiology. Pulp hyperemia may result from deep carious lesions or from physical and chemical injuries such as may occur during cavity preparation, the use of chemicals for sterilizing deep cavities, traumatic occlusion, or thermal conductivity from large metal restorations. Hyperemia may develop more readily in the teeth that have undergone

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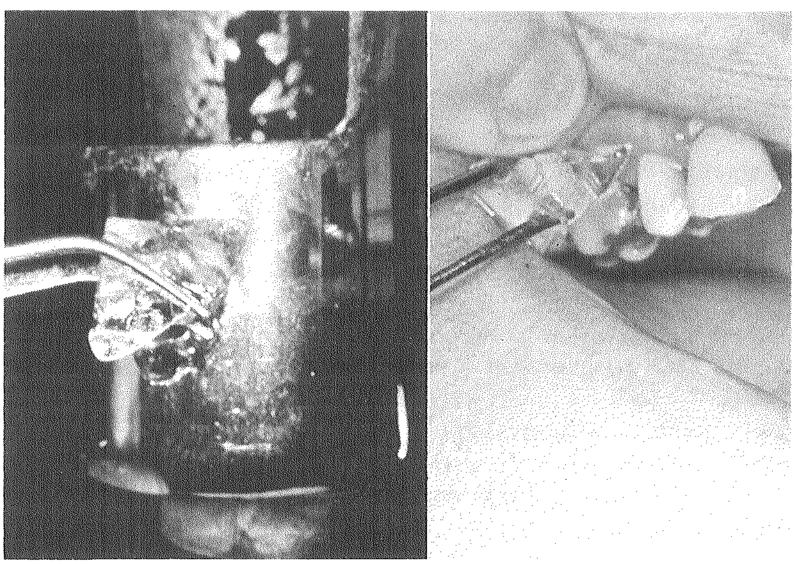

B

Fig. 11-2. A, Ice is held with forceps and tapered to a point by rotating it against the shield of a lighted bunsen burner. **B,** In testing vitality of teeth with this pointed ice it is most effective to apply it to buccal or labial surfaces of teeth near cervical line.

some degenerative changes and will be less likely to return to normal than will healthy pulps. Hyperemias that develop in teeth under deep carious lesions often are infected already and will not be reversible. Ice is the most useful single aid that is available to locate the offending tooth in early acute pulpitis. A small piece of ice is held with a cotton pliers and tapered to a point against the hot shield of a bunsen burner (Fig. 11-2, *A*). The teeth are tested by placing the point of the ice against the buccal or labial surfaces of the teeth near the cervical region (Fig. 11-2, *B*). The patient is asked to signal as soon as he feels a definite sensation in the tooth, and the ice is removed immediately. The recovery period is the time that is required for the tooth to be relieved of all abnormal sensation after the ice has been removed from the tooth. This must be established for each individual by testing several teeth before the suspected tooth is tested. A normal recovery period will range from one to ten seconds. In early pulp hyperemia the recovery period will be from ten to twenty-five seconds, while in acute pulpitis the recovery period may vary from twenty-five seconds to several minutes. Those teeth that fall within the range of hyperemia must be classified and treated as irreversible pulpitis if there is a history of spontaneous pain or carious exposure. Others may be tested forty-eight to seventy-two hours later and the response compared.

Before testing for a pulpitis a careful and complete history should be taken from the patient. Some important points to elicit from him are duration of pain, what elicits pain, when is it more pronounced, and does he have knowledge of a tooth that has had a pulp exposure. The soft tissue of the area is examined carefully and the roentgenogram evaluated as to caries, deep restorations, evidence of pulps that have been capped, or changes in the periapical regions. All teeth in the suspected region are tested initially by percussion, and then vitality tests are run with an electric vitalometer, ice, and heat. The electric vitalometer is of little value in determining the tooth with an early or serous acute pulpitis, but a slow or negative response often will help to isolate the tooth in later stages where considerable pulp tissue is necrotic. Ice is necessary to determine the involved tooth in early acute pulpitis since the tooth will respond quickly and the elicited pain will last much longer than it does in the adjacent normal teeth. Heat will elicit pain in later stages of acute pulpitis and in many instances confirm the diagnosis that was suspected from the poor or negative response that was elicited from the electric vitalometer. When the pulpitis reaches this stage, suppuration is present, and the pain often is spontaneous, penetrating, and severe. Although the pain often is relieved temporarily by applying ice to the tooth, in some cases ice will intensify the pain. Since we depend entirely on the patient's responses to these tests in arriving at the correct diagnosis, it is important that the patient understand the difference in a normal and abnormal response to the various tests. Thus it is wise to spend a little time explaining these tests to the patient. It is necessary to test two or three teeth in an uninvolved quadrant before going to the region in doubt, to help the patient give an accurate response. If the responses to the tests are not clear, often it will help to isolate one tooth at a time with a rubber dam for the series of tests. Whenever a positive diagnosis cannot be made, the tests should be repeated within forty-eight to seventy-two hours.

As previously mentioned, a tooth occasionally becomes percussion sensitive while still responding to temperature changes. Such a case is illustrated in Fig. 11-3. This tooth was hypersensitive to ice, recovering within twenty-five seconds; there was a history of moderate intermittent pain, and the tooth was percussion sensitive. The pulp was hyperemic when entered. At this point an incipient periapical lesion exists along with acute pulpitis. The temperature response is transient in such cases since the inflammatory process is of such magnitude that the pulp will undergo necrosis rapidly. The tooth illustrated was from a 57-year-old male, and it had a deep restoration of many years' duration. It is reasonable to assume that this tooth had undergone degenerative changes that allowed the inflammatory process to proceed rapidly once it had become infected.

Chronic pulpitis

If the tooth in the previously described case had been opened but proper endodontic treat-

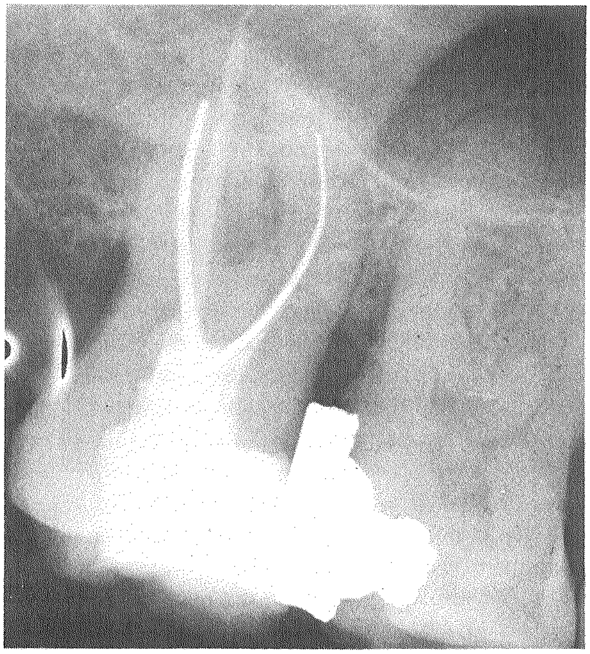

Fig. 11-3. This maxillary second molar was percussion sensitive and hypersensitive to ice. Pulp was extremely hyperemic. Buccal root canals were obturated with silver points and palatal root canal with gutta-percha.

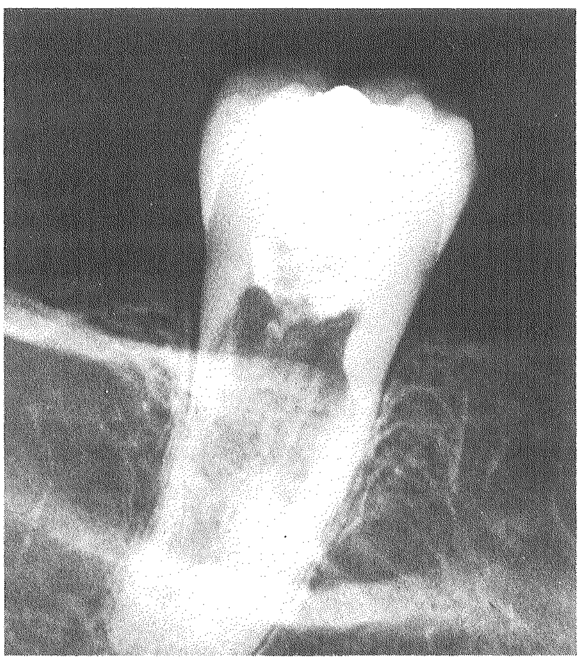

Fig. 11-4. Internal resorption has resulted following a pulpotomy that was performed in this molar tooth five years earlier.

ment not performed, the pulp would have existed as a chronic pulpitis for a while and would have become necrotic ultimately. A chronic periapical lesion could be expected to develop. Likewise, chronic inflammation may develop in a closed pulp. If a small area of the pulp is involved, the tooth often responds within normal limits to all tests. If a much greater area of the pulp is inflamed chronically, the response to clinical tests most likely will be below normal limits. This diagnosis is difficult to make on a clinical level since the roentgenogram is negative and the tooth totally asymptomatic. To invalidate the subnormal vitalometric response it is recognized that teeth with considerable irregular dentin and those that have undergone degenerative changes respond in an erratic manner to vitalometric tests. Chronic inflammation of the pulp sometimes will result in internal root resorption (Fig. 11-4).

Chronic hyperplastic pulpitis sometimes is seen in young individuals after pulp exposure. Clinically, it appears as an exophytic mass of tissue growing out of the pulp chamber. Essentially it is granulation tissue that is inflamed chronically and in some cases may become covered by epithelium, which grows over it, being implanted from the gingiva. In some such instances it is possible to obtain apical closure by performing a pulpotomy. If the apices are closed, the treatment of choice is total pulpectomy.

Subacute pulpitis is a chronic condition that is undergoing a mild exacerbation. The patient describes intermittent pain, which is of moderate intensity. He is not sure which tooth is involved but describes the pain as originating within an area. In such cases all tests often are inconclusive initially, and it is necessary to repeat them within a few days. Repeated percussion sometimes will help in locating the offending tooth. After a few day's delay the application of heat to the tooth may elicit a positive response that will confirm the diagnosis.

Periapical disease

ACUTE PERIAPICAL LESIONS

Acute apical periodontitis

Acute apical periodontitis develops in the periapical tissues from an acute pulpitis, periodontal lesion, or trauma. Roentgenographically,

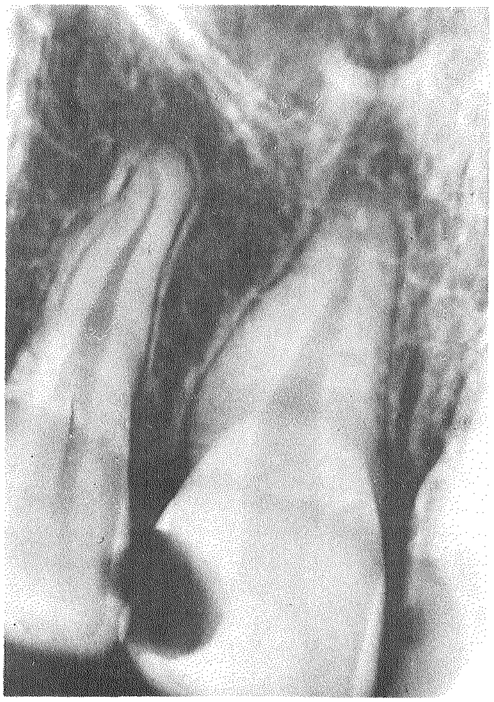

Fig. 11-5. Roentgenogram reveals changes in periapical region of central incisor which are compatable with acute apical periodontitis.

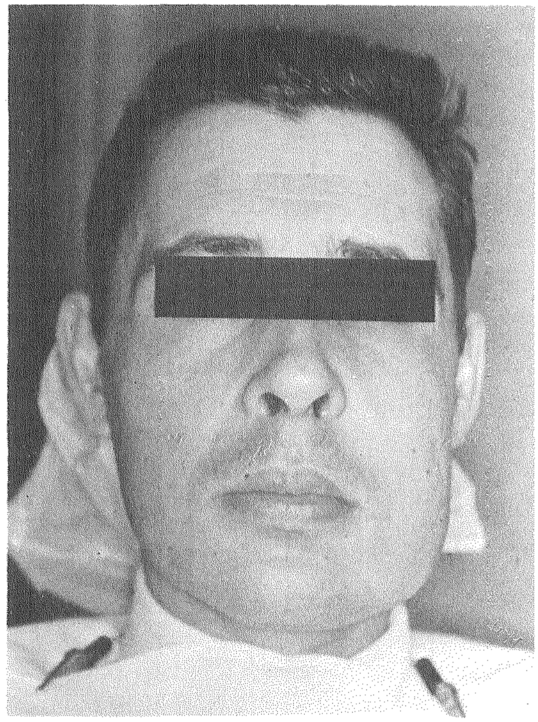

Fig. 11-6. Inflammatory process has extended into space of body of mandible and submaxillary space from acute periapical abscess of mandibular first molar. Tooth was percussion sensitive, and roentgenogram revealed only thickening of periodontal ligament.

the region is normal except for occasional thickening of the periodontal ligament (Fig. 11-5). The tooth is percussion sensitive and ordinarily gives a negative response to vitalometric tests. The rapidly spreading acute pulpitis, as described in Fig. 11-3, is an exception since it will respond to vitality tests. Acute apical periodontitis is characterized histologically by dilation of blood vessels and migration of polymorphonuclear leukocytes. This process may involve the overlying periosteum and soft tissue as well as the periodontal ligament and bone. In the cases of pulpal etiology, if the pulp of the tooth is removed and the root canal sterilized and filled, the periapical tissues will repair quickly, since the damage has been minimal up to this point. On the other hand, if the treatment consists of antibiotics and drainage without properly sterilizing and filling the root canal, the lesion will become chronic and expand. A dental granuloma will develop, since bone is resorbed gradually and replaced by chronically inflamed and infected granulation tissues.

Acute periapical abscess

Acute periapical abscess most often is the result of an exacerbation of one of the chronic periapical lesions. It is essentially a radiolucent lesion with a central lumen that contains purulent exudate. Acute inflammatory changes are seen within the surrounding tissue. (See Fig. 11-6.) In some cases very little or no periapical radiolucency will be present, while acute inflammation is evidenced by percussion sensitivity, swelling, and pain. This lesion will heal by conservative endodontic treatment if it can be drained properly.

CHRONIC PERIAPICAL LESIONS

Dental granuloma

The dental granuloma characteristically develops under conditions equivalent to a low-grade infection balanced against good patient resistance. At periods of increased activity of

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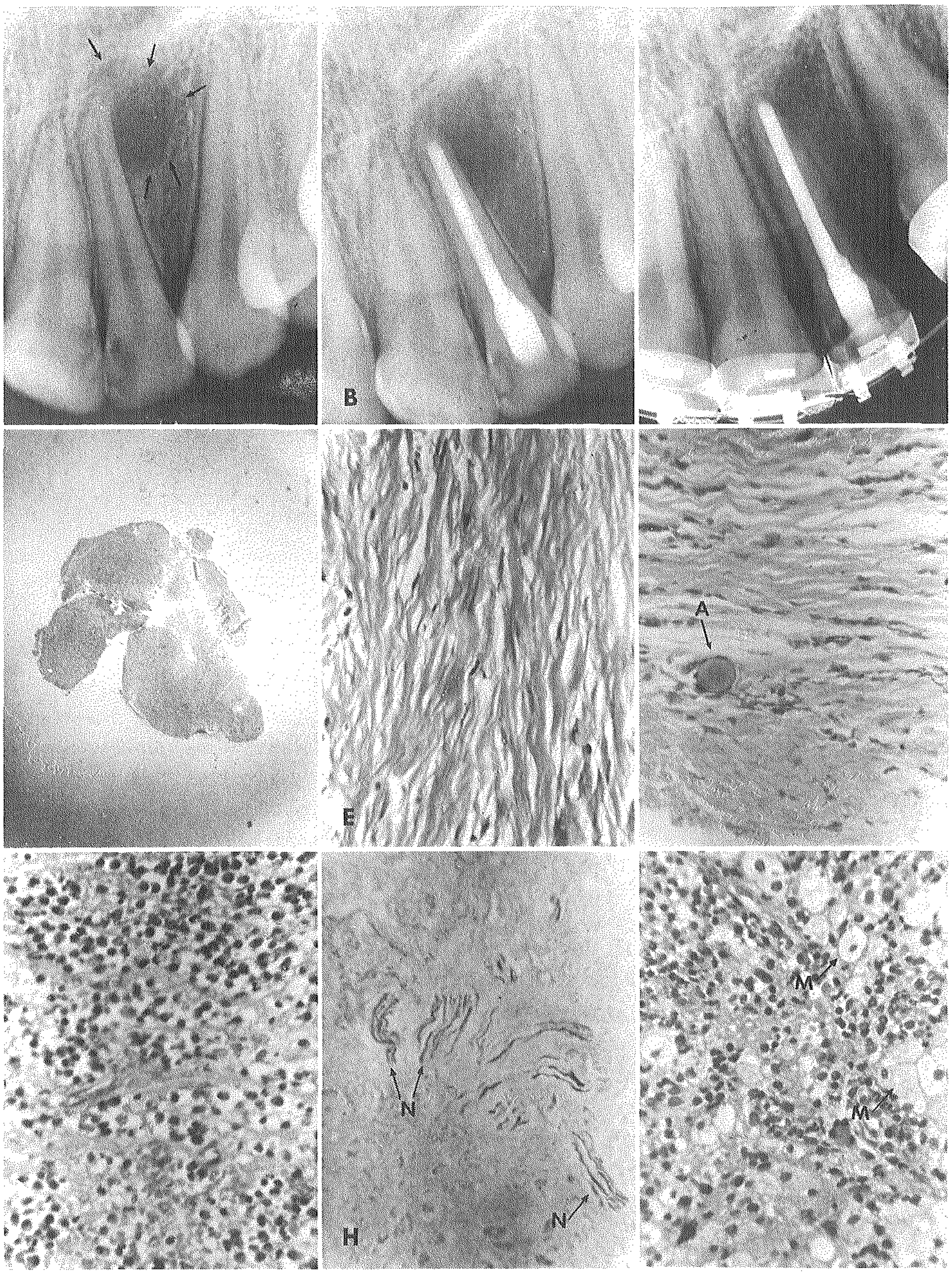

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Fig. 11-7. A, Roentgenogram of a tooth with a periapical granuloma. **B,** Roentgenogram of same tooth as **A** after root canal preparation, obturation, root resection, and curettement of granuloma. **C,** Roentgenogram of same tooth one year after treatment. **D,** Microscopic view of periapical lesion removed from **A. E,** Photomicrograph revealing type of connective tissue that is often found within wall of granulomas, abscesses, or cysts. This is usually found in region near bone and has very few chronic inflammatory cells within it. **F,** Photomicrograph taken from an area of lesion near center. More chronic inflammatory cells are seen than were present in **E.** Large round structure *(A)* is a Russell's fuschin body. **G,** Photomicrograph taken from near center of granuloma, demonstrating presence of numerous plasma cells, lymphocytes, and edematous spaces. **H,** Photomicrograph of a granuloma demonstrating presence of nerve tissue *(N).* Nerve tissue is also found in cysts and chronic abscesses. **I,** High-power photomicrograph from a dental granuloma revealing many lymphocytes and plasma cells. An occasional polymorphonuclear leukocyte is seen, and numerous large clear fat-laden macrophages *(M)* are evident.

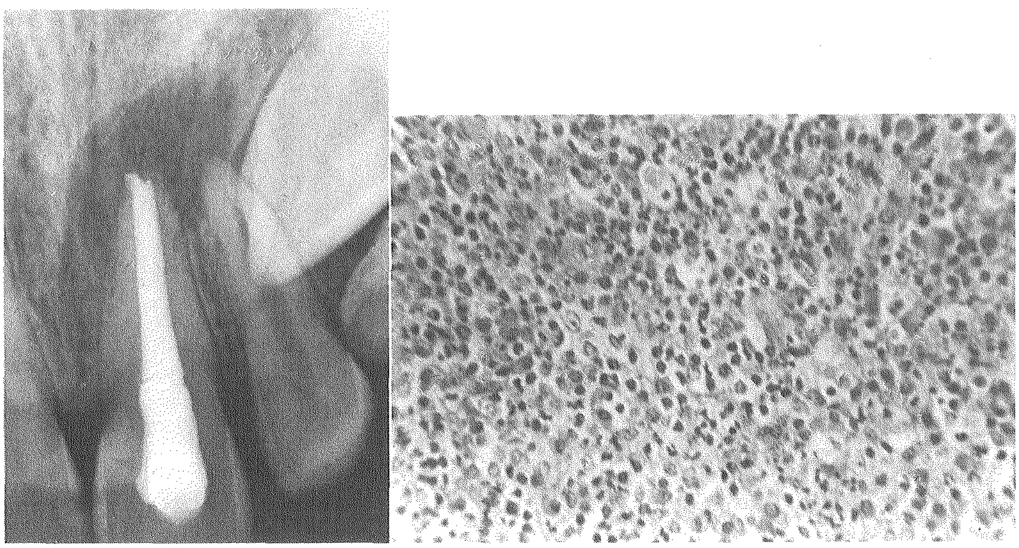
the microorganisms, or decreased resistance of the patient, bone resorption will take place. The resorbed area is filled in by granulation tissue that shows an abundance of new capillaries with many small dilated blood vessels and a variety of chronic inflammatory cells. Included among the inflammatory cells are lymphocytes, plasma cells, histiocytes, giant cells, and a few polymorphonuclear leukocytes. The lesion is essentially solid, but small areas of necrotic tissue may be present near the root apex. As the irritant from the infected root canal increases, the adjacent area becomes more involved and this will have an effect peripherally to produce more bone resorption. Polymorphonuclear leukocytes will be seen in these areas of activity. The process usually balances in a short time, and more granulation tissue forms around the root canal orifice, the total result being that the granuloma has increased in size. With proper conservative endodontic treatment the lesion will heal. (See Fig. 11-7.)

Chronic periapical abscess

Chronic periapical abscess results when the irritant from the root canal is too virulent, or severe, to be halted by the resistance of the patient; thus the area of granuloma adjacent to the root apex becomes necrotic. The resultant central lumen becomes filled with purulent exudate. This is essentially a chronic process, and little, if any, pain is experienced; however, the inflammatory infiltrate will be more likely to have polymorphonuclear leukocytes in it than will that of the granuloma. The chronic inflammatory cells that are seen in the granuloma still predominate.

If the inflammatory exudate is drained and the root canal prepared, sterilized, and filled properly, the lesion has an excellent chance of resolving with complete repair exactly as in the case with the granuloma. The only lesions that will require surgery are cases that are inaccessible for proper drainage through the root canal or lesions that contain excessive quantities of necrotic material (Figs. 11-8 and 11-9). If the root canal cannot be prepared and filled properly within the apical region, this segment of the root must be removed surgically. Necrotic tissue will be liquefied enzymatically and drained by lymphatics, but, when the quantity is excessive, the process may require so long that a cyst can be formed rather than healing completed.

A



B

Fig. 11-8. A, Roentgenogram of a chronic periapical abscess after root canal treatment and obturation of canal. Labial cortical plate of bone has not been perforated; therefore mucosa overlying root apex had a normal appearance. **B,** Photomicrograph is from tissue removed in **A.** Small multinucleated dark cells are polymorphonuclear leukocytes. It is expected that they would be present in such a case where mild exacerbations and remissions are common.

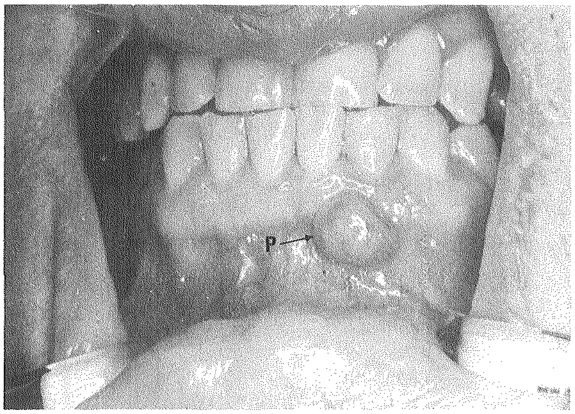


Fig. 11-9. In this case periapical abscess was subacute and labial cortical plate had been perforated by inflammatory process. Purulent exudate that lies in central lumen of abscess will break through labial parulis (*P*) and drain intraorally if there is a moderate exacerbation of inflammatory process.

Radicular cyst

The radicular cyst usually takes longer to develop than does a granuloma or abscess. Histologically, the three lesions are similar, and most, if not all, of these lesions were at one time a granuloma or abscess. The border of the cyst that lies adjacent to the bone is made up of fibrous connective tissue. Toward the cyst lumen the tissue becomes less mature and infiltrated with chronic inflammatory cells to a greater degree. The central lumen, which surrounds the root apex, contains a fluid that varies from a viscid to purulent material to a thin and serous type fluid.

The cystic fluid is separated from the adjacent inflamed connective tissue by a complete lining of epithelial cells that may be from one or two cells thick up to ten or fifteen cells in thickness. The fluid in the lumen is derived partially from necrotic tissue that originally was in the lumen of the abscess. It subsequently underwent autolysis. Intermittent acute inflammatory bouts also add to the lumen material after the cyst has formed. Part of the cyst wall may slough into the lumen and undergo autolysis. (See Figs. 11-10 to 11-12.)

The epithelium that lines the lumen of the cyst is derived from epithelial rests of Malassez, which are normally present in the periodontal ligament. With proper stimulation and possibly by specific balance that is reached between irritant and tissue resistance, the epithelium proliferates between the exudate and the granulation tissue as if attempting to protect[6,7] the vital tissue from the irritants within the root canal and the necrotic material in the lumen that are upon it. The lesion becomes a cyst at the moment that the epithelial lining is complete. It may expand by increased activity of the inflammatory process or by increased osmotic pressure within the cyst. Another mechanism of cyst formation is the continued growth of epithelium in a ball formation until the central cells become necrotic by reason of inadequate nutrition. (See Fig. 11-13.)

There is no doubt that the untreated infected root canal can be a source of increased bacterial invasion periodically, which may cause a mild or severe exacerbation. If the reaction is mild, part of the cyst wall, including the epithelium of that area, may slough into the lumen with concomitant vascular dilation and bone resorption. Little or no symptoms will be present if the body defense controls the acute infection. The epithelium will span the sloughed gap again to reestablish the cyst. If the exacerbation is severe, as will be evidenced by pain and swelling, virtually the entire epithelial lining and some of the connective tissue become necrotic and slough into the lumen. At this point the lesion again has become an abscess. If the purulent exudate is drained, either through the root canal or through the apical tissue, and the proper conservative endodontic therapy performed, the lesion will have an excellent chance of healing without surgical removal of the periapical tissue. (See Fig. 11-14.)

There is not a definite clinical method by which a cyst can be diagnosed. Roentgenographically, the radiopaque line, which has been described as encircling a cyst, simply indicates that the lesion has been present for some time and is expanding very slowly if at all. If it is expanding rapidly, there is no time for formation of a hypercalcified border that produces the radiopacity. Sometimes radiopaque borders are present around granulomas or abscesses.

Another clinical criterium that has been used for diagnosis of cysts is the presence of straw-colored fluid, but this type of fluid sometimes is found in lesions classified as abscesses. There-

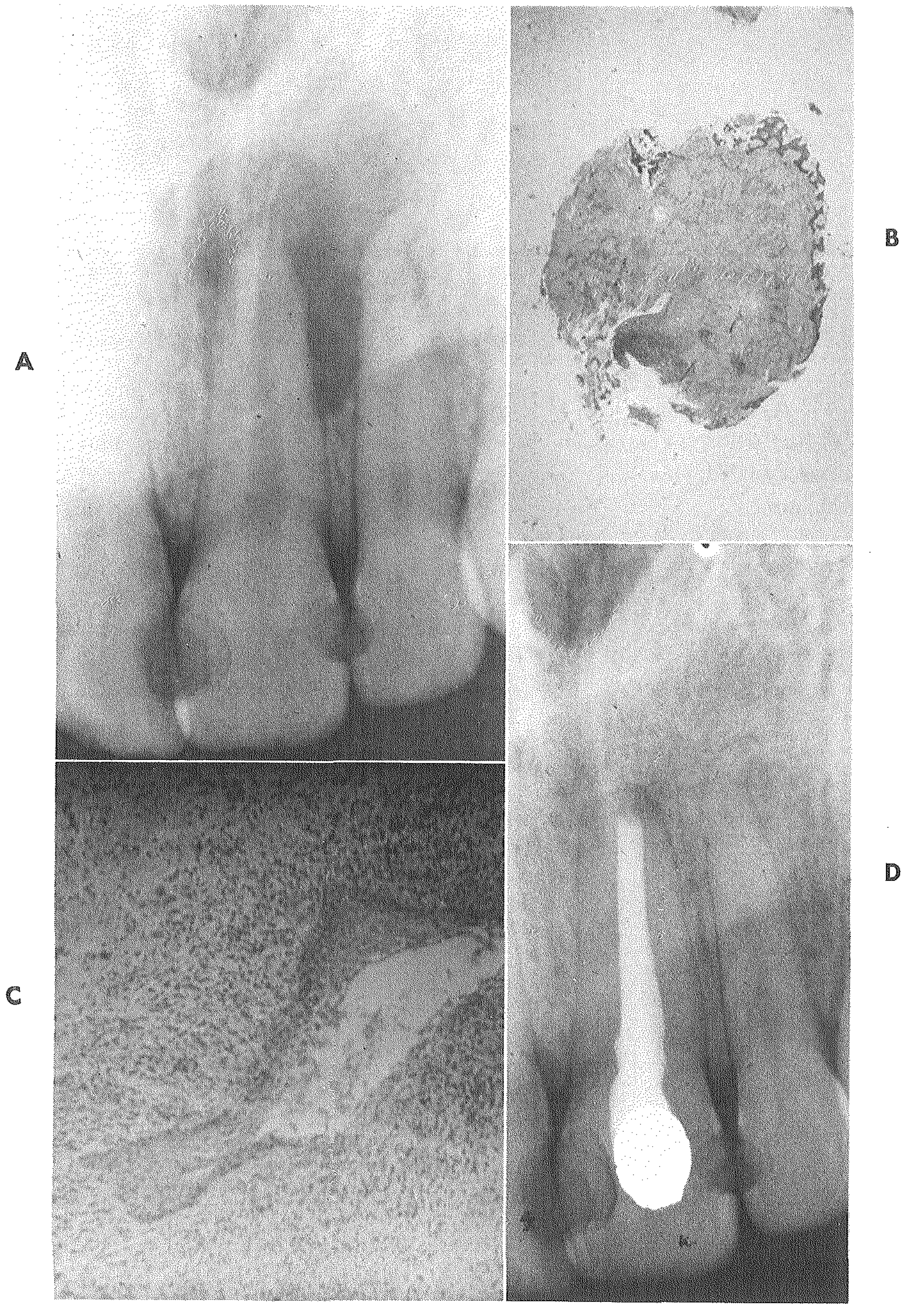
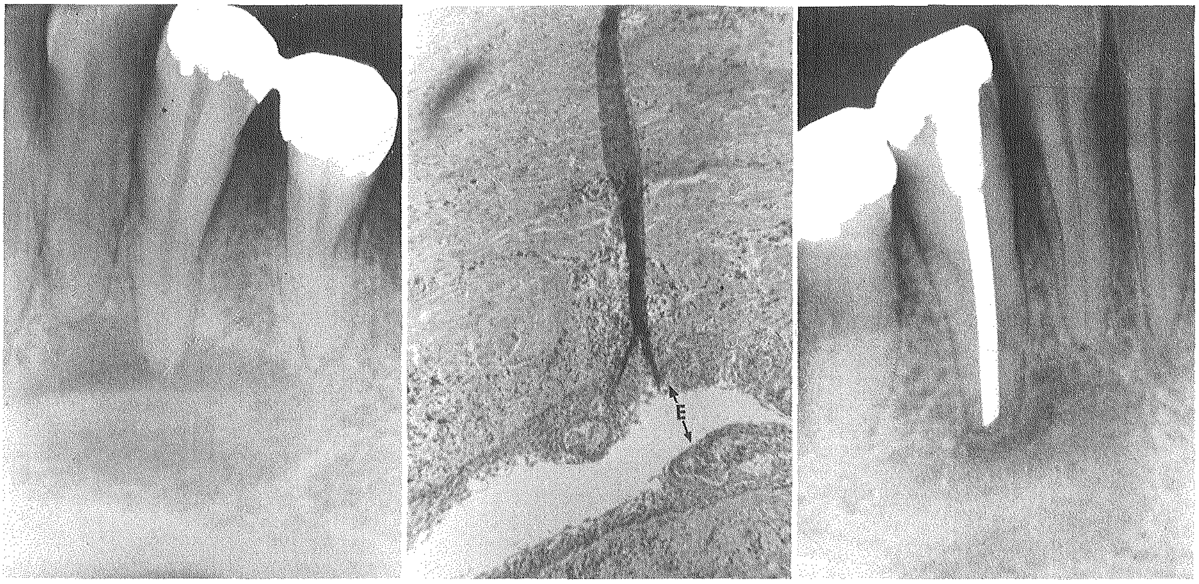


Fig. 11-10. **A,** Roentgenogram reveals a periapical radiolucency. **B,** Photomicrograph is of total lesion seen in **A.** Bone is seen on outer border; then a thick wall of chronically inflamed granulation tissue separates it from small central lumen, which is lined by stratified squamous epithelium. **C,** High-power photomicrograph of epithelium lining lumen of cyst in **A.** **D,** Roentgenogram of same case indicates that periapical healing has taken place nine months after treatment.



A B C

Fig. 11-11. **A,** Large periapical lesions noted at apex of mandibular cuspid. **B,** Lesion seen in **A** had a large central lumen, which was lined by epithelium *(E);* thus diagnosis of radicular cyst was made. **C,** Same case. Good bone regeneration is seen one year after treatment.

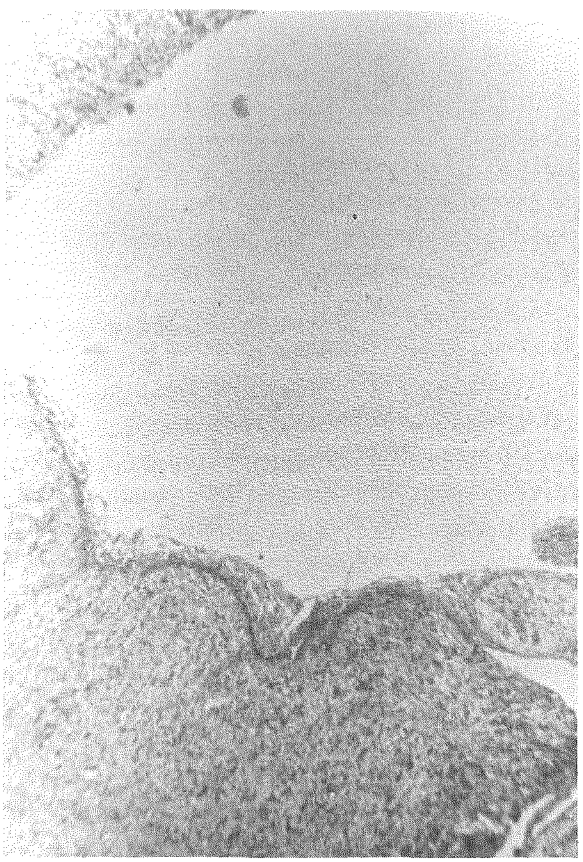


Fig. 11-12. In this case part of epithelium has sloughed into central lumen as a result of an inflammatory exacerbation.

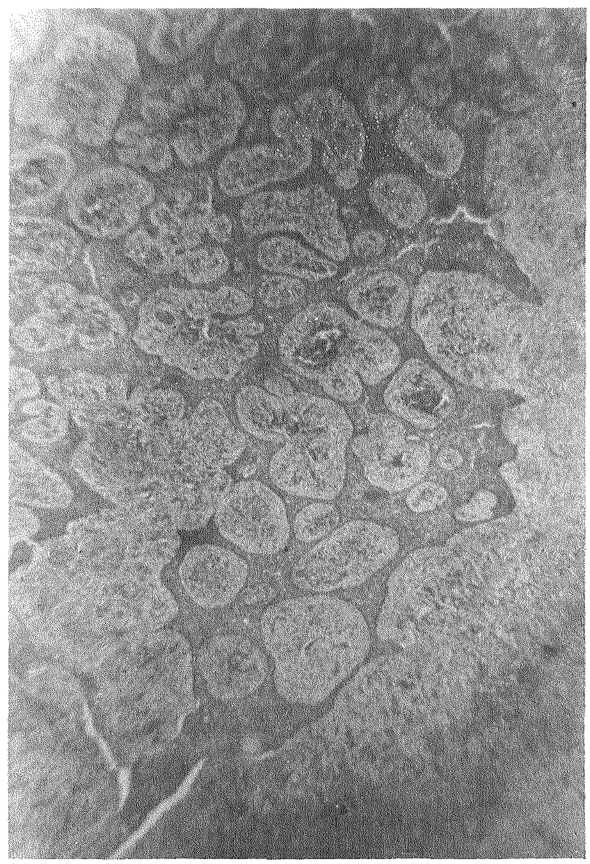


Fig. 11-13. Photomicrograph illustrates excessive proliferation of epithelium that is occasionally seen in periapical lesions.

A

B

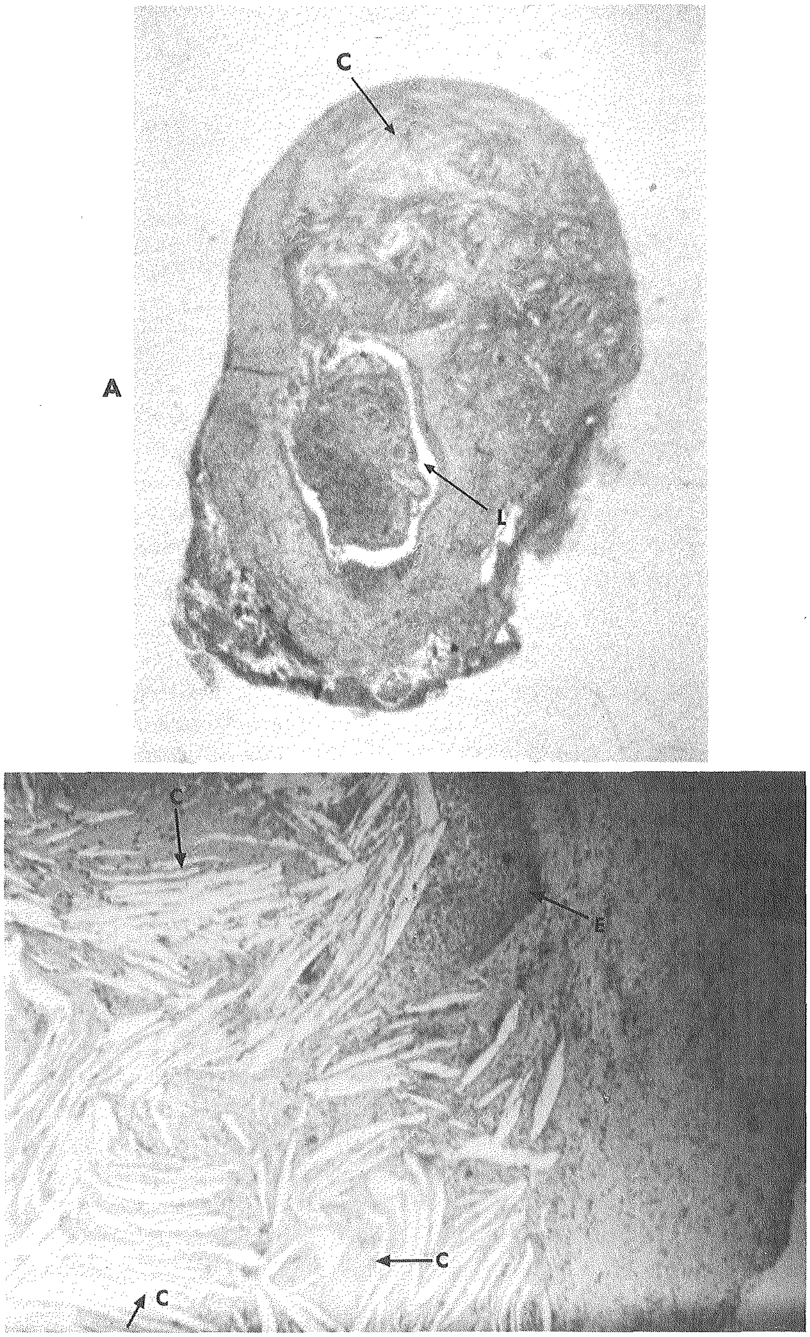


Fig. 11-14. A, Photomicrograph from a cyst demonstrates that lumen *(L)* is lined by epithelium of varying thickness. Slits seen to right of lumen represent cholesterol *(C)* crystals, which were dissolved in tissue processing. **B,** High-power view of cholesterol *(C)* slits and epithelium *(E)* that are seen in **A.**

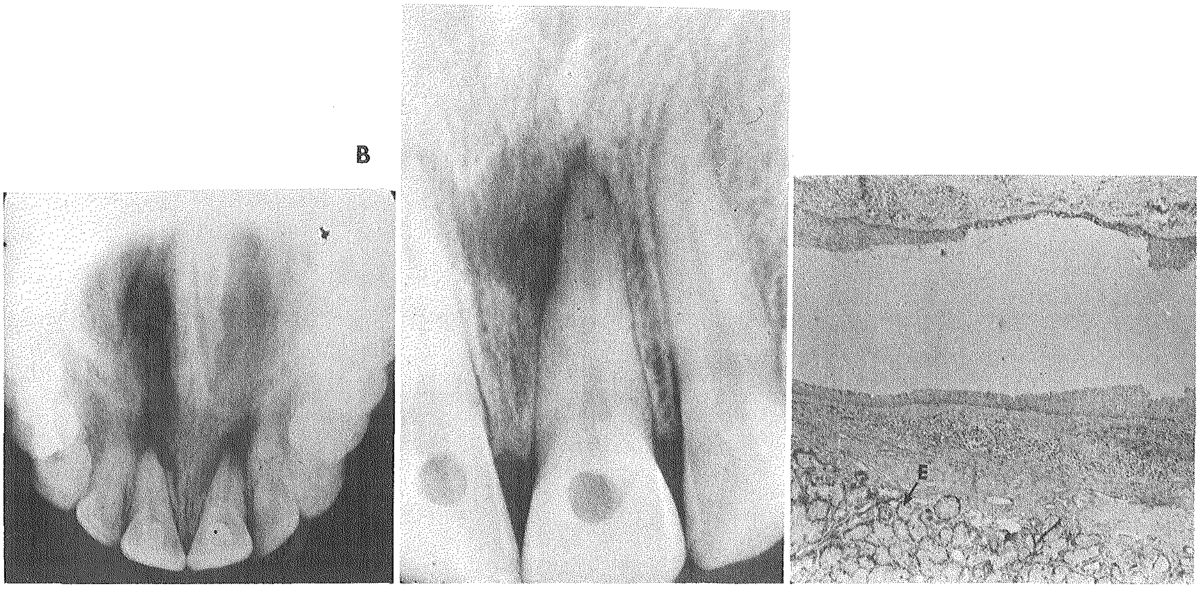


Fig. 11-15. A and B, Median anterior maxillary cyst was mistaken for periapical lesions by patient's dentist, and normal pulps were removed from the two central incisors. Lesion was removed from palatal approach, and it was found to extend around apices of both teeth, leaving only a thin labial cortical plate of bone. **C,** Photomicrograph illustrates characteristic histologic features of median anterior maxillary cyst. Lumen is lined by stratified squamous epithelium, and mucous glands *(E)* are present within wall.

fore the management of periapical lesions must be based on clinical judgment. If the lesion is large, yet a negative culture can be obtained and the exudate drained through the root canal, there is an excellent chance of success by conservative endodontic treatment. All such cases must be rechecked within one year. If there is no roentgenographic evidence of proper healing, periapical surgery can be performed. Periapical surgery is advisable when large lesions continue to produce considerable exudate after several treatments or if the lesion is extensive away from the root apex so that proper drainage of the exudate through the root canal is prevented. (See Fig. 11-15.)

The percentage of periapical lesions that are cysts have been reported by numerous investigators,[8-13] ranging from 3 to 65%. My clinical and histopathologic evaluation of one hundred periapical lesions revealed that 16% were cysts, 16% were classified as abscesses, and the remainder were granulomas.[14] In the same study patient age and lesion size were evaluated. A decrease in the mean age of the patients was noted as the size of the lesions increased. This would indicate that the higher percentage of the larger lesions are to be found in the younger individuals. In the large lesion group the youngest individual was 12 years, with 41% being under the age of 20; whereas the youngest individual in the group of small lesions was 25 years of age.

The study also revealed that there is a significant increase in the percentage of blood vessels as compared to other tissue components in the group of large lesions over that found in the group of small lesions. A proposed explanation for the significant increases in the number of blood vessels in the larger lesions is that, in general, these lesions require a greater blood supply because of their size and they are often more actively proliferating than are the smaller lesions. The proliferating feature is borne out by the fact that the collagen content is 25% lower in the larger lesions than in the smaller lesions. The fact that the larger lesions are in the younger age group is suggestive of rapid proliferation and a more active inflammatory process. The expansion of the lesion may be more rapid in the young age group, in part, because they

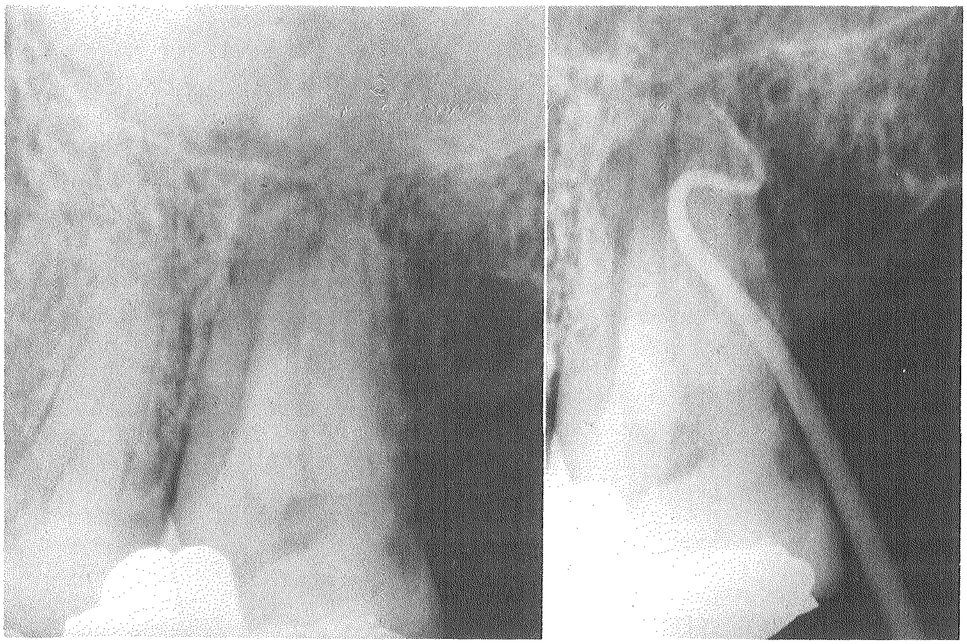


Fig. 11-16. This periapical lesion was around apex of a vital tooth. It was determined to be of periodontal origin since careful probing of gingival crevice allowed a probe to pass to apex without resistance.

have had less opportunity to develop immunity to the etiologic agent than have the older patients. The density and degree of calcification of the bone also may influence the rapidity and size of lesion development.

We have demonstrated the presence of nerve tissue in chronic inflammatory periapical lesions.[15]

It generally is accepted by endodontists that 90% or more of periapical lesions will heal by proper conservative endodontic treatment, eliminating the need for surgical removal of the lesion. This suggests that some radicular cysts will heal without surgical intervention or that the criteria for cyst diagnosis is inaccurate and not standardized. Some reports indicate that the lesion is designated as a cyst if epithelium is present in the specimen, while the more strict criterium is to determine that the entire lumen is lined by epithelium.

Lehmark[16] has concluded that, following endodontic treatment, mesenchymal tissue of the cyst proliferates and the epithelial lining undergoes regressive changes. In his experimental group of cysts the diagnosis was made by biopsy, endodontic treatment was completed, roentgenographic follow-up examinations were made at intervals, and roentgenographic evidence of complete healing was confirmed by biopsy. In the control group the diagnosis was made by biopsy, but the root canal was not

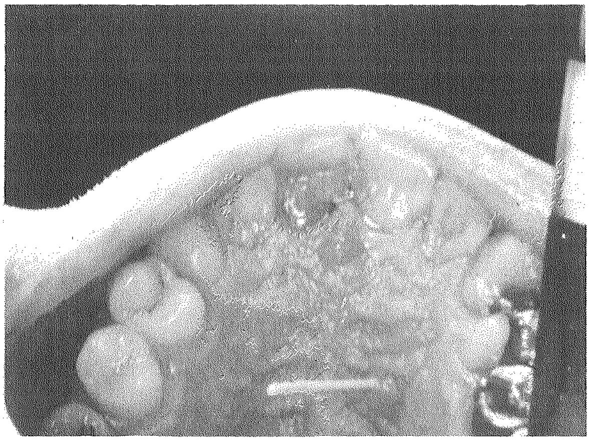


Fig. 11-17. Maxillary lateral incisors, maxillary first bicuspids, and first molars occasionally fistulate on palate, as is seen in this case.

treated and filled. When sufficient time had elapsed, another biopsy was taken and all control lesions were found to remain cysts.

In a histopathologic study of healing in chronic apical periodontitis Narita[17] concluded that the cavity of a radicular cyst sometimes disappears as a result of active proliferation of the surrounding granulation tissue and changes into a dental granuloma (Figs. 11-16 and 11-17).

Technical phases of endodontics

The pulps of teeth are involved by caries, fractures, trauma, degenerative changes, hematogenous infections, periodontal lesions, and cavity preparation. If the dentist does not have at his disposal a dependable endodontic method of treatment, his decision often will be to remove the tooth. A dependable endodontic method may be defined as one that will give the patient from 90 to 95% chance of retaining the tooth for as long as it could have been kept had the pulp not become involved. The procedure to be outlined and discussed meets all requirements of a dependable endodontic technique. It is not difficult technically; however, the operator must be dedicated to carefully following through on every detail. Some dentists claim to obtain excellent results by omitting certain steps, but there can be no doubt that over an extended period of time the percentage of successful cases will be increased if the total technique is precisely adhered to.

Selection of root canal instruments

Personal choice will prevail to a great extent in the selection of endodontic instruments. Several manufacturers produce excellent files and reamers that are effective in preparing the root canal. It is suggested that a few instruments from each manufacturer be tried before investing in a complete set of files and reamers. A slight difference in the shape of the handle may serve to increase the instrument efficiency for a particular operator. A choice in files and reamers between conventional or standardized and between stainless or carbon steel is available. The following instrument sizes are manufactured:

Conventional reamers and files—0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12

Standardized reamers and files—10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100, 120, and 140

There is a distinct advantage in using the standardized instruments over the conventional ones since the step-up gradations are smaller and thus there is less chance of producing ledges or breaking instruments. The standardized instruments are uniform in size, taper, and length of cutting surface. The smallest diameter in millimeters is used to designate the number of the instrument, and the largest diameter of the instrument cutting surface is uniformly 0.3 mm. larger than the smallest diameter. The cutting surface of the instruments is 16 mm. long. A No. 10 file or reamer is 0.1 mm. at the smallest diameter, and the largest diameter is 16 mm. toward the handle grip and increases to 0.4 mm. in diameter.

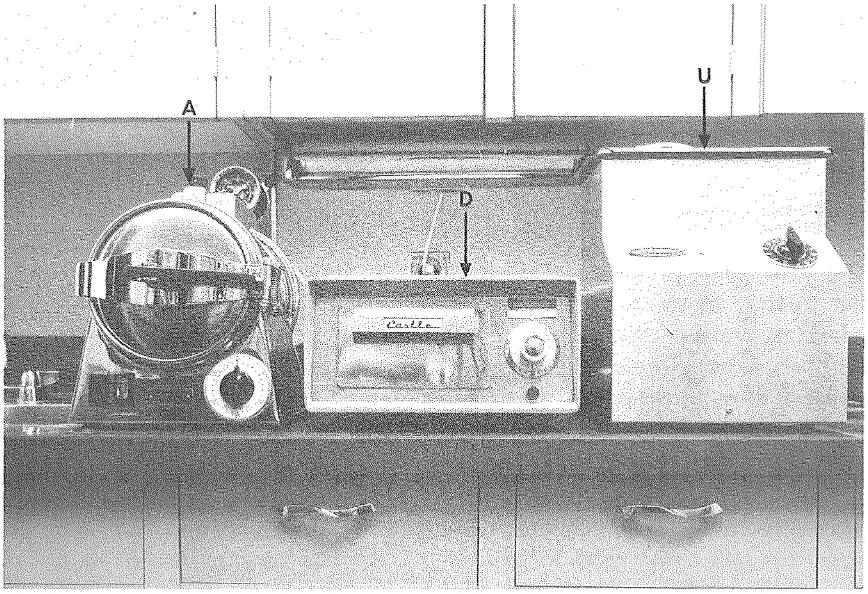
Silver points and gutta-percha points correspond in diameter and taper to the instruments and are available in most of the sizes in which the files and reamers are supplied.

Stainless steel files and reamers appear to hold considerable promise because of their resistance to corrosion. Torque resistance[18] of the stainless steel instruments of small sizes appears to be lower than that of comparable size carbon steel instruments. If an autoclave is available, stainless steel instruments may be considered, whereas carbon steel instruments will rust when autoclaved unless they are coated with a solution designed for this purpose. Such a solution is available through the dental supply dealers. Dry heat sterilization is most convenient and effective for carbon steel root canal instruments.

The breakage of files and reamers will be almost nonexistent after the dentist learns the strength of the instruments in their various sizes, provided a generous supply of new instruments are used. Discolored instruments and those that have been sterilized with a sharp bend in them should be discarded. New instruments are sharp and will save considerable time in preparing the root canal.

Other special instruments that are needed are burs for the high-speed and slow-speed contra-angles. High-speed burs in sizes 700, 701 XL, 557, 558, and 37 are recommended. Also needed will be round burs, sizes 3 through 8, and flame-shaped burs, sizes 1 through 9,

A



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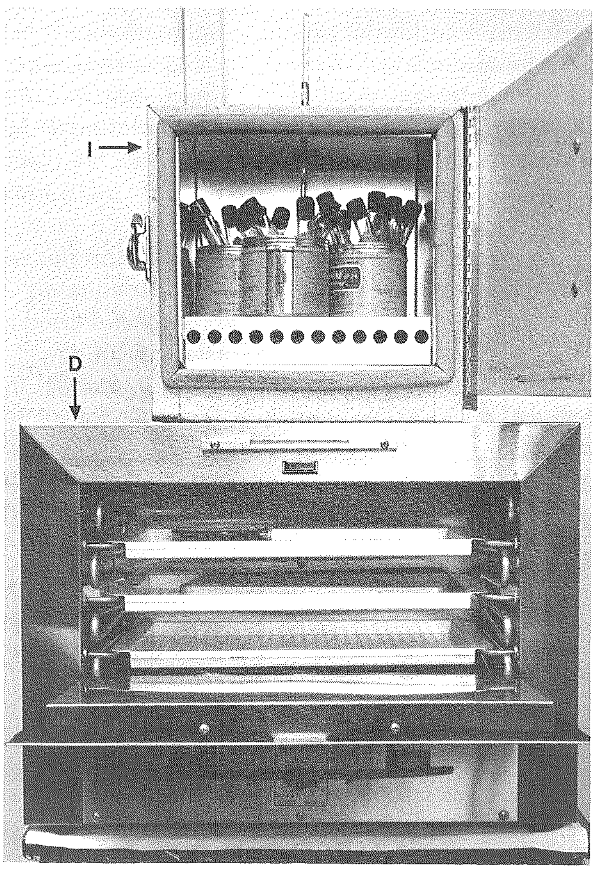


Fig. 11-18. A, Ultrasonic cleaner *(U)* to right; dry heat sterilizer *(D)* and autoclave *(A)* to left are all important for complete sterilization in endodontics. Contaminated instruments are washed and then cleaned in ultrasonic unit for fifteen minutes. They are rinsed, dried, inspected for removal of all debris, and sterilized in autoclave or dry heat sterilizer. **B,** Large dry heat sterilizer *(D)* is useful for sterilizing large trays of instruments and bulky materials. Sterilizer shown is an incubator *(I)*.

for the slow-speed contra-angle. For slow speed the miniature contra-angle is used with regular length burs.

Sterilization of instruments

An aseptic technique is absolutely essential in endodontics, and, if this is to be carried out, all instruments and materials must be sterilized. The only effective and practical methods of accomplishing this in the dental office is by the use of an autoclave or dry heat sterilizer. The autoclave will sterilize effectively if operated fifteen minutes at fifteen pounds of pressure and 121° C. The dry heat sterilizer is dependable for sterilization if operated two hours at 160° C. (See Fig. 11-18.) All stainless steel instruments, paper points, cotton pellets, gauze packs, culture media, and most high-speed handpieces can be autoclaved. Carbon steel instruments must be coated with solution to prevent rusting if they are to be autoclaved. This solution must not be used on injection needles since the content of oil can produce oil emboli or local tissue reaction if it should remain within the lumen at the time of injection.

The dry heat oven can be used for carbon steel or stainless steel instruments, burs, cotton pellets, paper points, and gauze packs. If the thermostat is inaccurate and the temperature rises above 180° C., the paper and cotton material will be scorched.

Boiling water and chemical disinfectants cannot be depended upon for primary sterilization. Cold solutions such as benzalkonium chloride are effective as holding solutions after primary sterilization has been effected.

It is essential to scrub all instruments thoroughly before sterilizing them. Instruments that are dry when placed in the autoclave will come out dry if the autoclave is operated properly.

Anesthesia

Most endodontic cases do not require special anesthesia techniques or anesthetic solutions that differ from those used in other types of dental procedures. Occasionally what may be termed "anesthesia-resistant teeth" may be encountered. These are usually teeth with vital pulps, which are acutely inflamed and often are in the stage that is classified as acute serous pulpitis.

Maxillary molars require a posterosuperior alveolar injection, an infiltration at the apex of the mesiobuccal root of first molars, and a palatal infiltration near the root apex. Maxillary premolars and canines require infiltration anesthesia over the buccal and palatal aspects of the roots near the apices. The maxillary incisor teeth require labial infiltration and are benefitted by injection into the incisive foramen.

The mandibular molars are the most difficult of all teeth to anesthetize for endodontic purposes. A good mandibular block is essential, but rarely does this give total anesthesia in hypersensitive pulps or acute pulpitis. Infiltration anesthesia buccodistal to the apex, along with infiltration lingual and distal to the apex, will supplement the block enough to give operable anesthesia in many cases. A few cases will require infiltration into the periodontal ligament, and the very few that remain anesthesia resistant can be managed by intrapulpal anesthesia.

Mandibular bicuspids may be anesthetized by a mental block, however, some will require lingual infiltration, and a few may require periodontal and intrapulpal anesthesia. Mandibular anterior teeth ordinarily can be anesthetized adequately by labial infiltration near the root apex. Periodontal and intrapulpal anesthesia is used for any tooth that is resistant to block and submucosal infiltration anesthesia. As a general rule for all injections, the solution must be deposited as near to the bone as possible.

Periodontal anesthesia is administered by injection through the gingival crevice and into the periodontal ligament, using a 30-gauge needle. The bevel of the needle is kept parallel with the long axis of the tooth, and the needle is forced into the periodontal ligament to a depth of 2 or 3 mm.; then the anesthetic solution is injected until the surrounding gingiva blanches. The injection is made on buccal, labial, lingual, mesial, and distal surfaces of the tooth.

Intrapulpal anesthesia is administered by injecting into the exposed pulp, using a 30-gauge needle. The exposed pulp is cauterized with a small amount of phenol on a cotton pellet before injection. This will decrease the pain as well as eliminate microorganisms. Only a few drops of anesthetic solution will be needed.

It has been shown that a mutually exclusive pharmacologic action of two local anesthetic solutions with different chemical structures is present.[19] There may be a patient for whom complete anesthesia cannot be obtained, but, if an anesthetic with a distinctly different chemical formula is used on a subsequent appointment, the desired result often will be obtained.

Endodontic technique

When the decision to perform endodontic therapy has been made, whether it is based upon pulp pathosis or is elective because of restorative requirements, a definite and organized procedure should be adhered to in every case.

Gaining access

Gaining access to the root canal should be done with minimal destruction of tooth structure; yet a straight line approach is necessary. The first procedure is to evaluate the tooth carefully as to its position in the arch, both mesiodistally and labiolingually or buccolingually. It is necessary to determine the approximate angle that the buccal or labial surface of the crown makes to that surface of the root. This can best be done by observation and palpation of the mucosa overlying the buccal or labial surface of the root. (See Fig. 11-19.) The roentgenogram is studied carefully for the location of the pulp chamber and root canal. If the tooth has drifted or has a full crown type of restoration, these relationships to the pulp chamber must be considered carefully (Fig. 11-20). Many mistakes of approach have resulted in a crown or root perforation by failure of the operator to take these careful steps before starting the high-speed drill.

The entire roof of the pulp chamber should be removed and all undercuts eliminated. The initial entry into the pulp chamber may be made with high speed, using a small fissure bur such as a No. 700 or 701. The cut should be kept small and should be directed toward the largest region of the pulp chamber. Molars and bicuspids must be entered from the occlusal surface; anterior teeth are approached from the lingual surface. The bur should be positioned in the same direction as the root. When the pulp cham-

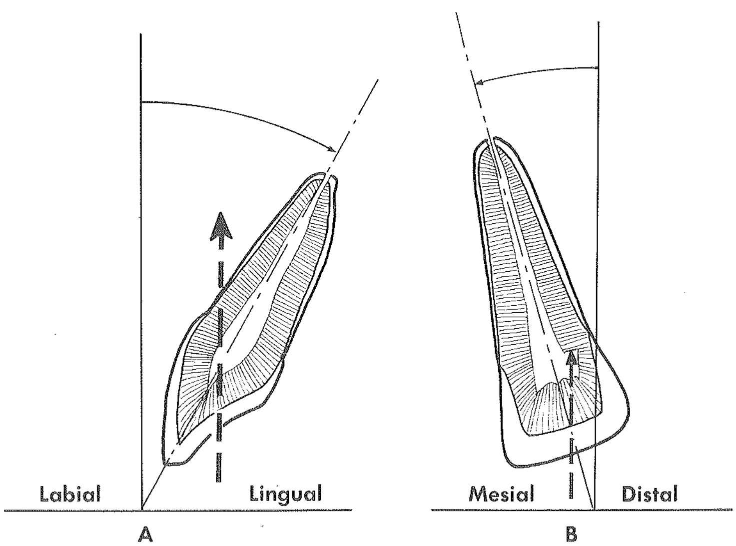


Fig. 11-19. Approach to root canal must be made in direction of root canal rather than in line with labial, buccal, mesial, lingual, or distal surfaces of crown. When teeth are malpositioned as illustrated, there is a tendency to follow line of approach that is followed for normal teeth, thereby perforating root or destroying tooth structure unnecessarily. An approach parallel with labial surface would result in perforation of root. Position of root canal is determined by use of roentgenogram and by examination of mucosa that overlies root surfaces.

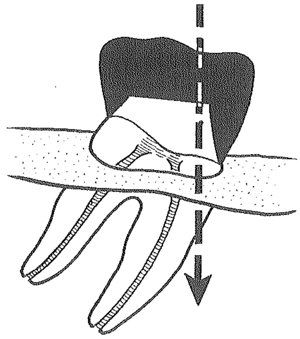


Fig. 11-20. When coronal anatomy has been restored on teeth that have drifted or those malpositioned in arch, special consideration in approach to pulp chamber is required. Perforations are not uncommon in cases such as is illustrated.

ber is reached, a decreased resistance is felt. The high-speed instrument should be put aside at this point and the position checked with an explorer. If the pulp chamber has been reached, the remainder of the pulp chamber roof is removed with slow speed, using round and flame-shaped burs. The flame-shaped burs are most useful to establish straight line approach in the root canal. If you have drilled to the predetermined pulp chamber location but have not entered it, you should stop to reevaluate the angle of approach and then proceed cautiously with a small round bur at slow speed. The round bur should be smaller than the size of the pulp chamber so that you will feel the entry. The initial entry into the pulps of multi-

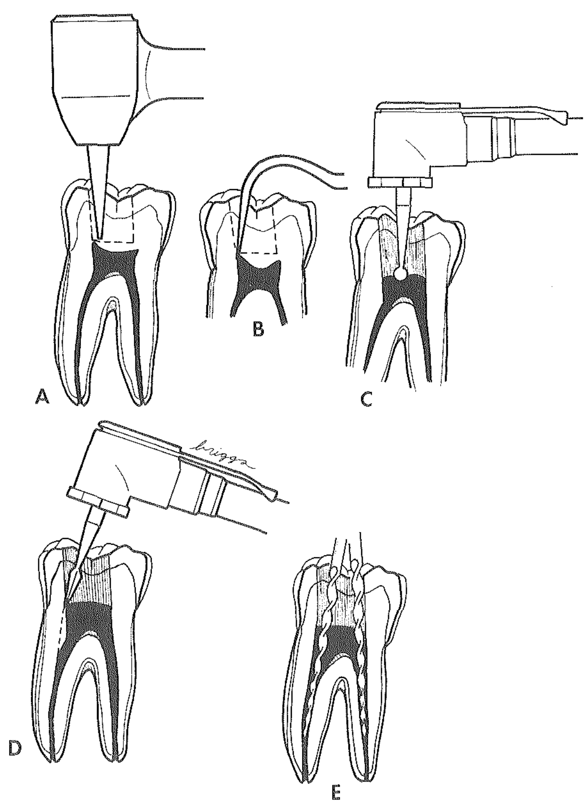


Fig. 11-21. A, Bulk of tooth structure is removed from roof of pulp chamber with high speed, using a 701 bur. **B,** Entry into pulp horns are confirmed by use of a sharp explorer. **C,** Round bur in a slow-speed instrument is used to remove remainder of pulp chamber roof. **D,** Straight line approach is made to root canal with a flame-shaped bur, which is used in a pedodontic slow-speed contra-angle. **E,** Reamers and files enter root canals without binding against approach cavity.

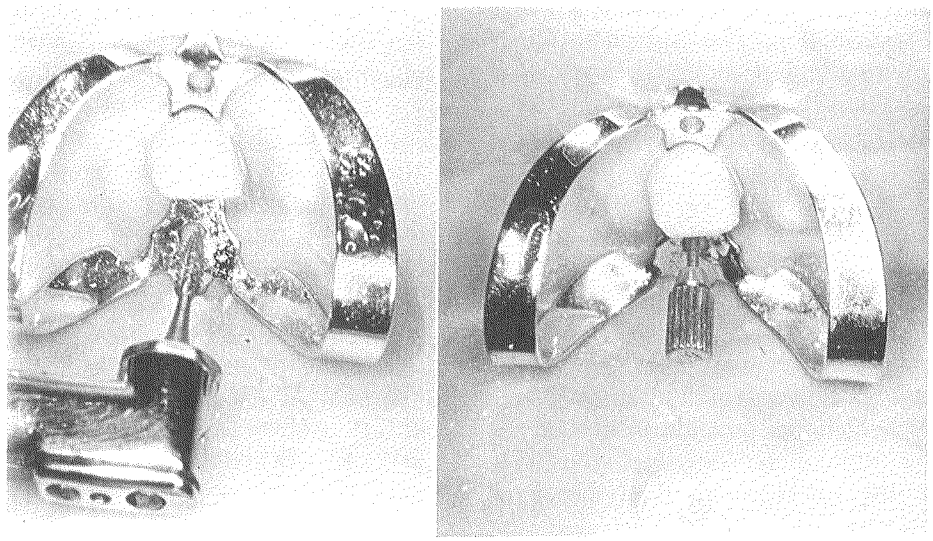
A  B

Fig. 11-22. **A,** Flame-shaped burs are used for obtaining straight line approach into root canals after initial entry into pulp chamber has been made with high speed, using fissure burs. No. 701XL high-speed bur is excellent for this purpose in most anterior teeth. **B,** Reamer will enter apical two-thirds of root canal without binding, as illustrated, if proper access has been obtained.

rooted teeth should be aimed toward the largest root canal, which is the lingual root of maxillary posterior teeth or the distal root of mandibular molars. After the largest root canal has been located in molars, the high-speed bur may be used to remove the remainder of the pulp chamber roof; however, the bur must be measured carefully to prevent cutting into the floor of the pulp chamber. The best policy in this procedure is to be conservative and to finish the cutting with slow speed, using flame-shaped burs. The flame-shaped bur may be carried into the canal orifice and in this way will facilitate the establishment of a straight line approach to each canal. (See Figs. 11-21 and 11-22.)

Pulp extirpation

The barbed broach is designed for removing the pulp. It is an excellent instrument for this purpose, but it must be handled with care to prevent breakage in the root canal. If the pulp is intact and the root canal is of medium size and is straight, the pulp can be removed by inserting the barbed broach into the pulp canal a few millimeters short of the apex and rotating it one turn before removing it. If the first attempt is not successful, the procedure can be repeated with an additional rotation of the broach. The broach must never be forced into the root canal. The appropriate sized broach must be selected by comparing it to the roentgenographic appearance of the canal.

In small canals it is often necessary to remove the pulp with reamers and files. The file usually is more efficient, but, if the pulp does not come out intact, the reamer must be used to complete the procedure. The files and reamers can be carried into the constricted regions of the canals more forcefully and with less danger of breakage than can the broaches.

It sometimes is necessary to use a file or reamer to remove large pulps from the teeth of young individuals since these pulps are composed of friable tissue, which has a low content of collagen. The barbed broach often will pull through the pulp and merely macerate the tissue. A file or reamer approximately the size of the pulp is inserted to near the apex and is rotated clockwise one or two turns before it is withdrawn. This procedure usually severs the pulp at the apical foramen.

The technique of removing the pulp from the small canal differs from this method in that the file is inserted gently and carried to near the apex with a one-quarter clockwise then counterclockwise motion. The instrument then is removed, with the last motion being clockwise. The procedure is repeated as many times as is necessary.

Root canal preparation

The objectives of root canal preparation are as follows:

1. To remove all necrotic and carious material.

2. To remove all irregularities of dentin so that the canal walls are rendered smooth and circular. It is not always possible to obtain the circular shape throughout the canal, but it is essential that the apical one-third of the canal be shaped this way.

Reamers and files are used to prepare the root canals. There are some dentists who use one type of instrument to the exclusion of the other; however, the more efficient method appears to be the use of reamers and files alternately. The reamer should be used first to remove remnants of pulp tissue, necrotic material, and dentin fragments. After this has been done and the root length has been determined, the file of corresponding reamer size may be used to smooth the walls of the root canal.

The root length is determined immediately after the pulp has been removed or even before if the pulp does not extirpate intact with the initial instrumentation. The tooth length is measured from the roentgenogram, the smallest reamer that will reach the apex without forcing it is inserted to this length, and a diagnostic roentgenogram is used to verify the length. (See Fig. 11-23.) If elongation or shortening of the projection is apparent, the exact length may be calculated by the following formula.

$$\frac{\text{Reamer length}}{\text{Reamer image}} = \frac{\text{Tooth length}}{\text{Tooth image}}$$

With experience it will not be necessary to use the formula since the adjustment can be made and confirmed by a second roentgenogram.

Instrumentation should be done in a wet field. Either sodium hypochlorite, instrumentation ease, or EDTAC is used to flood the pulp

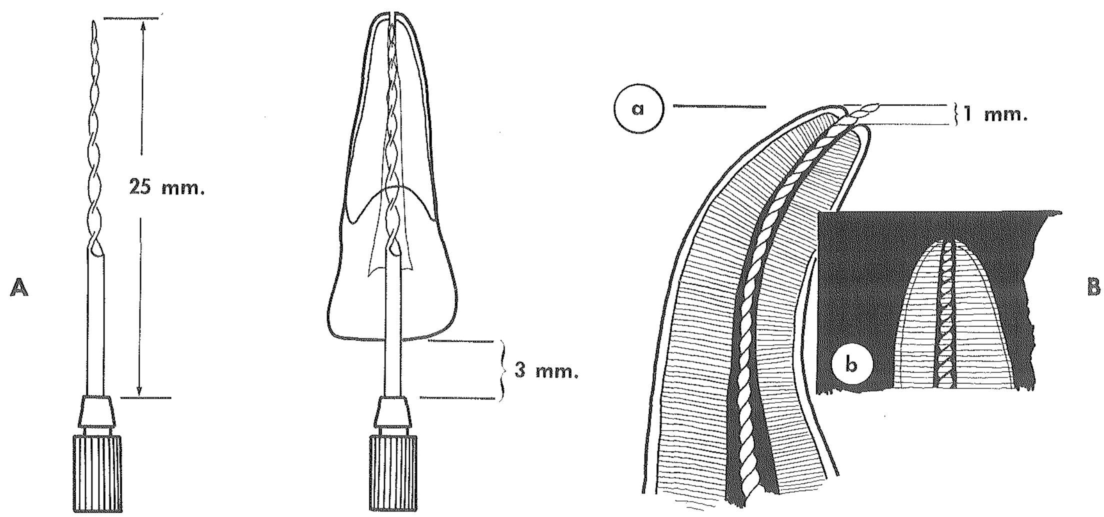


Fig. 11-23. A, Highest level of incisal or occlusal surface of tooth should be used as a reference point in measuring protruding portion of reamer at time of diagnostic roentgenogram. In this illustration tooth is calculated to be 22.5 mm. long since roentgenogram revealed reamer to be 0.15 mm. short of apex. **B,** When root is curved or canal does not exit exactly at root apex, calculation in **A** will be incorrect. Mesial view *(a)* indicates that reamer is 1 mm. beyond apex, and labial or roentgenographic view *(b)* shows reamer at apex. Exact length of root canal must be determined by observing absorbate on paper points following removal of pulp. Length must be verified again in this way when root canal is filled.

chamber and root canal. Periodically the pulp chamber and canals are irrigated gently with sodium hypochlorite solution. The instrumentation procedure is to place the reamer or file into the root canal until it meets resistance and then to turn it clockwise one-quarter rotation, to engage tooth structure before removing it with a straight outward thrust. The instrument is cleaned, and the process is repeated until the entire length of the root canal has been enlarged to this particular instrument size. The file also may be used to smooth the canal irregularities by short vertical outward strokes while it is held against the canal wall. The initial instrument should be of a size that will reach to within 1 or 2 mm. of the apex, and, when it has been used as previously described until it moves freely to the apex, the size immediately larger is used in a similar manner.

The reamer is used alternately to engage and remove tooth fragments that have been loosened with the file. After the initial enlargement through a wet field, the canal is dried with paper points followed by the use of reamers to engage the tooth fragments that have been packed against the wall of the root canal by the drying procedure. Instrumentation is continued through a wet field, increasing the instrument size until the operator is satisfied that the root canal is smooth, clean, and circular. This can be judged by the feel of the file in the canal as well as the appearance of the material that is removed by the instrument. The filings from the canal should appear to be only dentin and not a mixture of soft tooth structure or pulp remnants. This evaluation must be made with the canal dry; thus it is necessary to increase the root canal by one size file after it has been dried and cleaned of loose debris in order to determine the nature of the tooth structure. In the absence of acute infections or chronic periapical lesions most of the preparation is completed at the first appointment. Chronic periapical lesions are likely to exacerbate if considerable instrumentation is carried out at the first treatment, and acute cases usually are treated by allowing the root canal to be open two days for drainage.

Instrumentation is reevaluated at each treatment appointment and is finalized at the filling appointment. Teeth that have been nonvital for many years or those with large periapical lesions should be enlarged two sizes larger than a recently devitalized tooth of corresponding canal size. (See Fig. 11-24, *A* and *B*.) This will shorten lateral canals, allowing the medication to act more effectively. There is also the factor of removing dentin that may have been penetrated by bacteria, a great possibility in nonvital teeth of long standing.

Special considerations in instrumentation

Small curved canals should be entered with the smallest reamer. The reamer should be manipulated to the apex by gently rotating it clockwise and counterclockwise. If the canal resists instrumentation or the roentgenogram indicates that the root canal is not straight, the apical 1 or 2 mm. of the reamer must be precurved before entering the canal, and the reamer is directed to correspond to the curve of the root canal. (See Fig. 11-24, *C*.) When the apex is reached and confirmed, the instrument is retracted 2 mm. and reinserted several times before it is withdrawn completely. The reamer is followed with the same size file, filing fifteen or twenty vertical strokes of 2 mm. after the insertion to the apex. Instrumentation is continued, as previously described until the proper size and shape have been reached. In the curved canals the instruments must not be rotated more than one-fourth turn.

Instrumentation of small canals is facilitated by the use of chelating agent (EDTAC) or instrumentation ease (glycerin, 4 parts; Zephiran chloride 1:100, 4 parts; sodium borate 5%). EDTAC is beneficial when root canals are partially calcified. It acts by uniting with calcium to form a stable compound; thus the dentin is softened to a degree. For this reason it must be used with care so that the root is not perforated. The pulp chamber is flooded with the chelating agent, and the reamer is used to carry it into the root canal. The solution does not appear to be harmful to periapical tissues. The root canal should be irrigated with sodium hypochlorite solution following the use of EDTAC. By using sharp files and reamers it is not necessary to use chelating agents if the canal can be negotiated to the apex with a size 30 root canal file.

Instrumentation ease acts as a lubricating medium and also furnishes disinfecting properties. It especially is useful in small curved

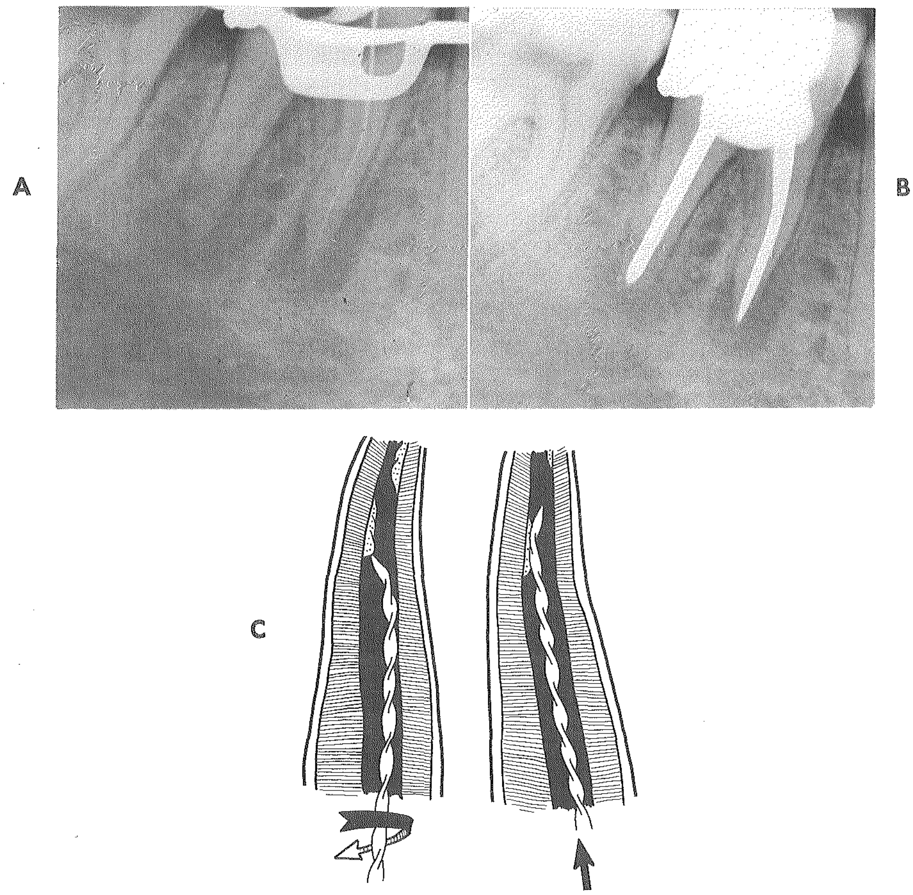


Fig. 11-24. A, At initial instrumentation only smallest reamer could be used in mesial root. By use of EDTAC and repeated irrigations mesial canal was reamed and filled to a size 90, and distal root canal was filled with a size 120 point. B, Same case as A after obturation of root canals. C, Reamer should be precurved at its apical end when carrying out instrumentation on teeth with curved root canals. The reamer is manipulated gently until it has reached apex. Irregularities of canal wall as illustrated may prevent reamer from reaching apex in a straight root, unless instrument is precurved.

canals to prevent binding of instruments. It is useful particularly in the multiple vertical stroke technique, using small files. Care must be taken not to force this solution beyond the apex. It is necessary to irrigate the canal thoroughly with sodium hypochlorite solution after its use.

Root canal sterilization

Microorganisms must be eliminated from the root canal before it is filled, and a method to determine when this has been accomplished is necessary. Microorganisms are removed from the canals by mechanical and chemical methods. Bacteriologic cultures and microscopic examination of direct smears from the canals are used to determine the absence or presence of microorganisms within the root canals. (See Figs. 11-25 to 11-27.)

The majority of microorganisms in root canals can be eliminated by the removal of all pulp tissue, enlargement of the root canal, and thorough irrigation with bacteriostatic solutions. Auerbach[20] has demonstrated that 78% of infected teeth yield growth-free cultures simply by mechanical cleansing and irrigation of the root canal without further medication.

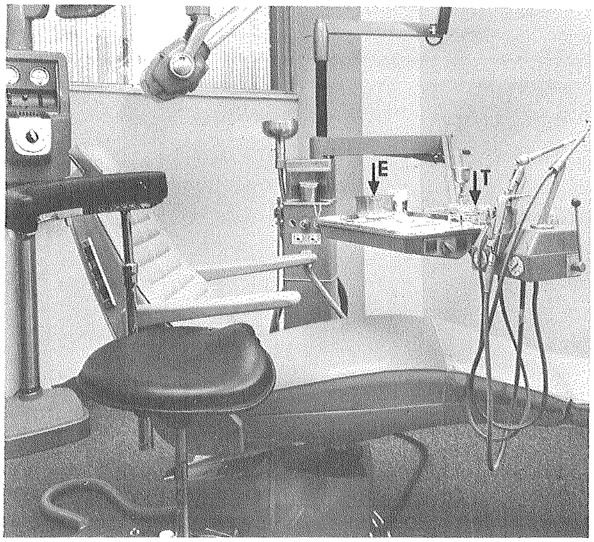


Fig. 11-25. Bracket tray setup must provide a sterile towel that has been folded so that it will maintain sterility of paper points, cotton pellets, or instruments that are placed within it for use on a patient. Enodon rack *(E)* holds a supply of files and reamers in cold sterilizing solution, and as used on a patient they are placed in the Tri-well sterilizer *(T)*, which also is kept on bracket table. Deep well of Tri-well is used for explorers and excavators and shallow well for files and reamers; sodium hypochlorite solution is kept in large center well.

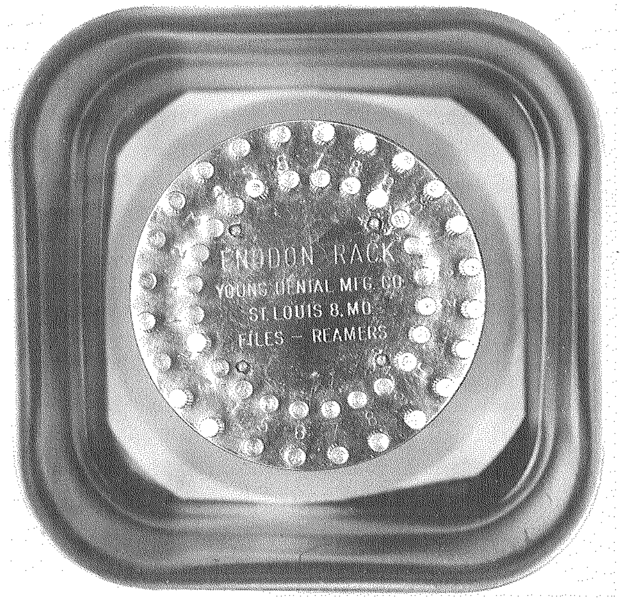


Fig. 11-26. Enodon rack.

Fig. 11-27. Trays in which instruments and paper points or cotton pellets are sterilized and stored.

Stewart[21] found that 76% of infected teeth that were treated by chemomechanical preparation alone were free of microbial growth. His percentages were calculated after two successive negative cultures were obtained.

If organisms remain after proper preparation and irrigation of the root canal, they are eliminated by sealing into the root canals such medicaments as antibiotics or bacteriocidal chemical agents. The drugs should be used in small quantities, with care being taken to avoid carrying them into the periapical tissues in which they may act as tissue irritants.

Hydrogen peroxide, 3%, will liberate nascent oxygen when it is used alternately for irrigating with sodium hypochlorite, and it is effective in removing small particles of debris and dentin filings from the root canal. Sodium hypochlorite has the added benficial effect of dissolving organic debris. These solutions also act as lubricants for instrumentation, as bleaching agents, and as antiseptics. They have the added advantage of being well tolerated by vital periapical tissue. The peroxide always is followed by sodium hypochlorite, to liberate all nascent oxygen before the tooth is sealed.

The root canal should always be dried thoroughly with paper points and cleaned with a dry reamer before a sterilizing agent is sealed.

Fig. 11-28. This and other similar lesions over patient's body were produced by oral penicillin that had been administered for an acute periapical infection.

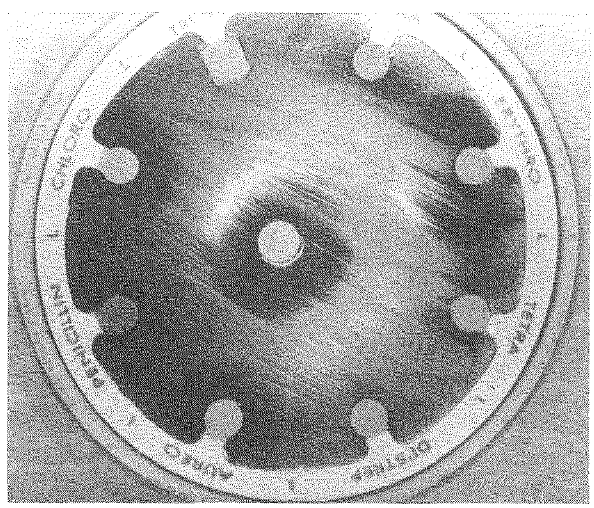


Fig. 11-29. Blood agar plates were used in this study. Plates were seeded from positive cultures of root canals, and if a definite clear zone developed around the antibiotic disk, organisms of culture were considered to be sensitive to antibiotic. Size of clear zone was not considered.

Selection of sustained root canal medicament

The sustained root canal medicament is sealed into the root canal between appointments and completes the sterilization process. The choice is between drugs and antibiotics and in most instances is an arbitrary selection.

Antibiotics. It generally is considered wise to use multiple antibiotics since singly they may allow an overgrowth of resistant microorganisms in the canal. Essentially this may be circumvented by using a single antibiotic and nonspecific drug on alternate treatments or by combining the antibiotic and a drug.

A polyantibiotic paste, P.B.S.C., was introduced by Grossman[22] in the late 1940's, and it has been used extensively in endodontics since that time. It is composed of penicillin, bacitracin, streptomycin, and sodium caprilate. P.B.S.N. contains nystatin as the fungicidal agent rather than sodium caprilate. Some of the advantages claimed for the polyantibiotics are that they produce less periapical tissue irritation than the drugs and that they eliminate infection more rapidly from the root canal and periapical area than do the drugs. The major disadvantage is the possibility of producing a hypersensitivity in the patient or eliciting a severe reaction in a hypersensitive patient (Fig. 11-28). Hypersensitization is produced when small increments of antigenic substances enter the bloodstream slowly over an extended period of time. Such a situation exists when antibiotics are sealed into root canals. Although medicament is kept well within the confines of the root canal, it may be carried into the periapical tissues by the interchange of exudate from the canal to the vital periapical tissues. It is contended by some endodontists that the cultures are not as accurate as with drugs since there are no inhibitors for the antibiotics other than penicillin.

We[23] have performed antibiotic sensitivity tests at intervals on all endodontic cases of that period in which positive cultures were obtained (Fig. 11-29). The results from 1959 to 1965 indicate a decrease in patients who are sensitive to penicillin (Tables 1 and 2).

A mixture of penicillin and camphorated parachlorophenol, as recommended by Sommer, Ostrander, and Crowley,[24] is effective against most types of microorganisms that are found in root canals. It is prepared by spatulating a 50,000-unit tablet of penicillin with one drop of camphorated parachlorophenol. This produces a creamy paste, which may be carried into the root canal by reamers, using a counterclockwise motion. A fresh mixture is prepared for each patient. With this combination penicillinase must be used in culture medium for accurate culture determination.

Drugs. The two drugs that can be used to fulfill most needs for root canal sterilization are camphorated paramonochlorophenol and Cresatin. Both are effective against most types of microorganisms that are found in root canals, and they do not interfere with the culture technique.

Camphorated parachlorophenol is prepared by combining three parts of crystalline parachlorophenol with seven parts of gum camphor. If triturated, the components will liquefy. It penetrates the dentin well and is relatively non-irritating to vital soft tissue. Hypersensitivities to the drug will occur in a few individuals, most of which are local because of drug penetration into the periapical tissues. The symptoms are local constant pain and percussion hypersensitivity to the tooth. If this develops, the medication should be removed, and the canal irrigated with sodium hypochlorite, enlarged by one size

Table 1. Results from antibiotic sensitivity tests on microorganisms cultured from root canals, 1959 to 1960

Antibiotic	*Number of cases*	*Number resistant to antibiotic*	*Percent effective or sensitive to it*
Propionyl erythromycin	398	16	96
Chlorotetracycline	398	22	94
Dihydrostreptomycin	398	309	22
Erythromycin	398	34	91
Oxytetracycline	398	23	94
Tetracycline	398	17	96
Tri sulfa	398	331	17
Penicillin	398	115	71
Chloromycetin	398	22	94

Table 2. Results from antibiotic sensitivity tests on microorganisms cultured from root canals, 1964 and 1965

Antibiotic	*Number of cases*	*Number resistant to antibiotic*	*Percent effective or sensitive to it*
Propionyl erythromycin	181	3	98
Chlorotetracycline	50	0	100
Streptomycin	181	79	54
Erythromycin	181	11	93
Oxytetracycline	50	1	98
Tetracycline	181	27	85
Tri sulfa	10	9	10
Kanamycin	131	120	8
Novobiocin	131	19	85
Penicillin	181	60	66
Chloromycetin	181	21	88
Neomycin	131	105	20

file, irrigated again, dried, and sealed only with a sterile cotton pellet in the pulp chamber. The occlusion must be relieved in most cases, and in a few instances it is necessary to leave the canal open for two days. As soon as the tooth is comfortable the canal should be remedicated with antibiotics or Cresatin.

Generalized systemic allergic reactions to camphorated parachlorophenol have been reported,[25] the symptoms being a skin rash with possible joint edema.

Cresatin is metacresylacetate, and it acts as a mild anti-bacterial agent that can be used to advantage in endodontics. It is a good antifungal agent and produces a very low degree of tissue irritation. Cresatin is used advantageously as the initial medicament in cases in which the root canal has been opened for a long period of time since these are the cases in which antifungal agents are more likely to be needed. If a single antibiotic is used, Cresatin may be alternated with it to prevent overgrowth of fungi. Cresatin is adequate for total treatment in patients who are hypersensitive to antibiotics or other drugs. It may be used as a sedative and antiseptic in the root canal or over a pulp exposure. It is excellent for the emergency when time or circumstances do not permit total pulp extirpation. By placing a cotton pellet saturated with Cresatin over a vital pulp exposure or over the vital pulp tissue in the root canal, the patient often will be relieved of all pain for a month or longer.

Methods of medication application

Three methods of placing the medicament into the root canal generally are used.

Paper point method. Medicament may be placed on absorbent paper points, and the points then are sealed into the root canal. If this method is used, it is necessary to use paper points that are smaller than the root canal so that the canal is not blocked completely. Exudate may enter the canal from the periapical tissues to produce swelling of the points. If the point is of the approximate size of the canal, it is likely to wedge into place and require tedious instrumentation for removal. The tight point also may produce pain since the periapical tissue fluids have no reservoir or escape. The second precaution is to be sure that the paper point is held at least 1 mm. short of the apex. A cotton pellet may be saturated with the medicament, blotted, and then placed in the pulp chamber over the paper point before the final seal is placed.

Ointment method. The medicament may be spatulated with Aquaphor ointment as suggested by Wolfshon.[26] The ointment may be carried into the root canals by reamers, using the counterclockwise motion. A reamer that is one size smaller than the canal is coated with the ointment and is carried to within 1 mm. of the apex. The reamer is rotated counterclockwise as it is removed from the root canal. Then a cotton pellet is saturated with the ointment and is placed in the pulp chamber before the canal is sealed.

The medicament may be mixed with a topical anesthetic ointment if Aquaphor is not available. After mixing, it should be thick enough to coat the reamer without falling away when it is lifted from the slab.

Pulp chamber medication method.[25] Some endodontists believe that the root canals should not be obstructed in any way; thus they advocate sealing a medicated cotton pellet in the pulp chamber without medicating the root canal. It is expected that adequate medication will enter the canal from the pulp chamber. This technique often will give optimal medication with a minimum of periapical irritation. Postoperative pain is caused by periapical medica-

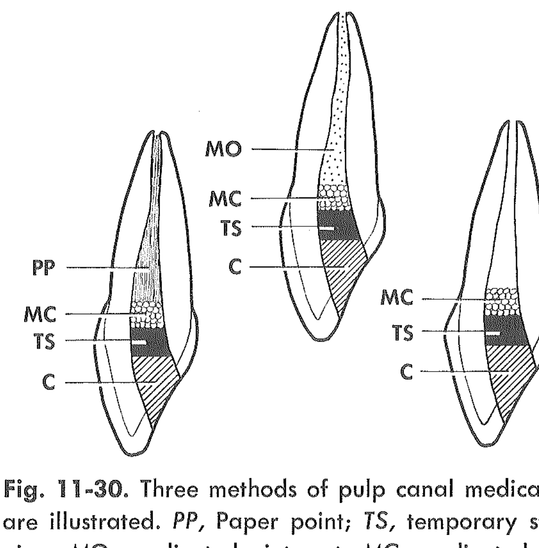


Fig. 11-30. Three methods of pulp canal medication are illustrated. *PP*, Paper point; *TS*, temporary stopping; *MO*, medicated ointment; *MC*, medicated cotton; *C*, cavit or cement.

tion irritation in many cases, and for this reason the latter method should be used if pain develops after one of the other techniques has been used. (See Fig. 11-30.)

Methods of sealing medicaments into root canals

The cotton that is placed in the pulp chamber should not be compressed by the sealing agent. Temporary stopping can be placed over the cotton in a manner that will not compress it. Cavit or any zinc oxide–eugenol preparation is placed over this, and it may serve as the final seal in areas of minimal occlusal stress. It affords a satisfactory seal in the anterior teeth with lingual approaches or in bicuspids with simple occlusal approaches and in some cases of molars with simple occlusal approaches. In cases with heavy occlusal forces or with a seal that is to remain for more than two weeks, a third seal of cement must be used. Silver alloy often is mixed with cement powder in a ratio of 1:4 to produce a tougher filling that does not fracture as easily as does cement alone.

Teeth that are badly broken down should be fitted with some type of temporary crown before beginning treatment. A cast gold crown that is cemented in place is best and usually saves time since aluminum shells or copper bands often must be replaced before the endodontic treatment has been completed. If they leak and allow contamination of the root canal, additional treatments are required to complete the endodontic procedure; thus time often is saved by the construction of a temporary casting for the treatment. This should definitely be done in cases of suspected fracture that may lead to a "split tooth."

Bacteriologic control

Two methods of checking for sterility of the root canal are available. The culture method is most accurate and should be used routinely. Exudate from the root canal may be examined microscopically for the presence of bacteria. If microorganisms are not present or if polymorphonuclear leukocytes are not seen upon microscopic examination of the exudate, the root canal probably is sterile. Polymorphonuclear leukocytes may be present as a result of medicament irritation. The culture method is used routinely, but, if the patient cannot return for additional treatment, the root canal may be filled after obtaining a negative smear, provided the tooth is comfortable and only a minimal amount of exudate is present, which can be dried with absorbent points.

Bacteriologic culture media may be prepared in the dental office by following the simple directions on the package of medium powder. A single culture medium is not universal enough to grow all the microorganisms that may be found in root canals. It generally is agreed by authorities in endodontics that enriched media of several types will grow most of the pathogens that occur in root canals. It is not feasible to culture each case both anaerobically and aerobically in private practice. Very few pathogens that are found in root canals are strict anaerobic organisms; thus a medium such as tryptocase soy or brain-heart infusion with 0.1% agar-agar will serve very well for practical purposes. Sommer, Ostrander, and Crowley[24] have recommended glucose ascites medium. It would have a base of beef infusion broth or brain-heart infusion to which glucose and agar are added. After the medium has been tubed, autoclaved, and cooled to 42° F., sterile ascites fluid is added aseptically until each tube contains 5% of the fluid. Thioglycollate broth may also be used as a root canal culture medium.

A simple and satisfactory medium may be prepared by dissolving 30 grams of tryptocase soy powder in 1000 ml. of distilled water. One gram of agar-agar is dissolved in this by heating it almost to the boiling point. Care must be taken to prevent boiling since this will alter the pH, which should be 7.2. The medium is poured into tubes, 10 ml. to the vial, and the caps applied loosely; then it is autoclaved at 15 pounds' pressure for fifteen minutes. The pressure must be released from the autoclave gradually to prevent blowing out of the medium. The tubes should be allowed to cool for a few minutes before they are removed from the autoclave and the caps are tightened. Penicillinase must be added to the culture medium after autoclaving if penicillin is used therapeutically in the root canal. Penicillinase deteriorates at room temperature; therefore it must be kept refrigerated.

Care must be taken to prevent false positive cultures in transferring the inoculum from the root canal to the culture tube. The paper point that is used to transfer the inoculum must be taken from the sterile storage tray or sterile towel to the root canal rapidly and by the use of a forceps that has been flamed. The paper point is carried to the apex and is moved to all regions of the canal. The cap of the culture tube is flamed and removed; the mouth of the tube is flamed, and the forceps is flamed again just before grasping the paper inoculum point for rapid transfer into the tube. After the inoculum point has been placed in the medium tube, its mouth is flamed again and the cap is replaced firmly. The paper point must go near the bottom of the medium since this is the area that will allow growth of anaerobes.

One negative culture should be an indication that the root canal is ready to fill. If at this time the tooth is uncomfortable or considerable exudate is present, another culture should be taken, and the medication is changed to one that produces less tissue irritation. If after a second negative culture the tooth is still uncomfortable, the decision to fill the root canal or not to fill it at this time must be based on clinical judgment. At this point a slide of the exudate examined microscopically is useful because, if microorganisms are found, it may well be that the root canal is infected and the culture medium is not adequate for growth of the organisms. Bacteria usually are not found however, which indicates that periapical irritation is most likely due to the medicament. These teeth usually become comfortable after the root canal is filled properly.

If the culture is positive repeatedly in the presence of a good seal, hyperdiameterization will be required. This means enlarging the root three or four size reamers above what ordinarily is considered sufficient for this root canal. It is not at all unusual to increase the size of the canal in such a case from a No. 40 to a No. 80 reamer; however, sharp instruments must be used. By this procedure lateral canals are shortened to allow better penetration of the medication, and organic material is removed from the previously unsuspected recesses in the root canal wall. Thorough irrigation along with instrumentation is manditory.

Persistent exudate does not necessarily indicate that a cyst is present and that periapical surgery will be necessary. If the lesion is small roentgenographically it may be related to irritation from the medication. Trephination of the area will eliminate this excess exudate problem in some cases. Some other cases can be managed by inserting the reamer into the periapical area to create bleeding after a negative culture has been obtained. If either of these procedures is used, the root canal usually can be dried by paper absorbent points within a week or two. Large lesions with persistent large quantities of exudate may be handled best by surgical curettement with or without apicoectomy. Trephination also gives good results from some of the large lesions.

Small incubators can be purchased inexpensively that will function most adequately for the dental office. The culture tube must be placed in the incubator soon after it has been inoculated and incubated at 37° C. for a minimum of forty-eight hours, preferably seventy-two hours. If the tube is clear after proper incubation, the root canal may be considered to be sterile for practical purposes. Turbidity of the culture indicates the presence of viable microorganisms. It is not necessary to determine the microorganisms that are present, but only to detect if all viable microorganisms have been eliminated.

Root canal filling procedure

The root canal must be sealed hermetically after the preceeding requirements have been fulfilled. The root canal filling materials used are gutta-percha and silver points. One of these major materials is fitted to the root canal and is sealed with a special-purpose cement. Gutta-percha is sometimes used with chloropercha as a sealing agent.

Regular gutta-percha technique

Gutta-percha is an excellent root canal filling material, which has been used widely for one hundred years. It is a flexible material that can be compressed against the root canal walls and is essentially nonirritating to periapical tissues. It can be warmed and formed into any desirable size or shape. It is soluble in chloroform or xylene, and, if necessary, it can be removed from root canals by reamers after softening it with these solvents. Its disadvantage is that it cannot be controlled easily in small curved canals. In these instances the filling often ends short or is

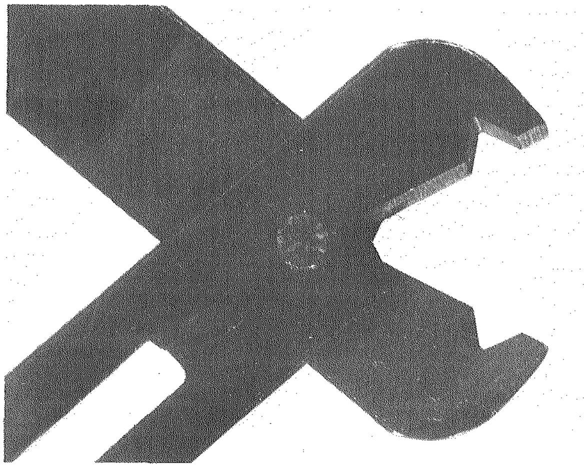


Fig. 11-31. Miller wire stripper used to cut silver points and gutta-percha points. Points are not flattened as with scissors.

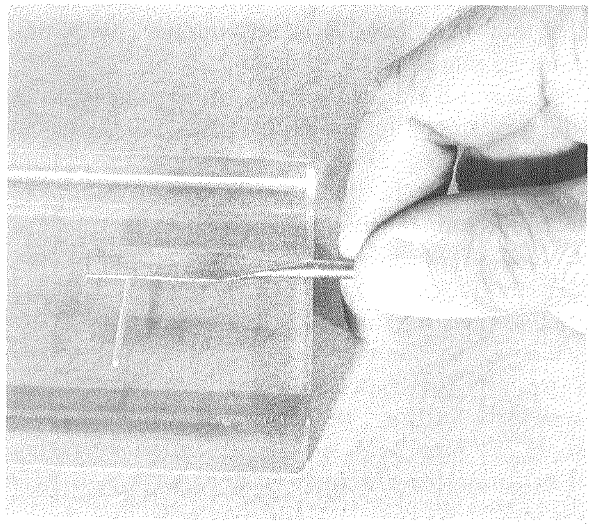


Fig. 11-32. Gutta-percha may be rolled and shaped to desired size by warming it in water or gently over a flame and then rolling it between two glass slabs. A broad spatula may be substituted for top slab and is recommended for final shaping, as illustrated.

forced through the apex into the periapical tissues.

Gutta-percha points can be obtained now in standardized sizes 25 through 140. This makes it much easier than previously to use gutta-percha in some of the smaller sizes as the smaller points are very difficult to roll. Gutta-percha can be used easily in a straight canal that has been reamed to a size 30 or higher and will be the material of choice in most such cases. The gutta-percha point that corresponds to the largest sized reamer used in preparing the canal is selected. It is sterilized by phenol or some other cold sterilizing solution. The point is measured and is grasped with a cotton pliers at a distance of 0.5 mm. shorter than the predetermined tooth length. It is placed into the root canal and should fit snugly at a point 0.5 mm. short of the apex. If the point is loose, 1 mm. is cut from the apical end with a Miller wire cutter. This instrument cuts on four sides simultaneously and does not flatten the point as will a scissors. (See Fig. 11-31.) If this adjustment leaves the point snug in the canal at the required length, a roentgenogram is utilized to confirm it. The check film may be seen within one and one-half minutes by using Collit's rapid roentgenogram developer, washing the film, and bringing it into the operatory in a small clear glass of fixer. The developing requires twenty to thirty seconds, and it will clear in less than one minute under a watchful eye if fresh fixer is used. For some adjustments one may be able to determine all that is necessary immediately upon bringing it from the darkroom. If the point will not go to the required position, the root canal can be reamed more with a new reamer of the same sizes or with the next larger sized reamer. An alternative is to use a point one size smaller and cut it back until it fits or to roll the larger point to a smaller size. Rolling a small gutta-percha point must be done carefully, and it is recommended that the point be warmed in water rather than direct flaming if it only has to be reduced in size by a small amount. After warming, it is placed on a smooth glass mixing slab and rolled with a broad spatula, which has been warmed by passing it through a flame (Fig. 11-32). The point is then immersed in ice water, or it is cooled by ethyl chloride spray, sterilized, and tried in the canal again for a roentgenographic check. The major obturating point must fill completely the apical one-fourth of the root canal. If the check film shows voids between the point and root canal in this area, a larger point must be used. If irregularity is seen in the canal, it must be enlarged until this is eliminated before the larger point is fitted. Space between the major point and the canal within the coronal two-thirds of the root may be filled satisfactorily by lateral condensation.

Lateral condensation should be attempted in all cases since there often is space in the coronal region that can be filled. This will ensure a final seated seal of the major point within the apical one-fourth of the root canal. The major point is sealed in place by sealer before lateral condensation is carried out. There are several sealers that are satisfactory. Kerr sealer or Grossman's sealer are recommended. The sealer is mixed vigorously with pressure for two minutes. It should be creamy, pull up on the spatula for a short distance, and, above all, be sticky rather than lumpy or granular. If it is not mixed long enough, it will set fast and will not cling to the point when it is seated, thus preventing an apical seal. If the sealer is too thick it will likely be pushed beyond the apex, or, if it is too thin, it may not seal the canal well. If the point fits well, very little sealer is required. Sealer can be placed on a reamer that is one size smaller than the canal, carried within 1 mm. of the apex, and spun to the canal wall by several reverse turns of the reamer. The major point is coated with sealer and seated. The point is seated by a gradual apexward thrust with a slight clockwise–counterclockwise rotation. Insertion should follow one side of the canal to allow the escape of air. If the point is seated too rapidly, pain will result, and excess sealer will be forced into the periapical tissues. The sealer usually is well tolerated. It is a foreign body; thus it is sometimes necessary to remove the excess surgically to obtain complete healing.

Lateral condensation is performed by using a No. 3 spreader, a No. 7 spreader, A extra fine gutta-percha points and A fine gutta percha points. (See Fig. 11-33.) As soon as the major point is seated with sealer, the No. 7 spreader is forced into the canal beside it. Care must be taken so that the spreader and major point are not forced out the apex since this can be done by exerting undue force on this small spreader. The spreader must be marked before use so that it is kept 2 or 3 mm. from the apex. The spreader is rotated several times after it is to this depth and is removed as the A extra fine point is inserted. The gutta-percha will recoil rapidly after removal of the compressor (spreader); thus there is no time for delay in placing the auxiliary

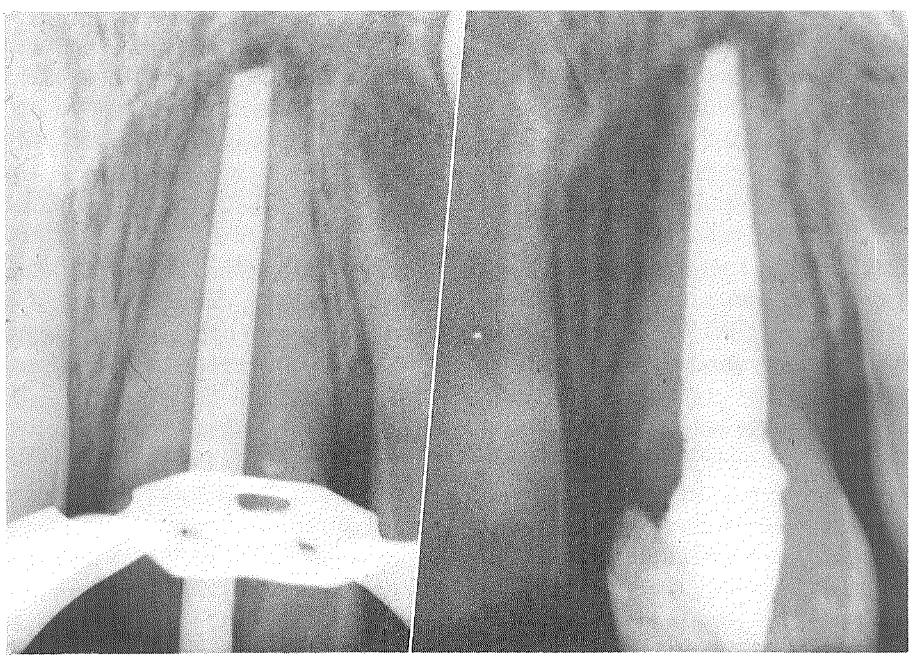


Fig. 11-33. Major gutta-percha point fits tightly within apical region of root canal, and right roentgenogram illustrates that lateral condensation has obliterated completely the remainder of root canal space.

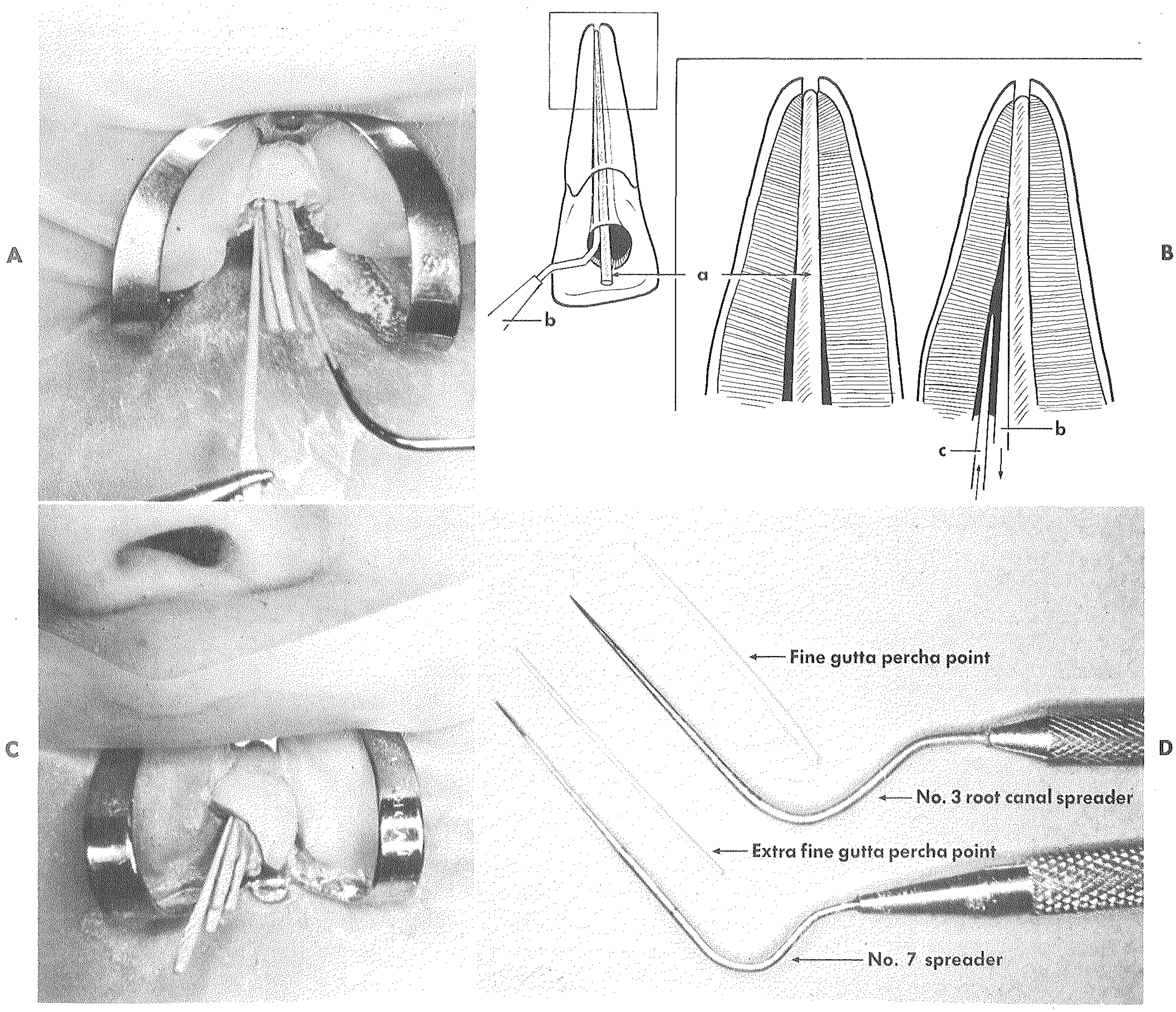


Fig. 11-34. A, Lateral condensation is performed by forcing root canal spreader down beside major obturating point to condense it and inserting auxillary gutta-percha point into space created. It must be inserted rapidly as spreader is removed since recoil of major point will eliminate space quickly. Process is repeated until canal is obturated well. **B,** Lateral condensation is illustrated diagrammatically. *a,* Major obturating point; *b,* root canal spreader; *c,* auxillary gutta-percha point. **C,** Variation in depth of insertion of auxillary points is seen after lateral condensation. **D,** Spreader and gutta-percha points that are needed for lateral condensation. Fine instrument and points should be used first.

point. This procedure may be repeated several times, and then several of the A fine points may be placed within the coronal half of the root canal if they are required to fill this portion of it. The No. 3 spreader is used in placing the A fine gutta-percha auxiliary points. (See Fig. 11-34.) After adequate lateral condensation the excess gutta-percha is seared off level with the cervical region, using a heated instrument such as a narrow carver or excavator. It is necessary to condense the canal filling with a small plugger after the excess has been removed. The excess sealer and gutta-percha are removed from the pulp chamber by wiping it with a cotton pellet that has been saturated with xylene. In anterior teeth the gutta-percha should be removed totally from the clinical crown. This is done with a sharp round bur slightly larger than the root canal in this region. It is run at slow to moderate speed. The same technique can be used to remove gutta-percha well within the root canal for the reception of a post.

Sectional gutta-percha technique

The gutta-percha point may be sectioned after it has been fitted to the root canal and marked for length. The apical segment is sealed into the canal by using a root canal plugger of the approximate diameter as the point to carry it into place. The plugger must be measured and marked to the length of the coronal segment of the point. This will leave room for a post. Additional gutta-percha segments may be heated and condensed against the apical segment if a post is not needed to restore the tooth. This technique is indicated in canals that are unusually large in the middle of the root as would be found in internal resorption or those large root canals that have an apical plug of cementum. Before the initial section of gutta-percha is seated the sealer is carried into all regions of the canal with a reamer. (See Figs. 11-35 and 11-36.)

Silver point technique

Silver points are handled basically in the same manner as gutta-percha. Silver points are ideal for use in small curved canals. The small canals, which are torturous and require precurving of instruments for instrumentation, likewise will require precurving of obturating points in filling the canal (Fig. 11-37). This is virtually impossible to do with small gutta-percha points. The silver point can be notched and twisted from the coronal half of the canal after the apical segment has been seated and sealed. This is an advantage for intraradicular retention preparations.

Silver points must be wedged tightly into the root canal, and by virtue of their strength they can be wedged with accuracy much tighter initially than gutta-percha. Considerable force should have to be exerted to remove the point even before it is sealed. Very little sealer should be requird to seal the point. Lateral condensation, when necessary, is carried out just as it is with gutta-percha. In the small canals, which have very little flare, it is difficult to force a spreader down beside the point. It always should be attempted, however, and as many gutta-percha points as possible should be condensed around the silver point. The No. 7 spreader and A extra fine gutta-percha points are more advantageous than the larger spreader and A fine points in the silver point technique. A tight well-fitting silver point will not be pushed down beyond the apex during lateral condensation, whereas gutta-percha may be since it is resiliant. (See Fig. 11-38.) It is important that the point wedge tightly into place barely short of the apex. This exact position is determined by careful examination of the exudate or blood absorbed by a paper point after it has been carried to the apex as previously determined by the roentgenogram. (See Figs. 11-39 to 11-41.) The apical blunt end of the silver point is hand tapered slightly, using a diamond disk, as the point is rotated continually with the other hand. The silver point is well tolerated by tissue, but it is more likely to produce mechanical irritation of the periapical tissue than gutta-percha or sealer if it extends beyond the root end. (See Fig. 11-42.)

A B C D E

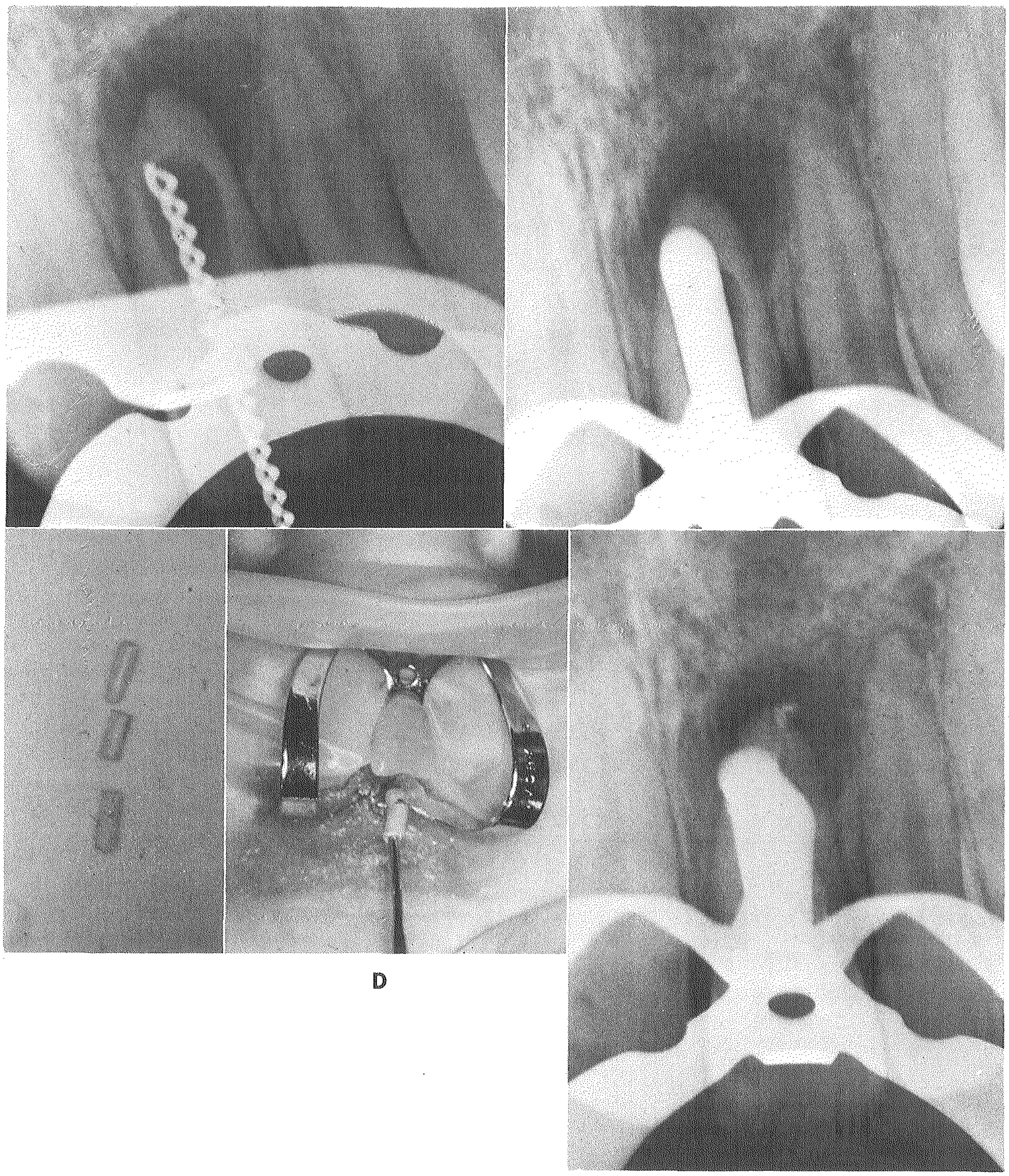


Fig. 11-35. A, Sectional gutta-percha technique is indicated when irregularities within root canal are not compatible with a cone-shaped point as in this photograph. **B,** After canal has been cleaned and smoothed with reamers and round burs, major point is fitted so that an apical wedging is present. **C,** Point then is cut into sections. **D,** Root canal is coated with sealer; sealer is placed on apical section of point and is carried into position with a root canal plugger as illustrated. It is firmly condensed with a root canal plugger, and after warming it with a heated instrument it again is condensed with plugger. Other segments are condensed into root canal in same manner until it has been filled completely, as will be seen in **E.**

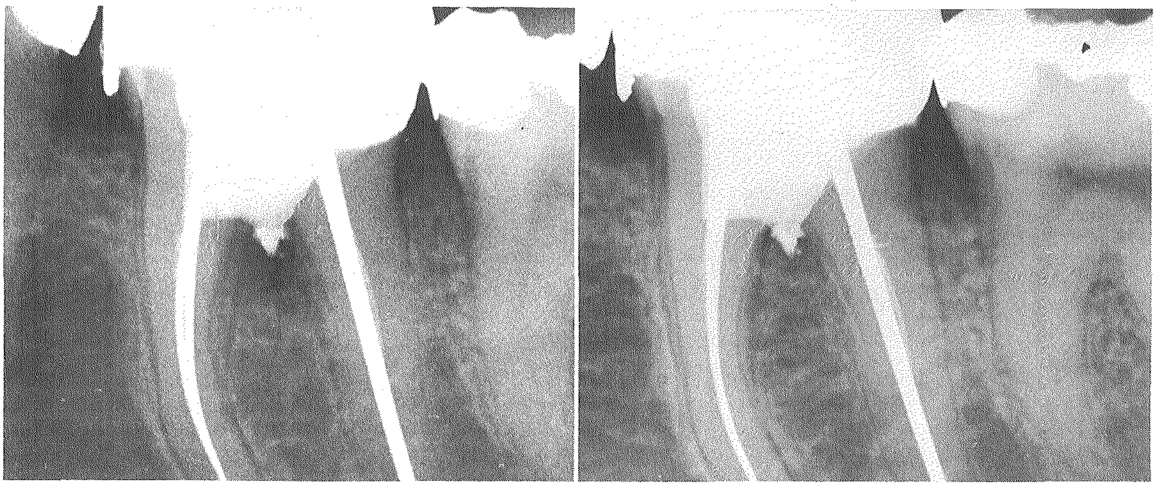
A  B

Fig. 11-36. **A**, Gutta-percha and sealer have been used to fill a mechanical perforation in pulp chamber floor of this molar. **B**, Good bone regeneration has taken place, and there has been no clinical evidence of inflammation at bifurcation two years later.

Fig. 11-37. Precurving of root canal reamers and files as well as silver point was necessary in preparing and obturating curved mesial root in this case. Twist off technique was used to remove silver point from distal root.

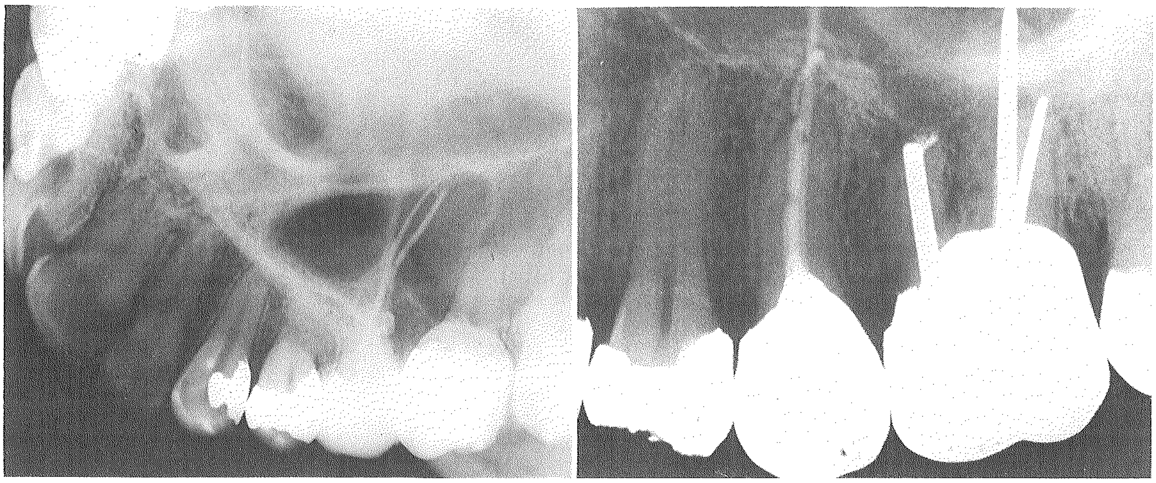
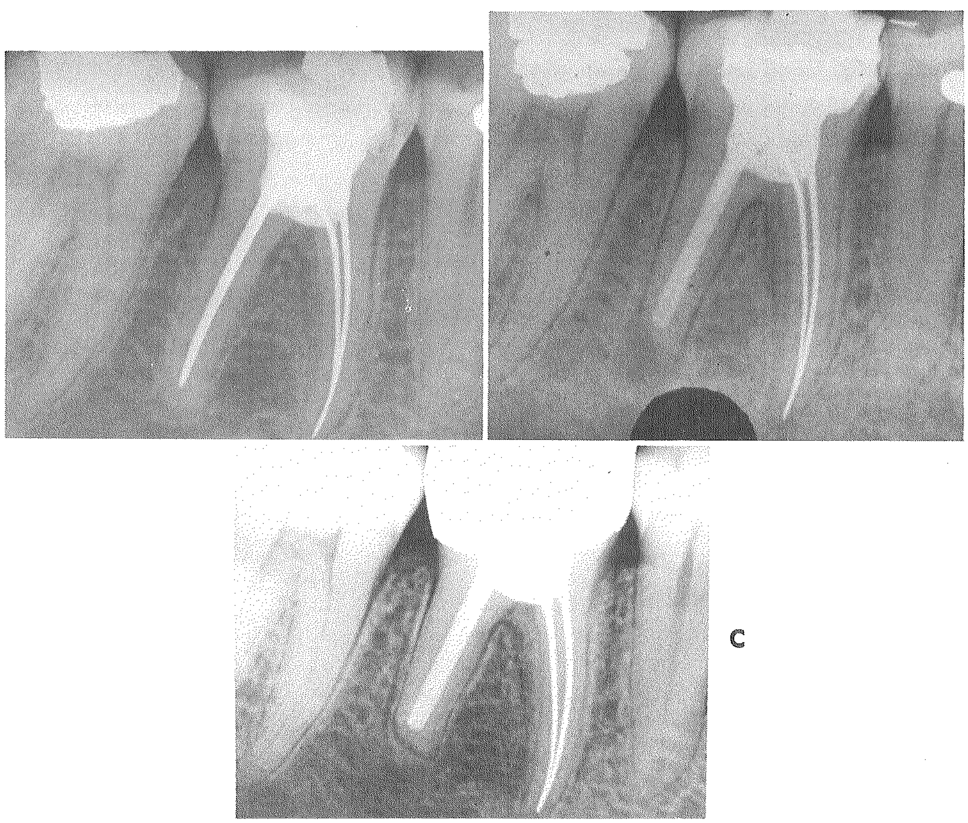
A  B

Fig. 11-38. A, Improper and overzealous lateral condensation by dentist resulted in forcing these gutta-percha points into maxillary sinus. **B,** Root canal was sealed well, and point that was attached remains in sinus ten years later. Tooth has remained totally asymptomatic; however, one point was lost through patient's nose several years after original film was taken.

A  B

C

Fig. 11-39. Distal root canal had been filled previously with a silver point. Lesion developed with apical root resorption, and gutta-percha was used upon retreatment of root canal. In **C** good bone regeneration is demonstrated one year after treatment.

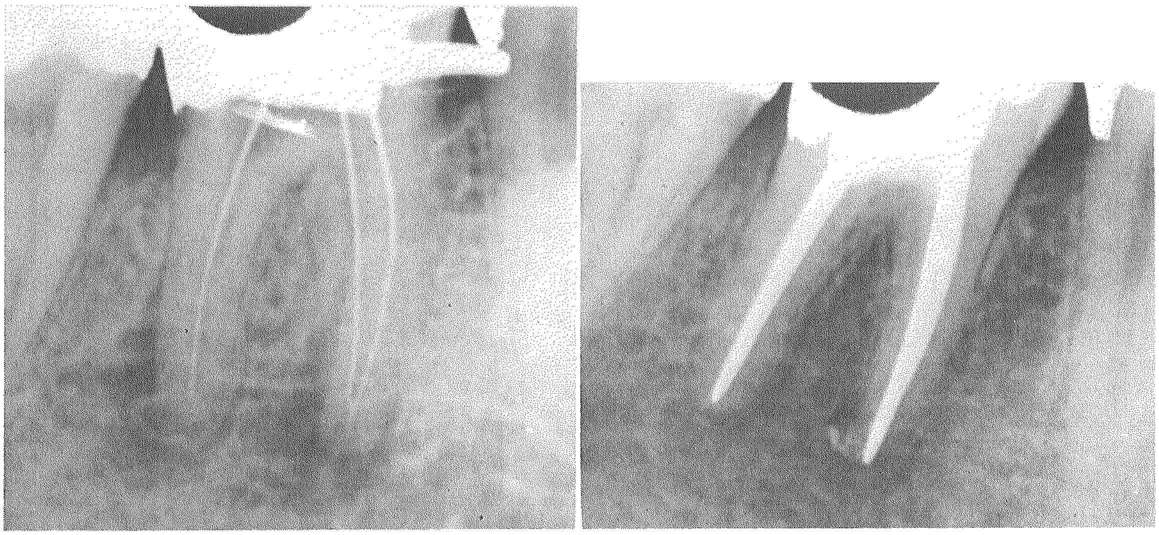
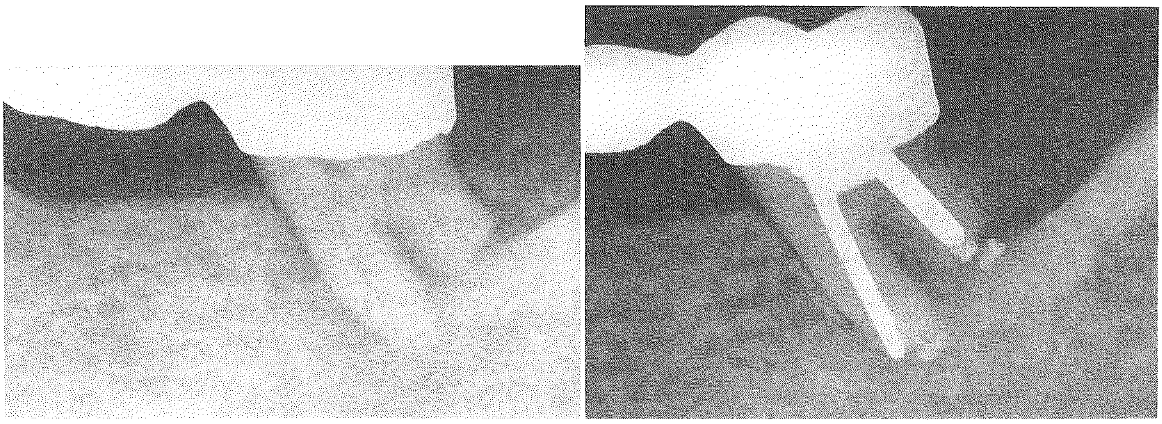


Fig. 11-40. Good bone regeneration of a diffuse periapical lesion is demonstrated six months after endodontic treatment.

A



B

Fig. 11-41. A, This third molar bridge abutment with a large periapical lesion and resorption of distal root had very poor prognosis. Mesial canal bifurcates within apical region, and it was not possible to do more than fill one branch with a major obturating material. By hyperdiamiterization of canals, through instrumentation, and irrigation of other branch, it was possible to fill it with sealer since major canal was obturated with a silver point. **B,** A recheck roentgenogram demonstrates good bone regeneration three years later, and case has been without incident.

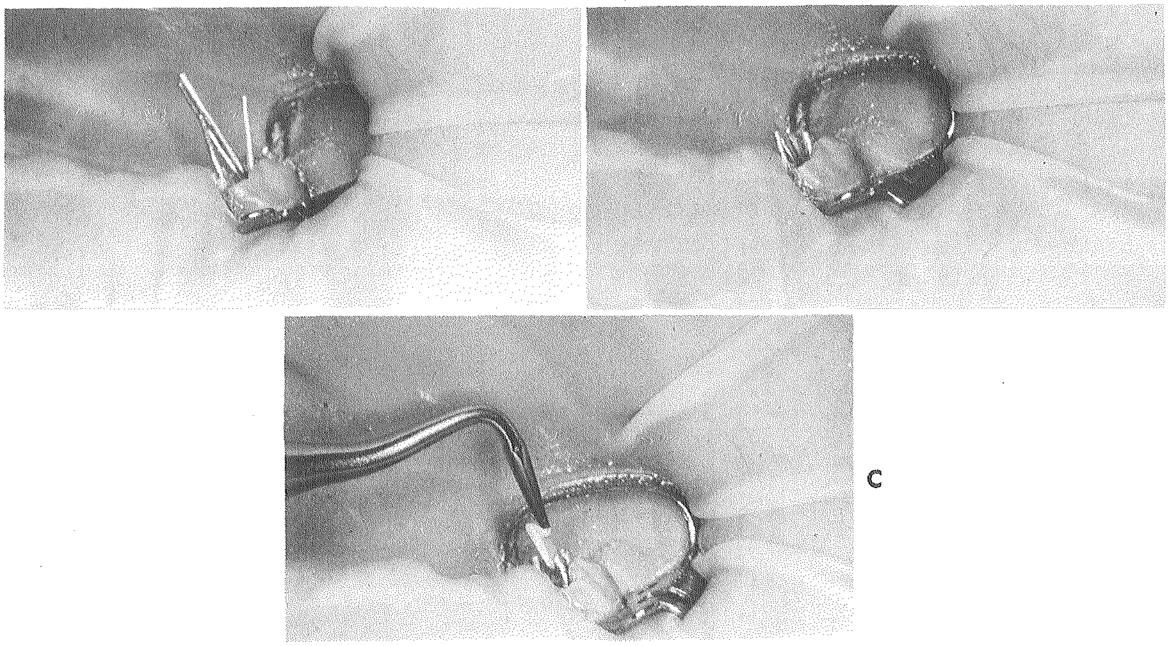


Fig. 11-42. Steps in silver point obturation. **A,** Points are fitted into prepared root canals to calculated length, and a roentgenogram is used to determine their exact position. **B,** Roentgenogram indicates that three points are fitted properly and they are cut level with the highest cuspal point. Fourth point is 1 mm. short of apex and is cut to extend 1 mm. above other points. Then it is moved down flush with other points by enlarging and extending canal or by decreasing the diameter or point. Points are sealed into place with root canal sealer, and their exact position is determined again by a roentgenogram. **C,** Pulp chamber then is filled by condensing warm gutta-percha around silver points. Points are cut off level with pulp chamber roof, using a No. 37 high-speed bur.

Twist off technique

The twist off technique facilitates preparation of the root for intraradicular retention of the restoration. After the silver point has been fitted properly to the root canal, it is removed from the canal and scored at the level of the anticipated post depth. The silver point is cut circumferentially with a carborundum disk so that the apical and coronal segments are joined by a narrow section of silver. (See Fig. 11-43.) The root canal is coated with sealer by the use of a reamer; the apical segment of the point is coated with sealer and is placed into the canal with a straight motion. The coronal segment is separated from the apical segment by rotating it clockwise while exerting apexward pressure on it. The excess sealer then is removed from the coronal segment of the root by the use of reamers. Then it can be prepared for a post of the operator's choice. (See Figs. 11-44 and 11-45.)

This technique is somewhat tricky since ledges in the canal can lead to improper seating of the point. The scored point may break when an attempt is made to retract it, leaving an incompletely filled canal with an obstruction that may prevent retreatment. (See Fig. 11-46.)

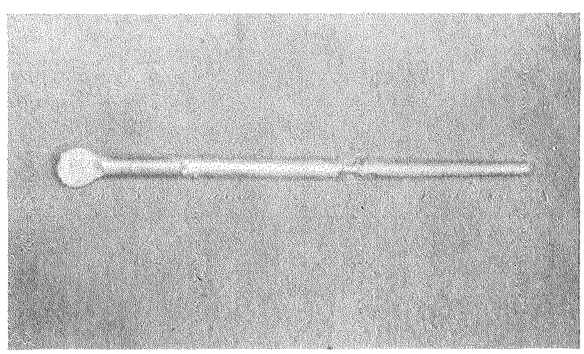


Fig. 11-43. Silver point has been marked for length reference and notched for twisting off after apical segment has been sealed into root canal.

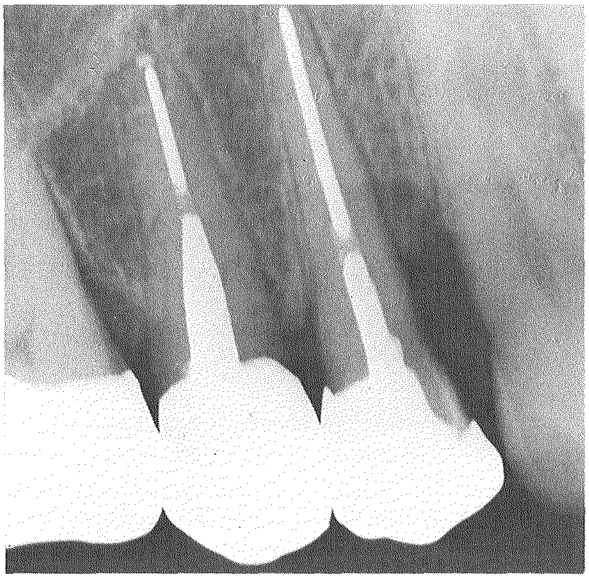


Fig. 11-44. Twist off technique was chosen in both bicuspids so that posts could be used in restorations. A cast gold post was used in second bicuspid and an endo-post in first bicuspid.

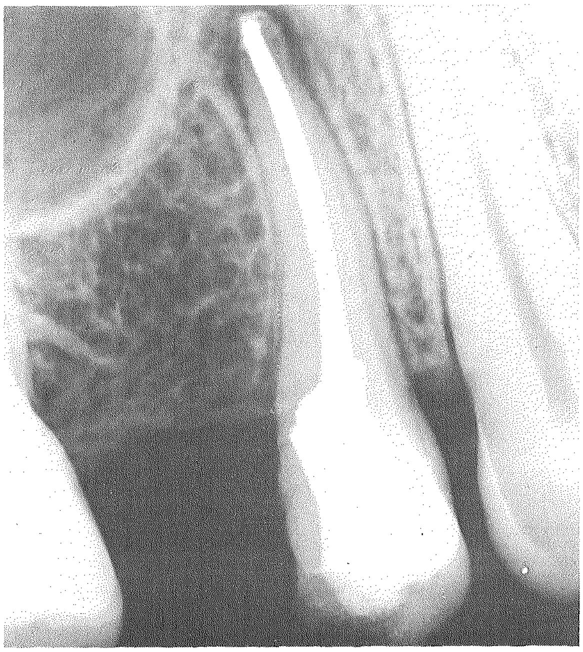


Fig. 11-45. Coronal segment of silver point was notched and twisted out after sealing of apical segment. This part of canal was filled with gutta-percha, which can be removed easily if intraradicular retention of restoration is necessary.

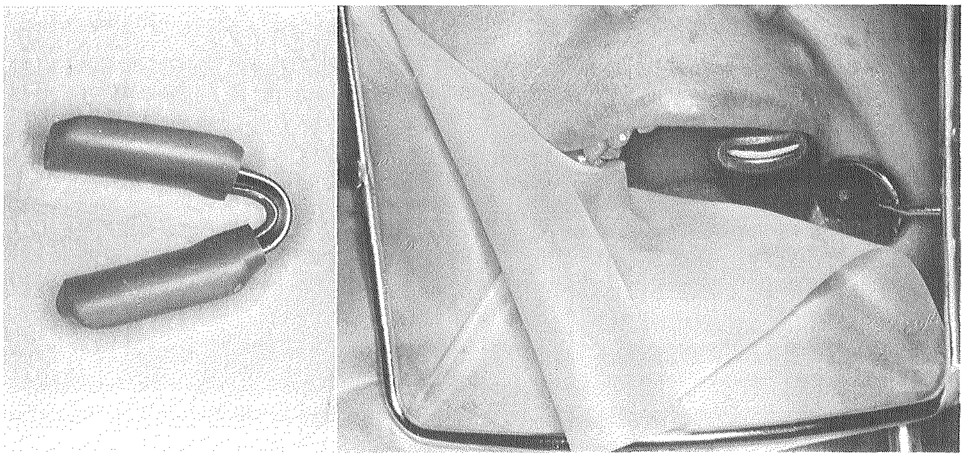


Fig. 11-46. This type of mouth prop is advantageous for long endodontic appointments.

Endodontic surgery

PREDISPOSING FACTORS

Surgery is necessary in only a small percentage of endodontic cases. All patients treated conservatively should be rechecked roentgenographically and clinically within a year. If there is no evidence of proper periapical repair, surgery may be necessary to correct the condition. Teeth that do not become comfortable to the degree that the patient is not aware endodontic treatment has been performed often will respond to periapical surgery. Root resection is required if necrotic tissue is present in a root segment that cannot be negotiated and if a periapical lesion exists. Teeth that have blocked canals, from either previous endodontic attempts or calcification, must have existing periapical lesions removed and the root apex must be sealed with amalgam or gutta-percha. Teeth that have satisfactory dowel crowns but poor root canal fillings with existing periapical lesions will require surgery and reverse obturation. Perforated roots may require surgery to seal the defect, and periodontally involved teeth often require resection of one or more roots. Teeth that do not respond to conservative treatment will require surgery immediately. This group is made up largely of those cases that show large lesions and continue to deliver considerable exudate at each treatment. Many of these will respond to a modified surgical operation (trephination).

In rehabilitation dentistry endodontic surgery is more often a procedure that follows conservative endodontic treatment. On occasion, however, surgery is necessary immediately rather than following a period of observation. Some endodontists feel that, if surgery is to be done, the total procedure of preparing, sterilizing, and filling the root canal, as well as the surgery, can be done in one appointment. I believe the procedure that will give the greatest percentage of success over a long period of time is to perform carefully the usual conservative treatment before the surgery is done. Proper instrumentation, sterilization, and filling of the root canal is absolutely necessary before surgery can be of long-range value. Resecting the apex of the root will remove most inaccessable lateral canals that harbor bacteria, but some such canals may be within the remaining segment of the root. If one rushes through this tedious exacting procedure, it is quite possible that the instrumentation will be cut short. The sterilization of lateral canals and dentin obviously will be slighted. In conservative endodontics the practice is to do most of the instrumentation during the first visit. The instrumentation is rechecked at each appointment and again at the time of obturation. In almost every case it is necessary to enlarge the canals by one or two instrument sizes. In carrying out good instrumentation no substitute for time and careful manipulation of the instruments has been developed. Obviously poor instrumentation leads to poor sterilization and inadequate filling of the root canal. It is not uncommon for a case that has been rushed through in one appointment to show clinical and roentgenographic signs of healing for awhile and then break down because the most important part of the procedure was not done with proper care. The success of the case does not depend on surgery to the degree that it is determined by the way the root canal was prepared, sterilized, and filled. For these reasons then, we may conclude that there is seldom a case that immediate, or one-appointment, endodontics is indicated in rehabilitation. Too much is at stake in these cases to take the risk. To do the case properly will only involve two or three additional treatment appointments.

MINOR ENDODONTIC SURGERY

Trephination

Trephination is performed to establish drainage from a periapical lesion, and it can be done at the apical region of most roots. It is indicated when there has been repeated exacerbations following instrumentation of the root canal and sealing in of medication. This procedure also will serve to eliminate symptoms of mild pain and soreness, which persist in a few cases after filling of the root canal. Other such cases will require a more radical surgical procedure.

A local anesthetic is administered, and a 5 to 10 mm. horizontal incision is made near the root apex. The tissue is separated with a small periosteal elevator, and the bone over the root apex is probed with a pointed instrument. The cortical plate is thin and can be penetrated with the instrument point occasionally, but, if it cannot be penetrated, a 560 fissure bur is used to

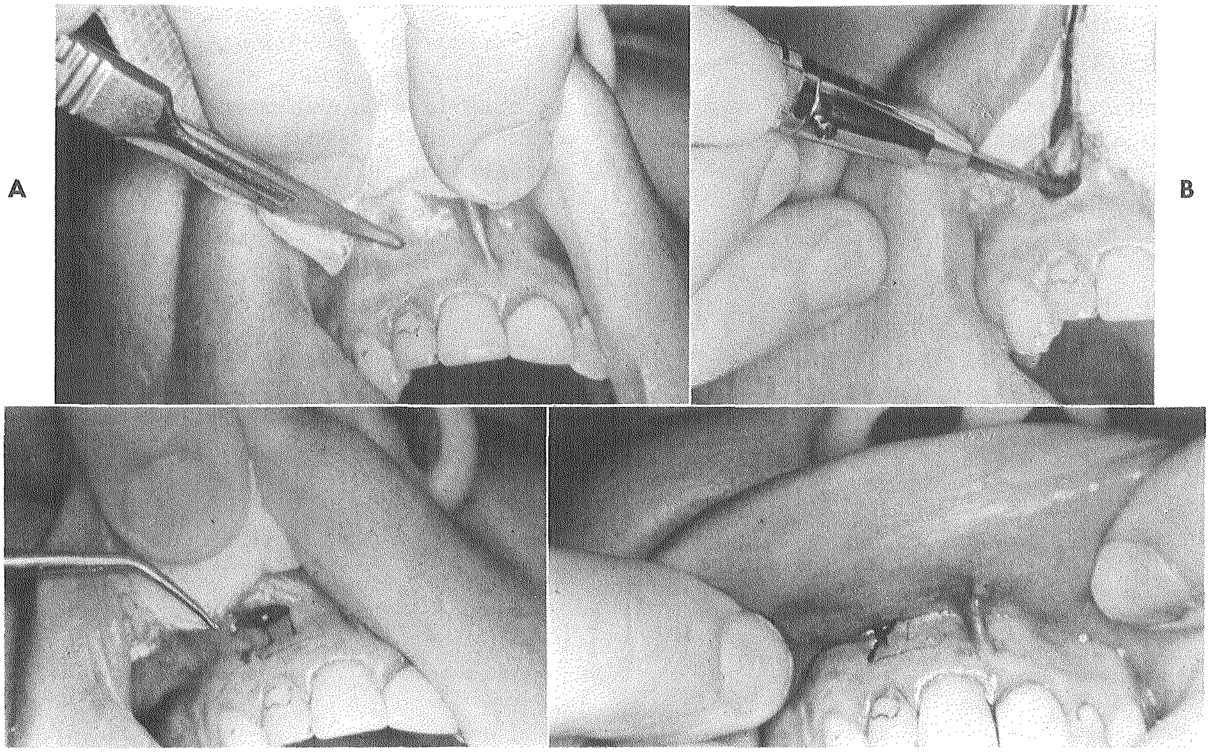
A B C D


Fig. 11-47. A, Incision for trephination operation should be near root apex. **B,** Cortical plate of bone is perforated by using a No. 560 bur at slow speed. **C,** A rubber drain, which is cut in the shape of a capital I, is placed. **D,** One suture is used to close incision.

drill through the cortical plate. The lesion is probed with a thin periodontal curette but is not curetted totally. A piece of rubber dam is cut into the shape of a capital I and is inserted into the mucosal incision. It may be necessary to use one suture to close the incision and maintain the drain. (See Fig. 11-47.) The drain should be removed after one week. It is always wise to seal medication in the root canal at the same appointment as the trephination. Some dentists prefer to clean and seal the root canal before the operation, whereas other prefer to irrigate the root canal through the crown while recovering the irrigating solution at the incision with an aspirator.

Incision and drainage

Incision and drainage is performed when there is a fluctuant area in the soft tissue swelling. It differs from trephination in that perforation of the cortical bone is not necessary, and it is performed in the presence of swelling, whereas trephination should not be done when there is swelling or acute inflammation. The incision should go deep into the area and should be directed to the lowest level of the fluctuant mass to take the maximum advantage of gravity (Fig. 11-48). A local anesthetic is not necessary always but will allow for thorough probing with

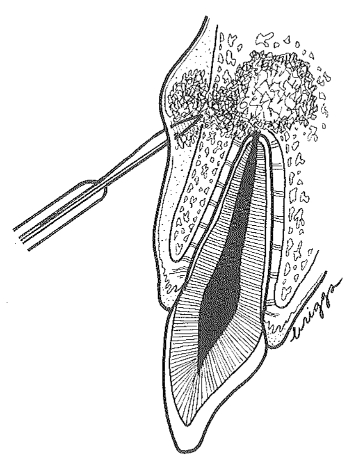


Fig. 11-48. Incision is made so that gravity will aid drainage to greatest extent.

a small curette. This will speed up the elimination of necrotic material.

MAJOR ENDODONTIC SURGERY

Preliminary procedures

In contrast to minor endodontic surgery, which can be done quickly on an emergency basis, major endodontic surgery should be planned with adequate time allowed for it. With rare exceptions it can be done in the office, using a local anesthetic. Better results can be obtained if the patient is premedicated. An antihistamine is prescribed for the patient to begin taking the night before the surgery and to take for two days following. Its purpose is twofold since it tends to relax most patients and will minimize postoperative swelling by counteracting histamine that is released by injured tissues. The patient is told that the prescription will relax him, decrease postoperative swelling, and promote healing.

Mr. John Doe, Jr. Date:
Address:

Rx Chlor-Trimeton 8 mg.
Disp. 8
Sig: 1 q. 8 hr., begin night before appointment

James W. Bynum, D.D.S.

The patient is requested to arrive one-half hour before the surgery is to begin, and upon arrival he is given from ½ to 1 ounce of elixer Nembutal. The amount is determined by the degree of sedation that the antihistamine has produced. The patient should be quite relaxed by the time a local anesthetic is administered.

Periapical curettage

Periapical curettage is indicated when the canal has been well filled and a lesion becomes cystic—or if the canal is well filled laterally but overfilled vertically, with the excess material producing irritation or preventing periapical bone regeneration.

Adequate local anesthetic is given. The area to be operated upon is infiltrated labially or buccally, and supplementary infiltration injections are given at a distance of two teeth on each side of the one that is involved. For mandibular molars and bicuspids a mandibular block is given along with buccal infiltration. For maxillary anterior teeth about 0.5 ml. of anesthetic solution is injected into the incisive canal. For maxillary or mandibular molars and bicuspids an infiltration anesthetic is administrated near the root apex on the palatal or lingual aspect of the involved tooth. One Carpule usually is necessary for the buccal and labial infiltration or block and approximately ½ Carpule is used for the lingual or palatal aspect. (See Fig. 11-49.)

The horizontal incision is made either at the junction of the mucosa and attached gingiva or at the gingival crest. If adequate bone to suture the flap back over can be anticipated, it is best to use the mucosa flap. This flap may be a single semilunar incision, or it may be basically horizontal, with a gradual turn into a vertical flap. In either case it is well to develop a reference point for repositioning the flap by carrying it onto the attached gingiva in one area.

If the flap is reflected from the gingival crevice, the horizontal incision is made almost straight across, with the scalpel point being directed at approximately a 45-degree angle into the crest of the alveolar bone. The incision dissects the gingiva at the bottom of the crevice and leaves the interdental papillae undisturbed. The vertical incision begins one tooth beyond the involved one, turning downward just before reaching the interdental papillae or just after passing through it. Only one vertical incision is needed.

The flap is reflected along with its periosteum by a periosteal elevator. It often is necessary to use the scalpel to complete the flap reflection. (See Fig. 11-50.)

The bone over the labial or buccal surface is often thin or may be eroded completely. In either case the window can be made with a sharp periosteal elevator or St. Louis wax spatula.

If the bone is dense, which is probable, over the apex of maxillary lateral incisors, a bone bur or 558 straight fissure bur can be used to shape the window. While drilling, the assistant should spray the field with saline solution to which a few drops of antiseptic has been added (Fig. 11-51). She simultaneously aspirates, to keep the field clean.

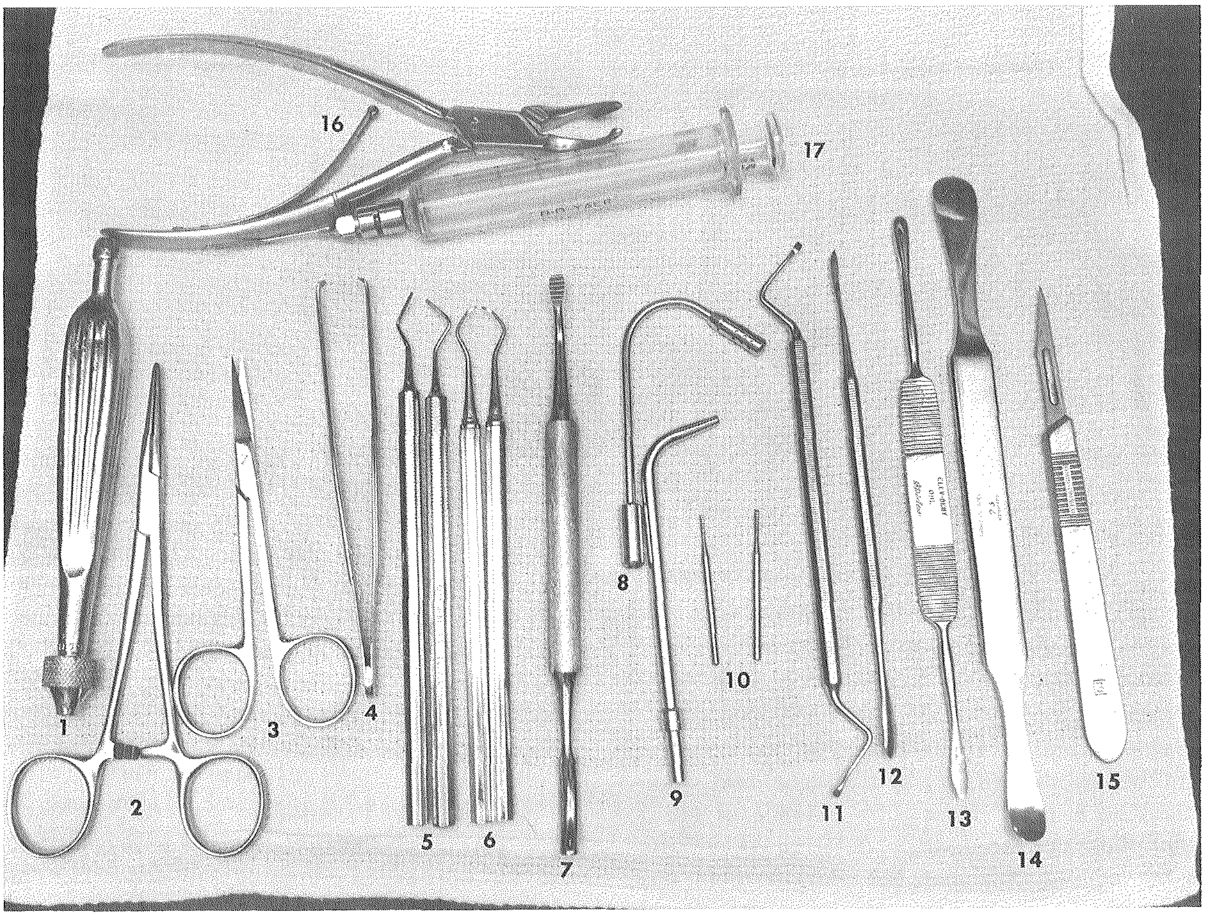
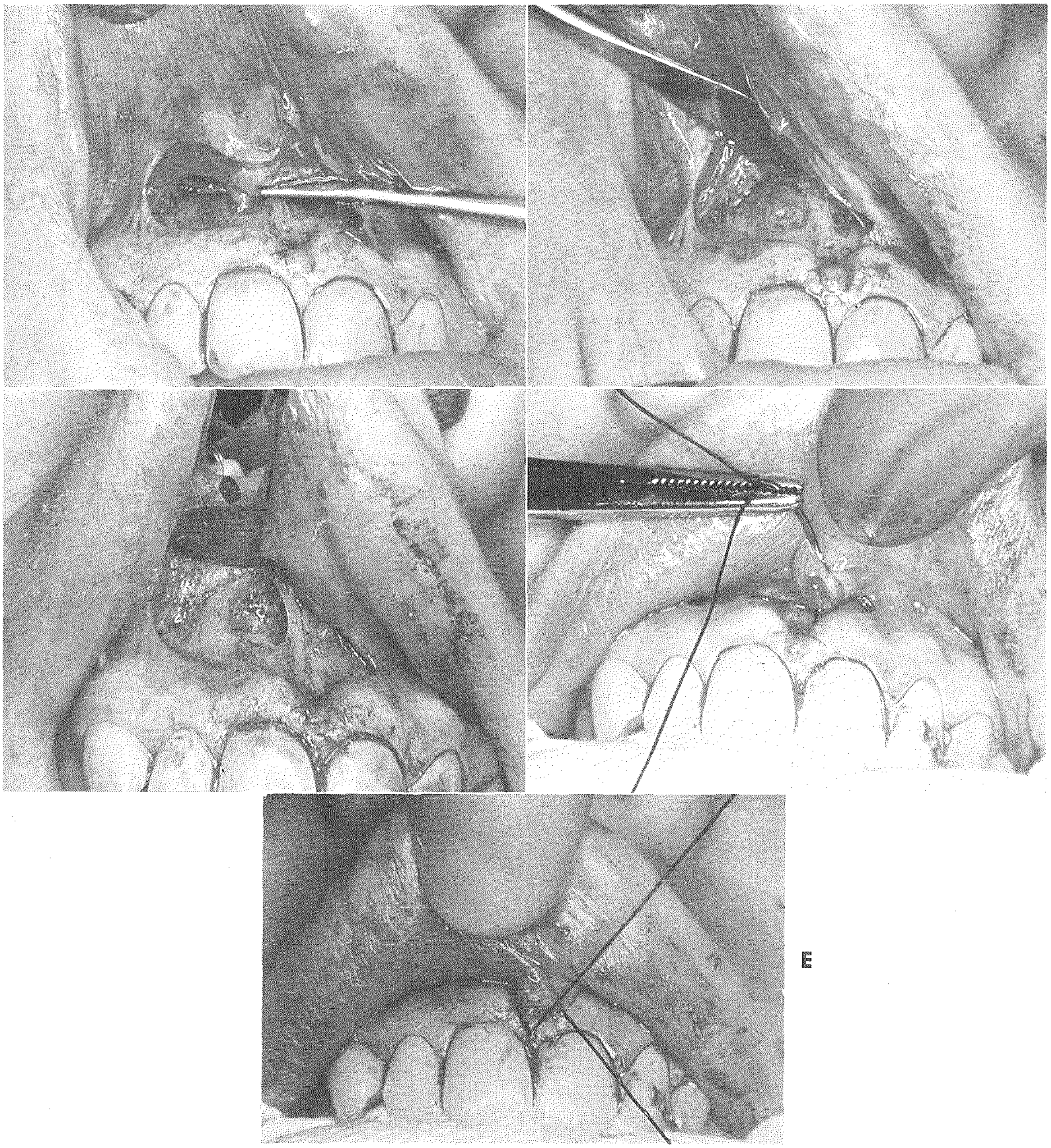


Fig. 11-49. These instruments are all that will be needed in most cases of periapical surgery. Additional instruments for condensing amalgam are necessary for reverse obturation.

1. Aspirator handle
2. Needle holder
3. Scissors
4. Tissue forceps
5. Nos. 11 and 12 plater files
6. Nos. 5 and 6 tarno curettes
7. Bone file
8. Saliva ejector
9. Aspirator tip
10. Burs
11. No. 2 curette
12. No. 7 wax spatula
13. Periosteal elevator
14. No. 23 tissue retractor elevator
15. Scalpel
16. Bone-cutting forceps
17. Syringe

A



B

C

D

E

Fig. 11-50. A, Mucosal flap is illustrated in this case. Periapical lesion has perforated cortical plate and has fused to mucosa. Fused area is incised after flap has been reflected around it. **B,** Flap now has been totally reflected, and lesion is exposed. **C,** Lesion has been curetted and apex of root smoothed with a periodontal file. **D** and **E,** When labial frenum has been incised, it is best to suture it from both sides with a continuous suture, as illustrated.

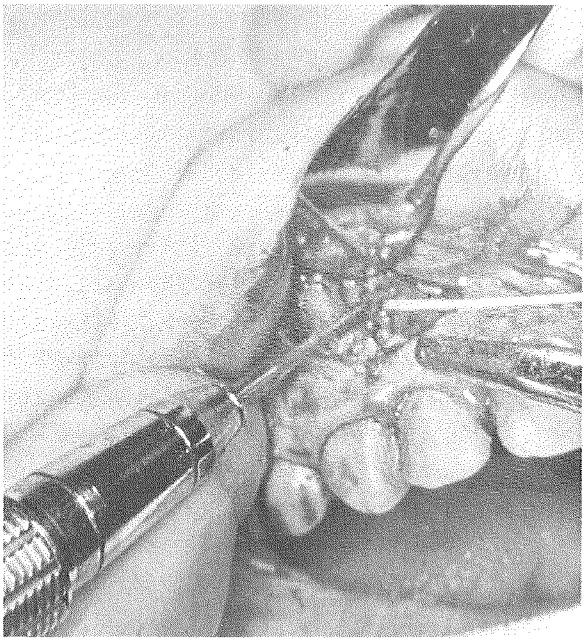


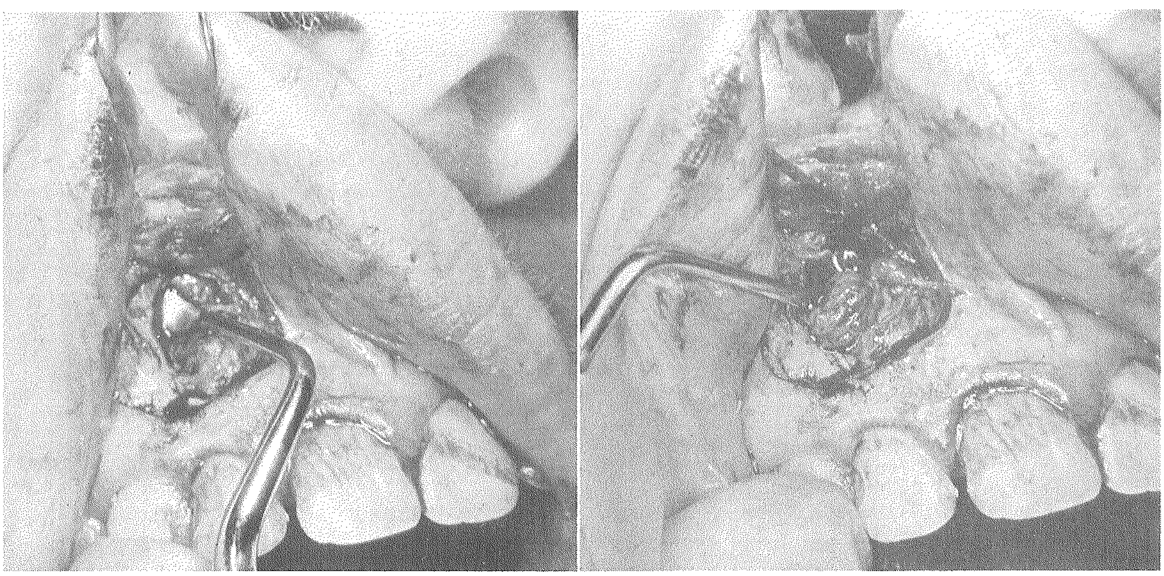
Fig. 11-51. Normal saline solution is sprayed onto bur as access window to lesion is prepared.

First the lesion is separated from the labial or buccal region of the bone by an elevator. A No. 2 or 3 curette is used next, delicately dissecting with the concave surface toward the bone after the buccal or labial half of the lesion has been detached from the bone. (See Fig. 11-52.)

Small periodontal curettes then are used to separate the lesion from the root apex. Periodontal files are used to separate the most tenacious segments of tissue. (See Fig. 11-53.) The root apex is shaved lightly with a straight fissure bur and is smoothed with the periodontal file. All fragments of granulation tissue are removed from the bone and from around the root apex. The cavity again is irrigated thoroughly and aspirated. If there is uncertainty about removal of all excess foreign material, a roentgenogram should be taken before the flap is sutured. If the mucosal gingival flap is used, the gingiva should be elevated 2 mm. before suturing.

To insure a good grip into the tissue when the flap has been reflected from the gingival crevice, the suture should be carried through the gingiva, the interdental papilla, around a tooth, back through the contact, and tied. The vertical incision ordinarily will require only one suture.

A



B

Fig. 11-52. A, Lesion is separated from its lateral and superior walls by using a No. 2 or 3 curette with its concave surface toward bone. **B,** Lesion then is curetted from its deep wall by use of a No. 2 or 3 curette with concave surface toward lesion.

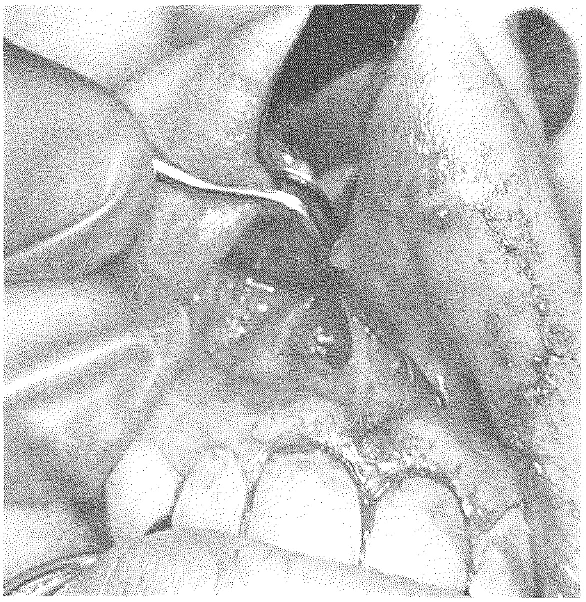


Fig. 11-53. Small periodontal curettes or peridontal files are used to remove firmly attached segment of lesion from root apex.

Root resection

Root resection is indicated when the apex has not been filled properly or when lateral canals prevent proper healing. It also is necessary to resect the apical segment of the root if it is not possible to curette the lesion properly. If the canal bifurcates within the apical one-third of the root, it usually is not possible to prepare properly and obturate both segments of the canals; thus the unfilled one must be removed. (See Fig. 11-54.)

The flap procedure and window formation are the same as described for curettage. A 558 crosscut fissure bur is used to cut through the root. After the apex has been resected the root end is smoothed and rounded with peridontal files. Residual granulation tissue must be removed; this often can be done better after the resection. (See Fig. 11-55.)

Root amputation

For root amputation the flap is reflected from the gingival crevice, and the entire root is sectioned at the base of the crown. The crown must be decreased in size in proportion to the lost root. If one of three roots is removed, the crown should be no more than two-thirds its original size, reduction being made in a buccolingual direction. This tooth must be relieved of at least one-third of its original load. Many of these teeth are involved periodontally, and this treatment is necessary when the root apex communicates with the periodontal lesion. If this tooth is part of a multiple restoration, it may be impractical and unnecessary to reduce the crown size until the restoration is remade. (See Figs. 11-56 to 11-58.)

Reverse obturation

Reverse obturation is indicated when the root canal cannot be negotiated and a periapical lesion exists. The root canal can be sealed at the apex with amalgam, provided it is accessible. This operation is limited primarily to maxillary anterior teeth, bicuspids, and the buccal roots of molars. Mandibular anterior teeth are accessible in some mouths. They are usually quite narrow and do not allow space for the proper preparation.

The technique is to expose the root apex as previously described and to resect the apical one-fourth of the root at a labial angle so that the root canal can be visualized. A slot that includes the root canal is cut from the apex down the labial wall to a distance of 3 mm. with a 557 bur. A round bur that is larger than the first cut is used to enlarge the canal, starting at the apex and moving it down through the canal before withdrawing it labially at the base of the first cut. This gives a double-lock retention preparation.

Another technique is to prepare the canal from the apex, using inverted cone burs in a contra-angle. A preparation is made with retention points leaving the labial surface undisturbed.

Zinc-free alloy is mixed and condensed into the cavity. It should be flush with the surfaces of the tooth but need not be contoured. (See Figs. 11-59 and 11-60.)

The area must be irrigated and aspirated since it is difficult to prevent small pieces of alloy from collecting in the tissue. A roentgenogram must be taken before suturing. Further irrigation while using a curette in the area of the loose amalgam will meet with success in removing amalgam fragments.

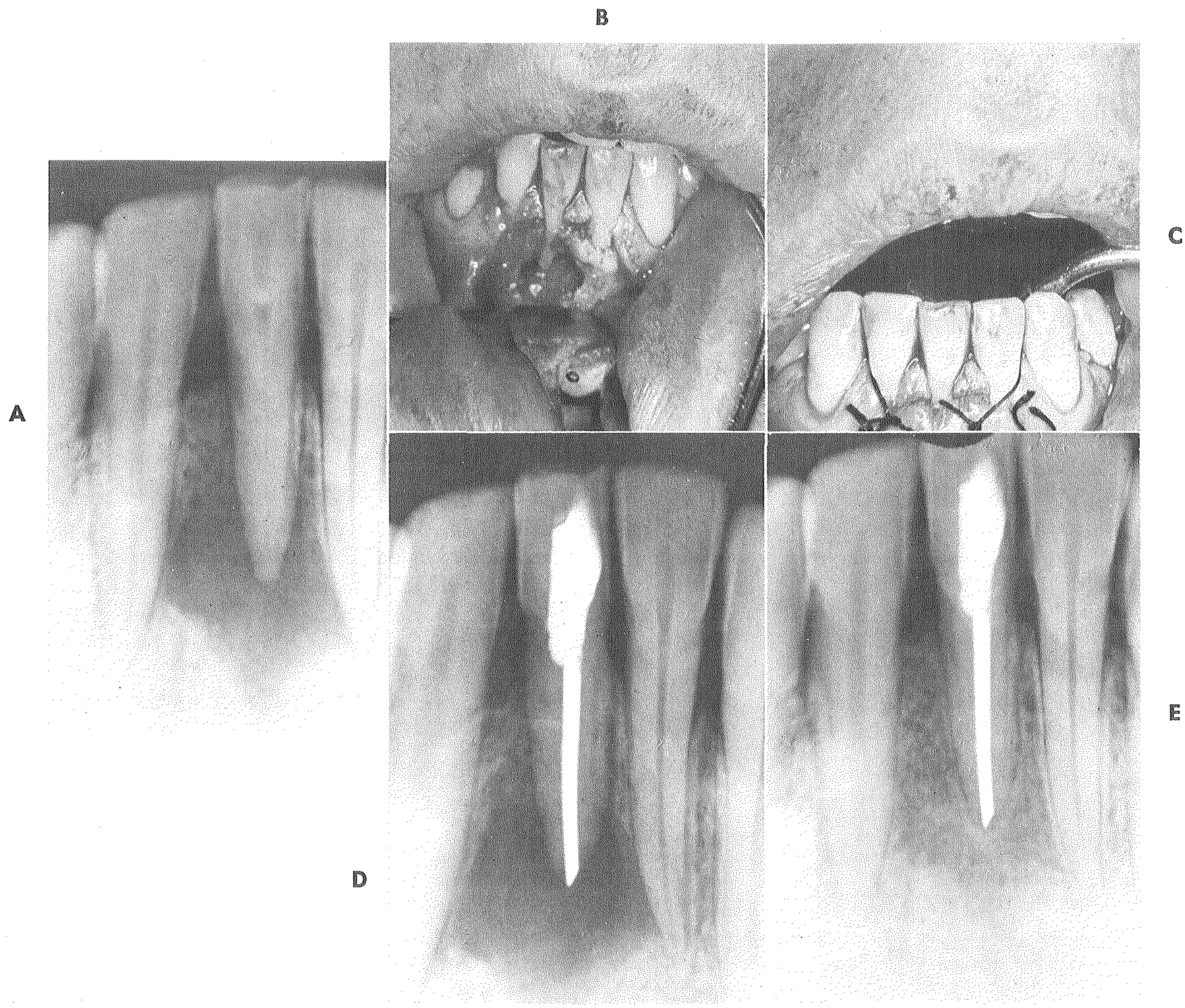


Fig. 11-54. Series on root resection. **A,** Preoperative roentgenogram of root resection case. **B,** Flap has been reflected and lesion curetted. **C,** Flap has been sutured through interdental papilla and around teeth. **D,** Roentgenogram after root resection. **E,** A re-check roentgenogram demonstrates good bone regeneration one year after surgery.

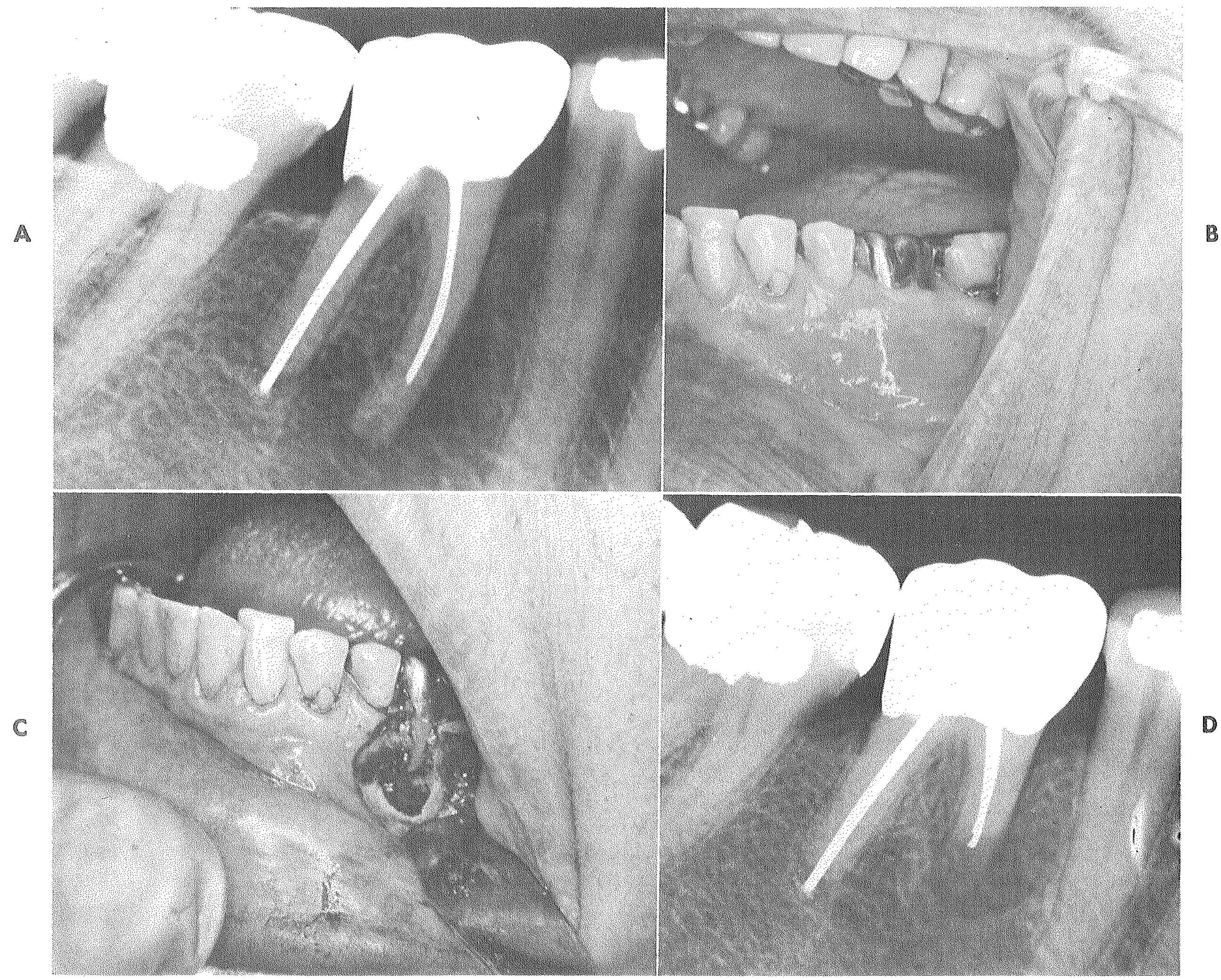


Fig. 11-55. Molar root resection series. **A,** Preoperative roentgenogram and a history from referring dentist indicate that apical region of mesial root canals are calcified and that canals were filled properly to that level. **B,** Preoperative photograph. **C,** Flap has been reflected, root apex resected, and lesion curetted. **D,** Postoperative roentgenogram reveals that only mesial root was resected. It was judged to be better to remove distal point and obturate to apex rather than resect it.

A B C D E F

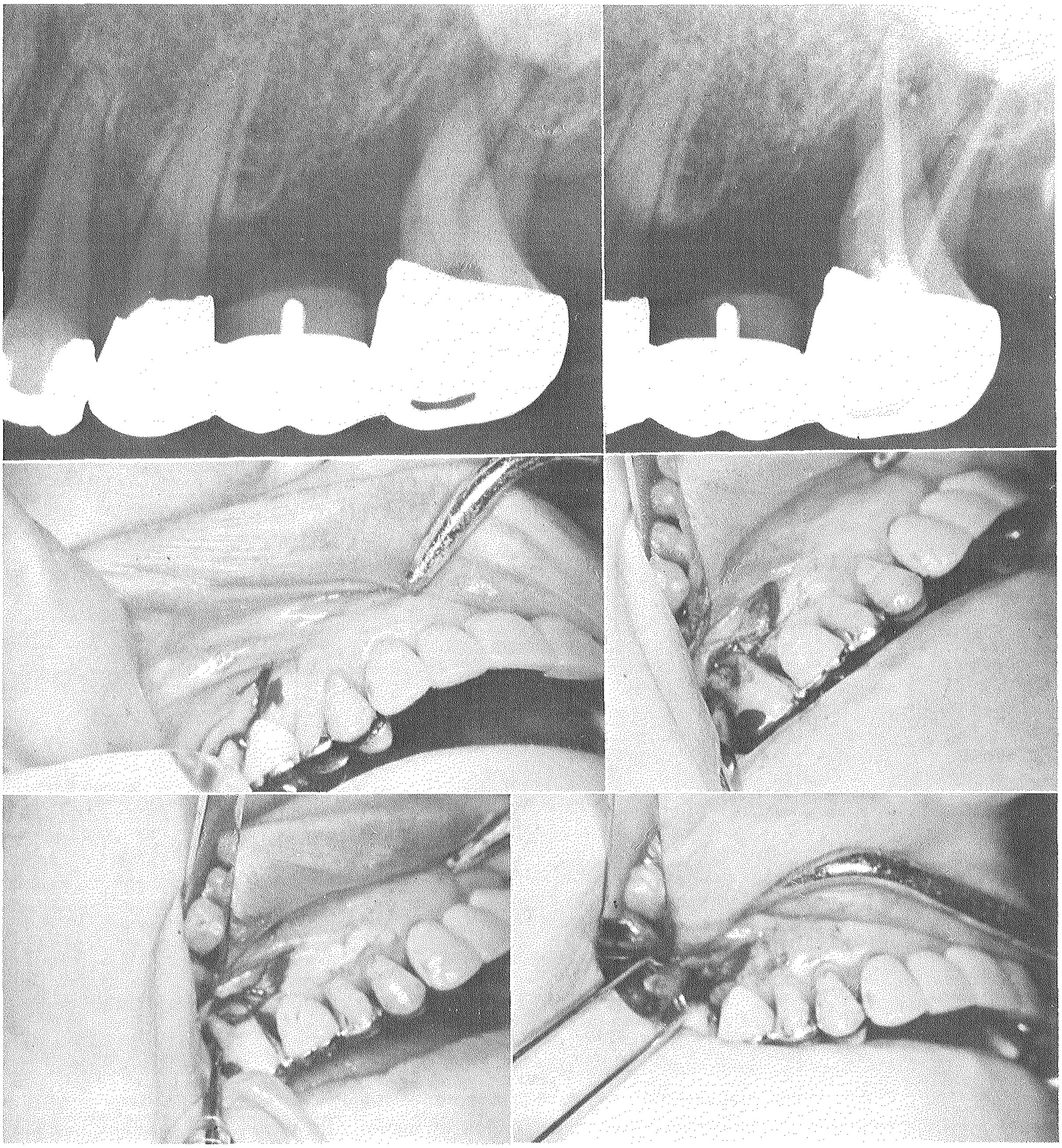
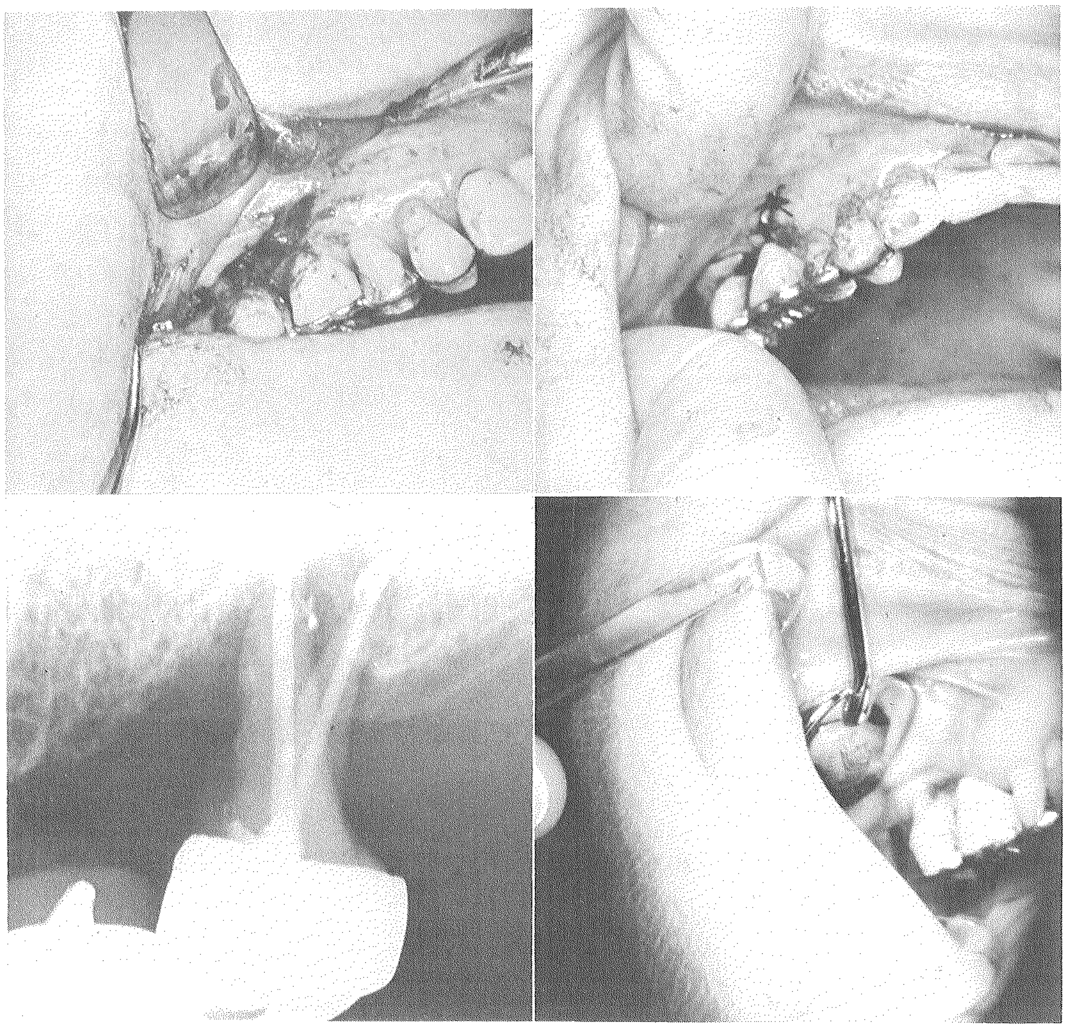


Fig. 11-56. Root amputation series. **A,** Preoperative roentgenogram reveals a curved mesiobuccal root with a periodontal lesion extending to apex. **B,** Postobturation roentgenogram. **C,** Incision for flap has been made. **D,** Reflected flap has exposed mesiobuccal root. **E,** Mesiobuccal root has been sectioned with a No. 558 bur at base of crown. **F,** Root is being removed. **G,** Postamputation view. **H,** Flap has been sutured into position. **I,** Postoperative roentgenogram reveals mesiobuccal root resected. **J,** Photograph taken one month postoperatively.

G H



I J

Fig. 11-56, cont'd. For legend see opposite page.

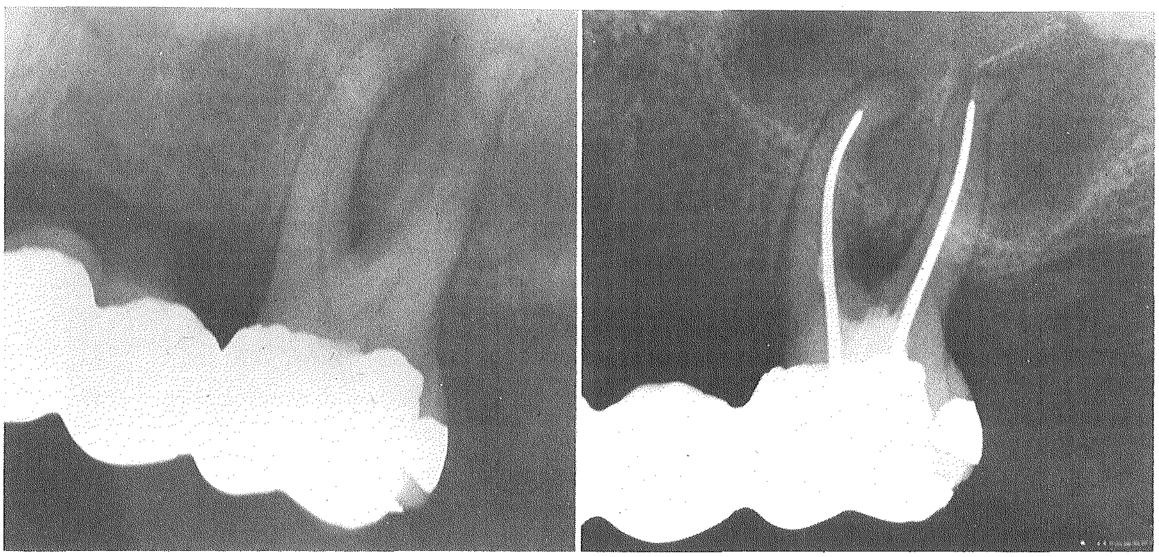
A  B

Fig. 11-57. Palatal root amputation series. **A,** In this case periodontal lesion extended to apex of palatal root and treatment was to remove a healthy pulp, obturate buccal root canals, and amputate palatal root at crown level. **B,** Palatal root has been amputated and buccal roots obturated. It was not possible to negotiate buccal root canals to apex, but resection of unfilled segments was not done, since it had been a vital extirpation and possibility of subsequent difficulty was not considered to be as great as consequences of loss of additional root support.

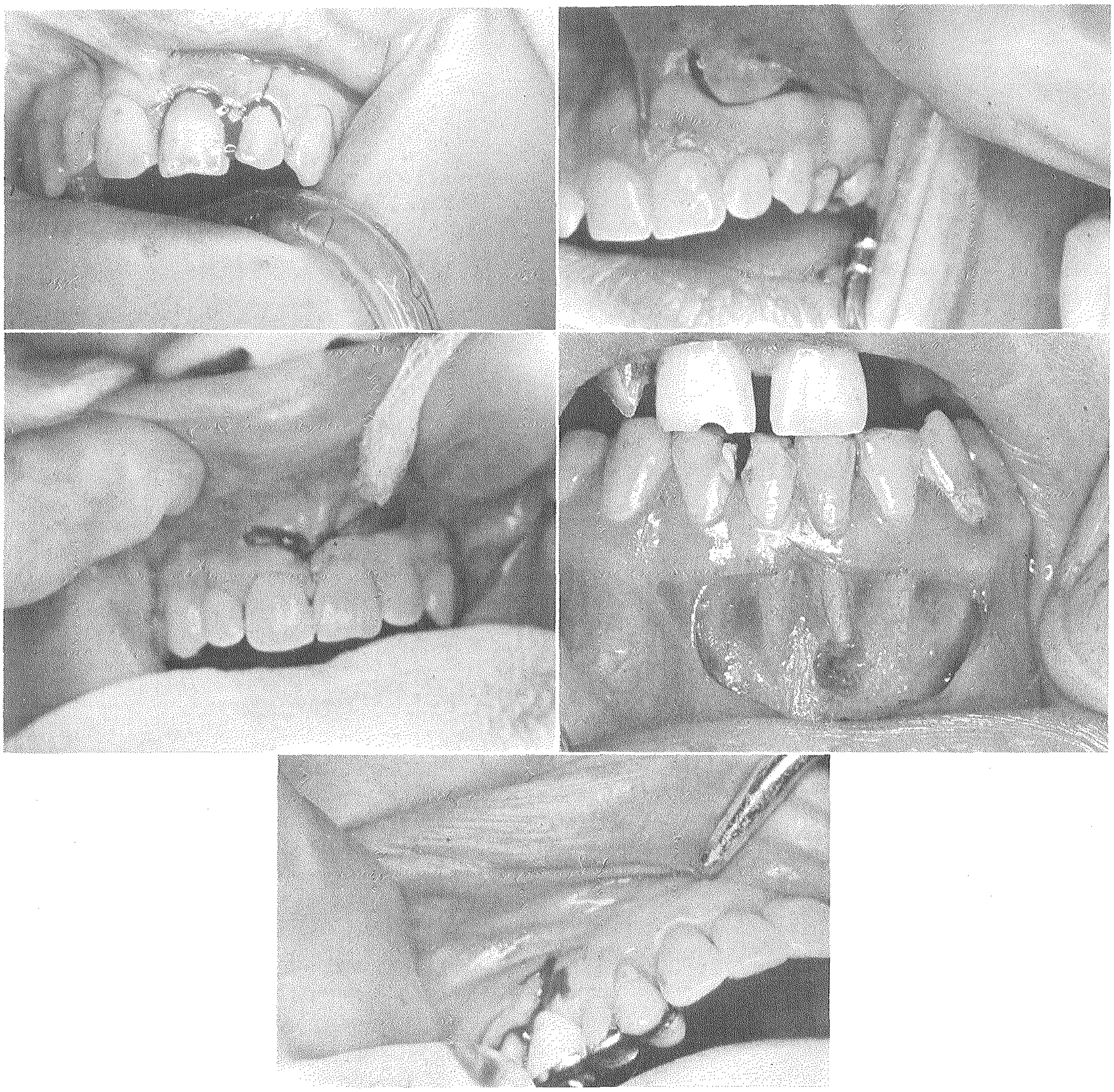


Fig. 11-58. Types of flap incisions used in endodontics.

A
B
C
D

Fig. 11-59. Reverse obturation series. **A,** Preoperative roentgenogram of a case requiring reverse obturation. **B,** Postoperative roentgenogram. **C,** One year recheck roentgenogram of case in **A,** which was sealed at apex with zinc-free alloy. **D,** Buccal root canals of this molar were calcified with periapical lesions present. Roentgenogram was taken after reverse obturation with zinc-free alloy.

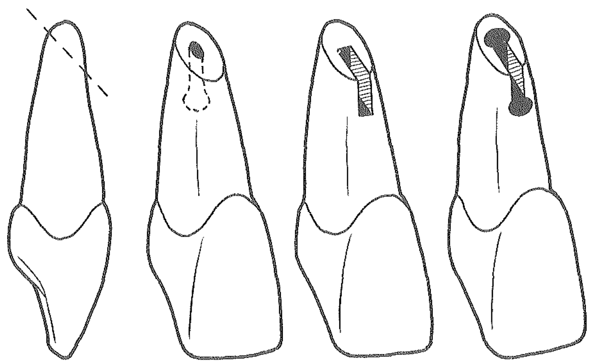


Fig. 11-60. Two preparations of root for reverse obturation are illustrated. Preparation B was completed in two steps (**A** and **B**), and preparation **D** was completed in three steps (**A**, **C**, and **D**).

Preparation of root canals for coronal retention

Intraradicular retention of the coronal restoration is an important link in the chain of long-term success of endodontically treated teeth.

Removing the filling material from the coronal segment of the root can lead to failure of the endodontic case if it is done improperly. Gutta-percha may be removed by using reamers and a solvent such as chloroform or xylene. If too much solvent is used, the total filling may be damaged. Gutta-percha may be removed from the canal with a round bur that is slightly larger than the root canal. The use of a latch type miniature contra-angle with regular length burs gives an advantage. The root canal filling must not be disturbed in the apical third of the root. It is much safer to stop the post preparation at the middle of the root if adequate retention can be obtained. Although there is some danger in using a shorter post than is ideal, there is equal danger that the case will fail because the root canal seal has been disturbed. After the proper length has been reached by using the sharp round bur at medium speed, a flame-shaped bur is used to flare the coronal segment. This will enable you to obtain a good impression in the root canals. If additional depth is needed after the bur length has been exhausted, a reamer with xylene or chloroform can be used. It is wise to dip the reamer in the solvent before using it rather than to flood the root canal with the solvent. Excess solvent will cause shrinkage of the root canal filling and destroy the apical seal.

If a post is anticipated at the time the root canal is filled, the sectional gutta-percha technique or silver point twist off technique may be used. Only the apical half of the root canal is filled. (See Figs. 11-61 and 11-62.)

Fig. 11-61. Distal canal was prepared for taking a postimpression by twisting out silver point and enlarging canal with a flame-shaped bur.

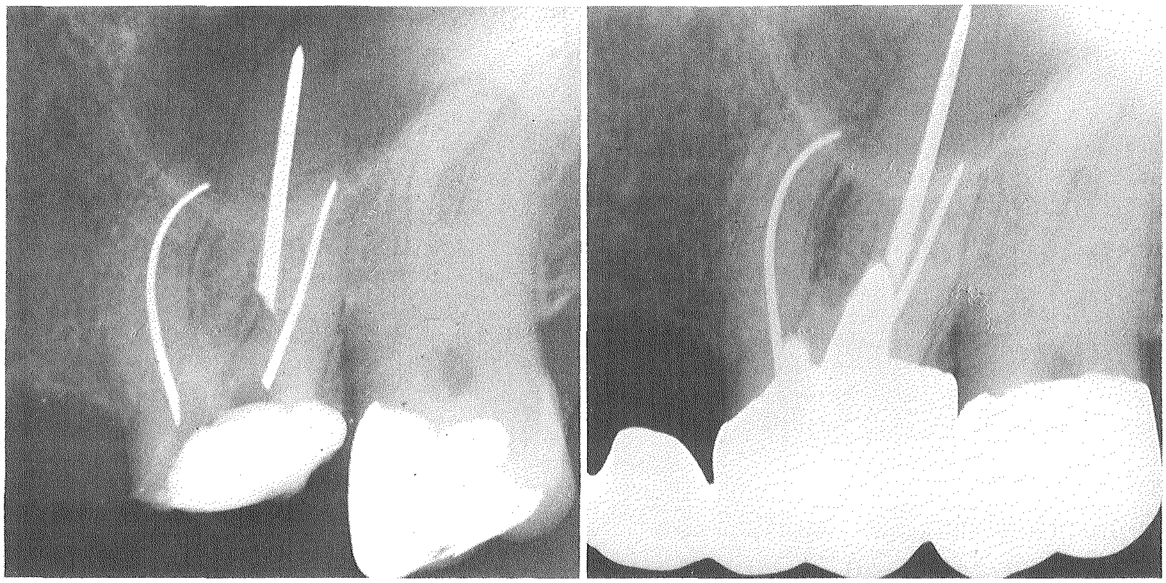
A  B

Fig. 11-62. A, Intraradicular retention became necessary several years after endodontic therapy had been performed; thus it was necessary to prepare tooth for posts by drilling out silver points. Bur used must be sharp and larger than silver point. **B,** Restoration has been placed in tooth seen in **A.**

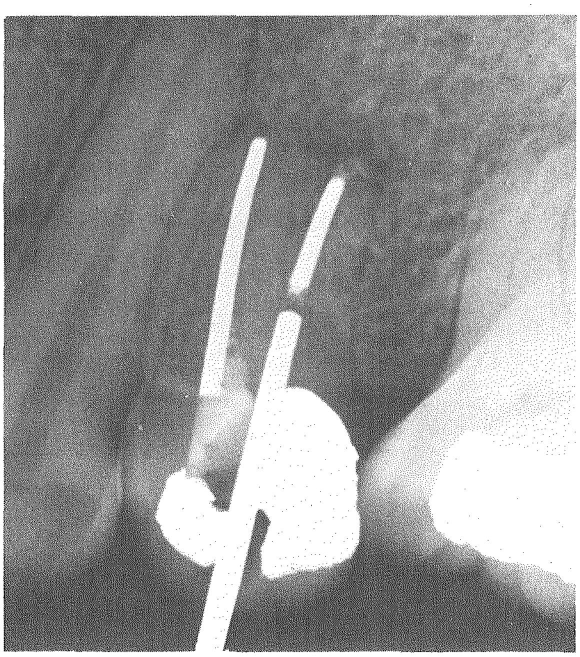


Fig. 11-63. Endo-post has been fitted into buccal root.

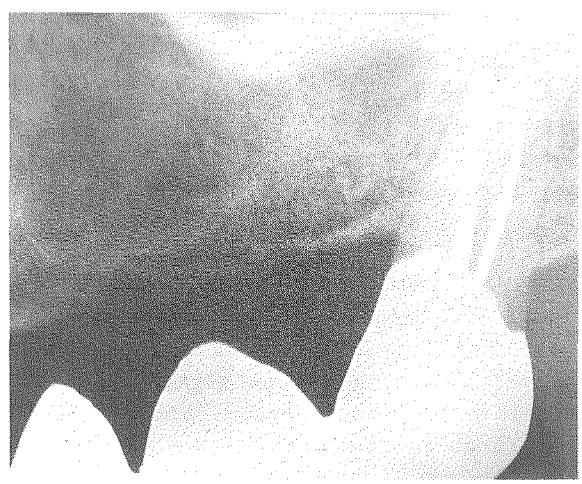


Fig. 11-64. Endo-post was fitted to palatal root at time root canal was obturated, and it now has been made part of finished restoration.

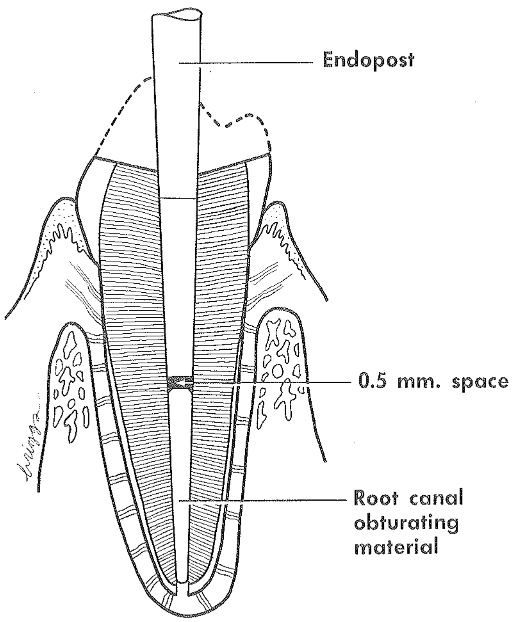


Fig. 11-65. Size and position of endo-post in relationship to root canal filling material is illustrated.

The recent development of the Kerr endo-post makes it possible to conserve tooth structure. These are most useful in the case of small roots and others that would present difficulty in taking an impression. They correspond in size and taper to standardized files and reamers. They are available in sizes 70, 80, 90, 100, 120, and 140 and can be obtained as regular or high-fusing types. They are suited especially for canals that are of uniform taper and shape throughout and are contraindicated for wide flaring ovoid canals such as are present in many maxillary central incisors and canines.

It may be used easily with the silver point twist off technique or the gutta-percha sectional technique.

After the filling material is removed from the segment of the root that is to receive the endo-post, the canal should be reamed at least three reamer calibrations and the corresponding post fitted. A 1 mm. space should be allowed between the root canal filling material and the base of the endo-post. The post should go in freely but should not be loose. (See Figs. 11-63 to 11-65.)

This space will allow for excess cement in placing the final casting and prevent interference with the apical seal by undue pressure.

It is wise to fit the endo-post at the same appointment that the root canal is filled. If the patient has been referred, the endodontist can fit the endo-post, mark it to an occlusal or incisal high point, and return it to the referring dentist.

The endo-post may be picked up with the impression or can be picked up with the wax pattern made by the direct method.

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Chapter 12

Mandibular physiology

ANTHONY J. DE PIETRO, B.S., D.D.S.

"Technics are mere servants to principles. When anyone takes over the technic of a predecessor without sharing the vision which animated it, he takes over a mental body, but loses its immortal soul."
Andrew Francis Jackson

Spatiotemporal continuum

GENERAL CONSIDERATIONS

Every restorative task that dentists are called upon to perform involves the positional relationship of one occlusal surface to its antagonist; the function of the occlusal surfaces of the teeth becomes the final expression of the entire masticatory organ. This organ consists of the temporomandibular articulation with its muscles and ligaments and the teeth with their supporting structures, synchronized into a functioning unit by the integrated action of the fifth, seventh, and twelfth cranial nerves.

The following discussion is predicated on the "discipline of balance" in an effort to present a more tangible visual image of mandibular movements as they relate to the fixed maxilla. It should be understood clearly that, at this particular time, I in no way believe or endorse this type of occlusal function when called upon to restore natural teeth.

The function of the masticatory apparatus is the efficient preparation of food for deglutition and digestion. This organ performs the task with occlusal forms functioning in a *spatiotemporal continuum* that is produced by numerous individual factors. A spatiotemporal continuum may be defined as a three-dimensional interocclusal space bounded by six imaginary unequal sides; the angle between any two adjacent faces may or may not be at right angles to one another and is continually changing in angulation, size, and shape at different time intervals when the mandible is rotating and translating. It is the space formed by the various relationships of the mandible to the maxilla. The factors that influence the continuum can be classified into two groups—variable and fixed. The variable group consists of all factors that can be altered in a limited degree by the operator. The fixed group of factors are those that are presented by the patient, and the operator cannot alter them in any way. They must be recorded and used as presented. (See Fig. 12-1.)

Fixed factors of occlusion

By observing the functional patterns of the mandibular teeth to their counterparts in the maxillary arch, a variety of excursions are noted and may be divided into centric and eccentric positions.

Centric position is that *static* relationship of maxillary lingual and mandibular buccal cusps in the opposing embrasures and fossae when both condylar elements are positioned in the most su-

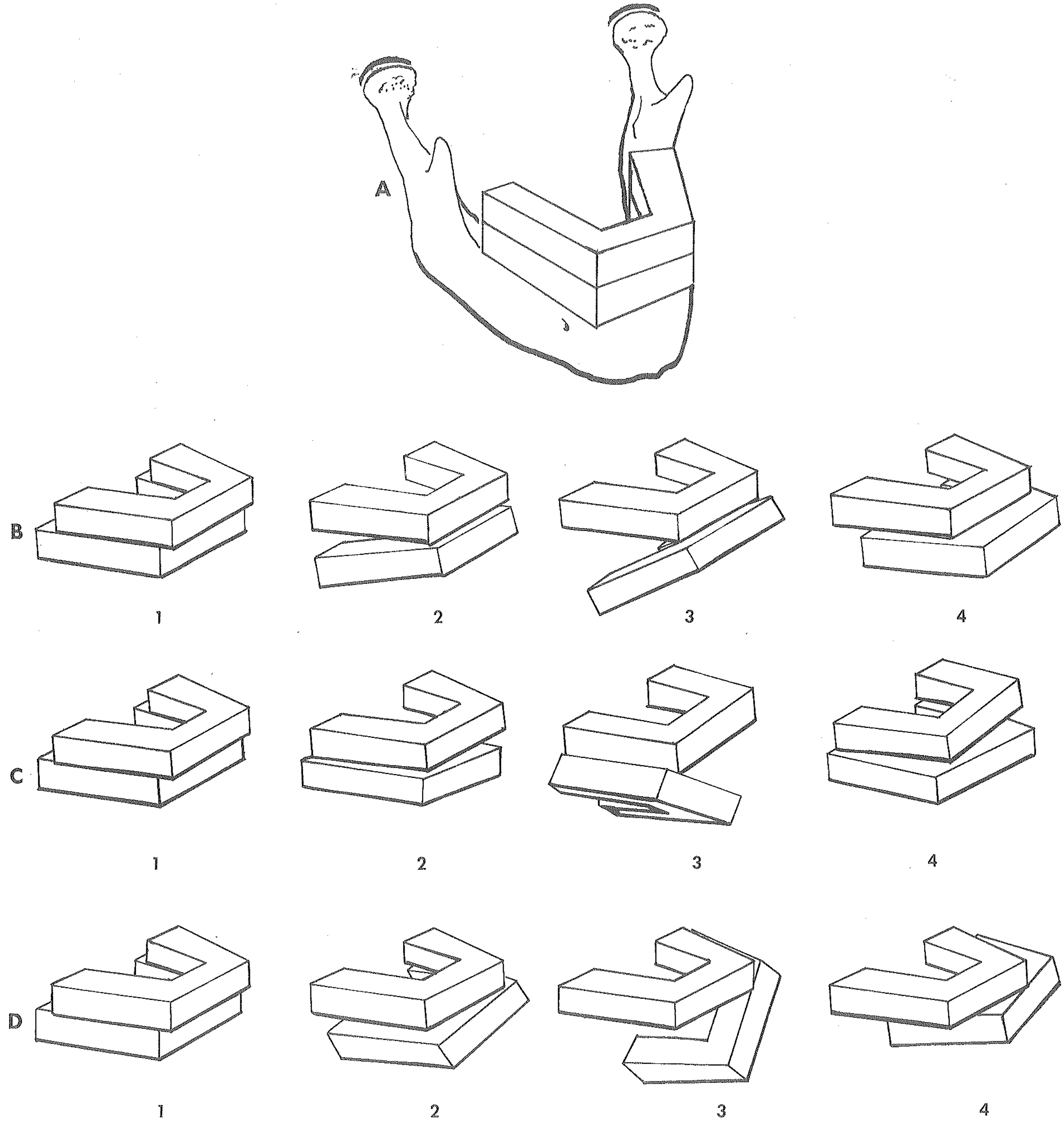
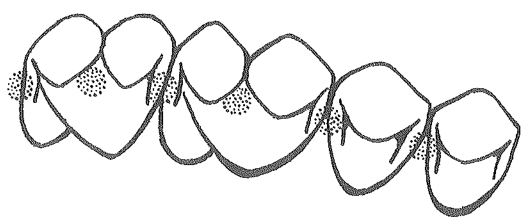
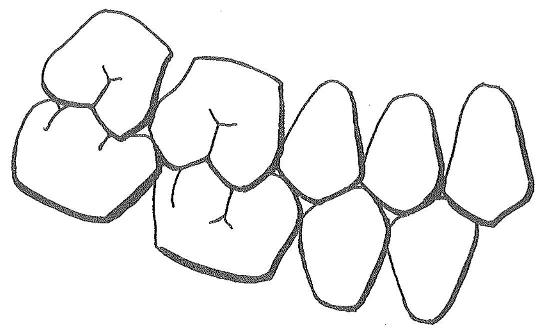


Fig. 12-1. A, With mandible in centric relation position bite blocks are constructed to present continuous contact along occlusal surfaces of maxillary and mandibular rims. **B,** As mandible moves from centric relation (*1*) to any degree of protrusion (*1* to *4*) there is a continuous change in spatiotemporal continuum. **C,** In lateral movement spatiotemporal continuum is changing not only anteroposteriorly, as in protrusive movement, but laterally as well. **D,** In opposite lateral movement, reverse takes place, this everchanging spatiotemporal continuum dictating cuspal position and height.





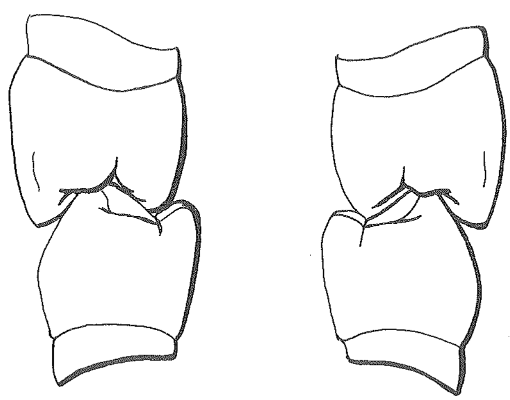


Fig. 12-2. **A,** Centric position of mandibular buccal cusp tips (in complete balance concept) from an occlusal view. **B,** Centric position as viewed from lateral side. **C,** Centric position as viewed from anterior view.

perior, posterior, and medial position in relation to the glenoid fossae. (See Fig. 12-2.)

Eccentric position is the *dynamic* relationship of mandibular teeth to maxillary teeth when both condylar elements are rotating and translating simultaneously in all planes within the glenoid fossae through the complete range of mandibular movements.

As the mandible moves from its centric position to one eccentric position (a lateral movement), the mandibular buccal cusp tips on the right and left sides of the arch behave in a definite given pattern in relation to the maxillary teeth. On the working side of the arch, where the condylar element remains relatively fixed in the fossa, the mandibular buccal cusp tips pass through the buccal grooves, and embrasures perform in the same manner, passing adjacent to the maxillary buccal cusp tips. (See Fig. 12-3.)

At the same time the mandibular buccal cusp tips, on the balancing side, travel from their centric position downward, forward, and inward to make contact with the maxillary lingual cusp tips. To achieve this positional relationship the condylar elements on the balancing side move away from the centric seat in the fossa and translate along the inferior surface of the articulating eminence in a downward, forward, and inward pattern. This is a definite three-dimensional movement generated by the rotation of the working condylar element with primary manifestations on the balancing side. When the reverse lateral movement is performed, the same three-dimensional function is observed.

The protrusive movement is two dimensional. As the condylar elements are made to perform this movement, they move downward and forward along the glenoid fossae. The mandibular buccal cusp tips and maxillary lingual cusp tips move anteriorly and posteriorly, respectively, along the central grooves, and these cusp tips make contact with the *rises* of the buccal and lingual cusps of both arches. (See Fig. 12-4.)

These observations indicate that each condylar element of the mandible is capable of three-dimensional rotation—accompanied by horizontal, vertical, and lateral translation—giving rise to the variety of complex movements performed by the mandible.

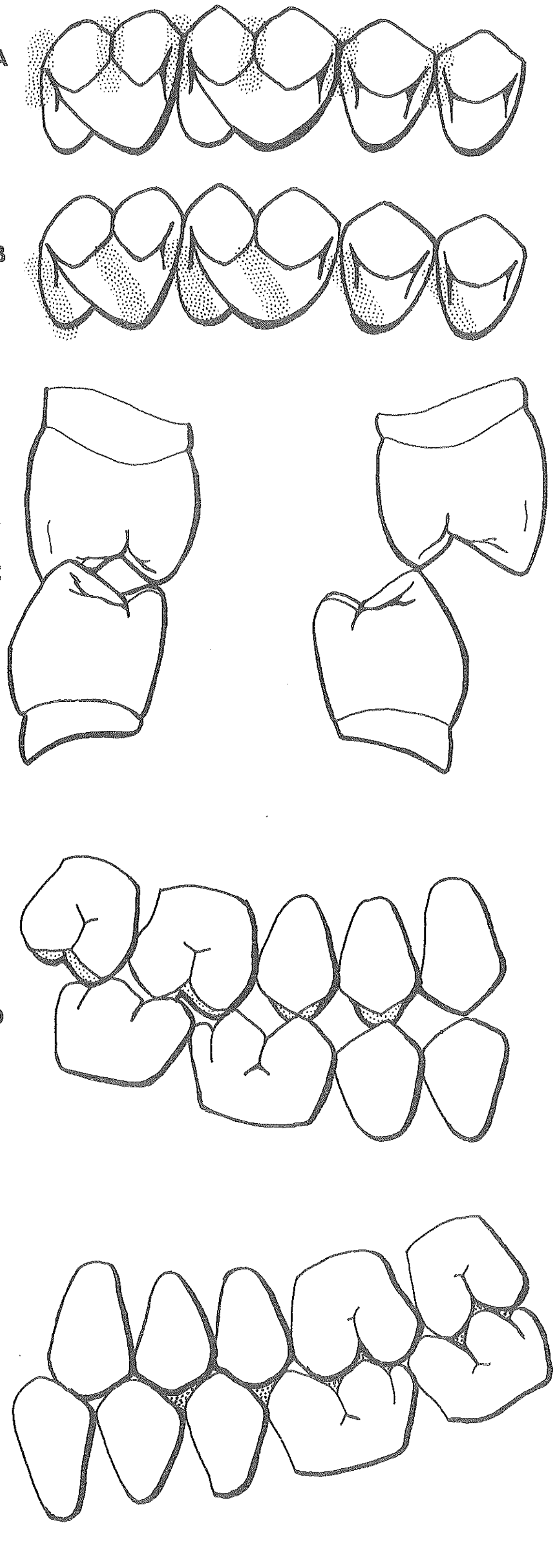


Fig. 12-3. **A,** Occlusal view of paths formed by mandibular buccal cusp tips as they translate from centric position to working position. These paths are dictated by fixed factors of occlusion. **B,** Occlusal view of paths created by mandibular buccal cusp tips as mandibular condylar element translates downward, forward, and inward to balancing position. **C,** Anterior view of maxillary and mandibular teeth creating positional relationship of cusp tips to fossae in working and balancing positions. **D,** Segment of dental arch in lateral view. As balancing condylar element moves downward, forward, and inward, it is relationship and contours of maxillary lingual cusp to mandibular buccal cusp that accommodate spatiotemporal continuum. **E,** In working function it is contour and relationship between cusps to embrasures and grooves that accommodate spatiotemporal continuum.

Fundamental concepts of mechanics

To aid in a better understanding of the mechanics or the science that describes and predicts the conditions of rest and motion of bodies under the action of forces, some fundamental concepts and principles are reviewed in the following paragraphs.

The basic concepts used in mechanics are *space, time, mass,* and *force.* These concepts cannot be truly defined; they should be accepted on the basis of intuition and experience and used as frames of reference for the study of the mechanics of the mandible. Other pertinent concepts are those relating to rigid bodies—concepts of moments, vectors, coordinate systems, centers of rotation combining rotation and translation along with external and internal force.

Rigid body

The gross appearance of numerous mandibles that were isolated and examined revealed an asymmetrical, rigid, three-dimensional body. A rigid body is one that does not deform. Actual structures are never absolutely rigid and they deform under the load to which they are subjected. These deformations usually are small in dental work but not in many other fields. They do not appreciably affect the condition of equilibrium or motion of the body under consideration.

A

B

C

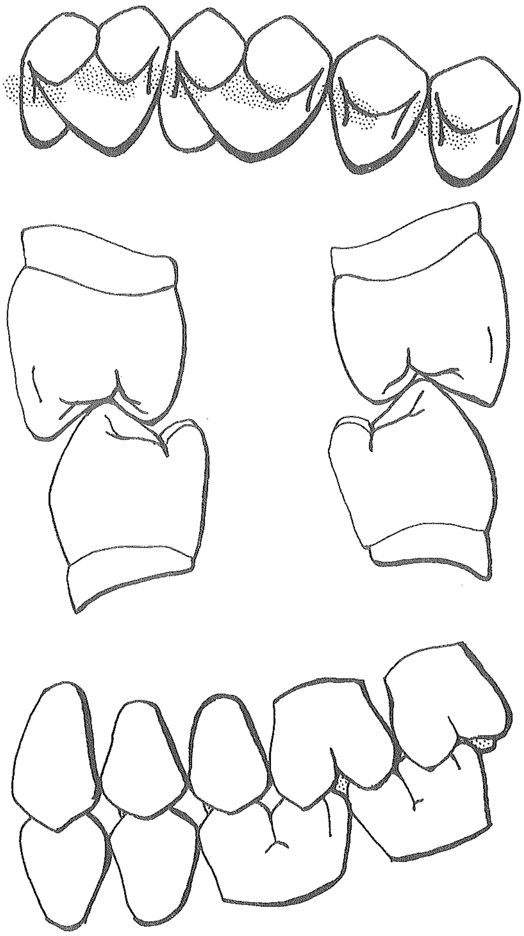


Fig. 12-4. A, Occlusal view of paths followed by mandibular buccal cusp tips in protrusive movement. B, Anterior view showing contact of mandibular buccal cusps with the buccal and lingual rises of maxillary teeth. C, Lateral view of dental arches and position of mandibular buccal and maxillary cusp tips in central groove.

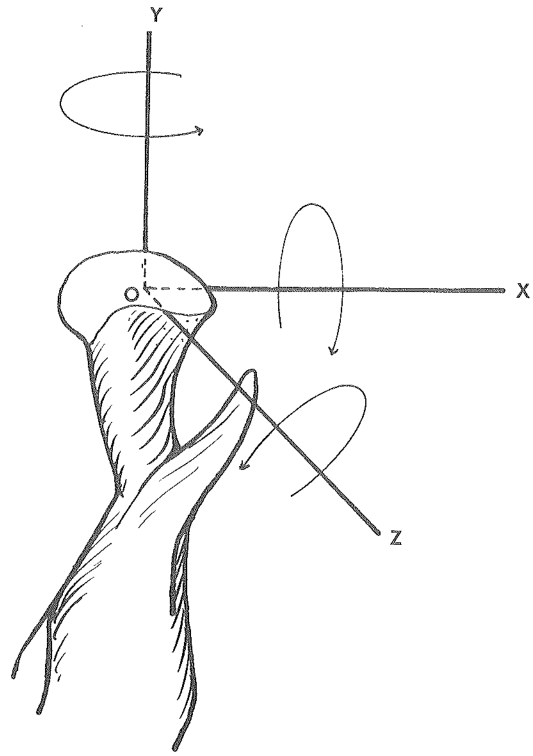


Fig. 12-5. Line OX represents horizontal axial center; line OY, vertical axial center; and line OZ, sagittal axial center. Point of convergence O is common center of rotation.

External and internal force

A rigid body may be subjected to two types of force: external and internal. *External force* represents the action of other bodies on the rigid body under consideration and is entirely responsible for the external behavior of the rigid body. This force will either cause the body to accelerate or assure that it will remain at rest. Muscle action on the mandible is an example of such a force.

Internal forces are the forces that hold together the particles forming the rigid body.[1] If the rigid body is structually composed of several parts, the forces holding the component parts together are also defined as internal forces. This relates to Newton's third law.

For the rigid body, the mandible, to translate in the various planes, each condylar element must present three axial centers of rotation, or a center of motion for each plane (Fig. 12-5).

Space

The concept of space is associated with the motion of the position of a point, P. The position of P may be defined by three lengths measured from a certain reference point, or origin, in three given directions. These lengths are known as the coordinates of P (Fig. 12-6).

Time

To define an event, it is not sufficient to indicate its position in space. The time of the event

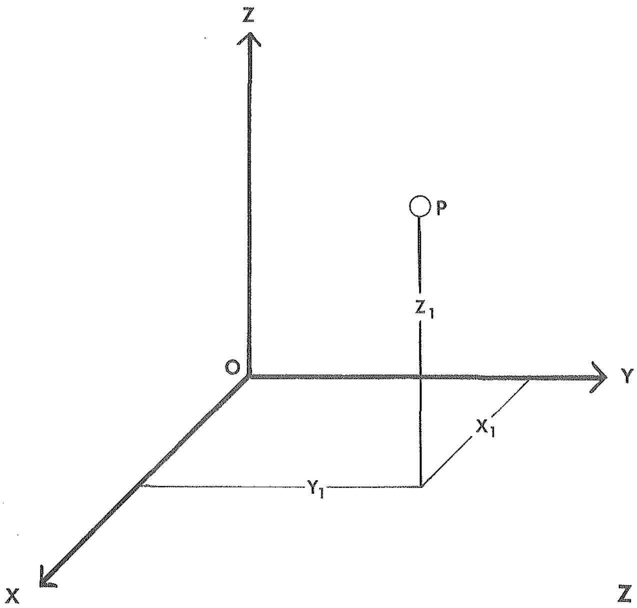


Fig. 12-6. Three coordinates to determine point P in space.

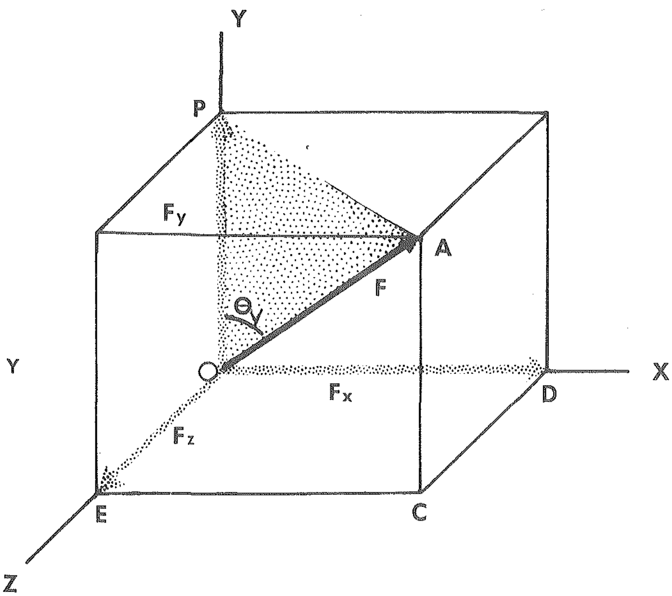


Fig. 12-8. A force F is represented and is acting at origin O of system of rectangular coordinates X, Y, and Z. Given force F can be resolved into three rectangular components F_x, F_y and F_z. These three component forces together produce same effect as does F.

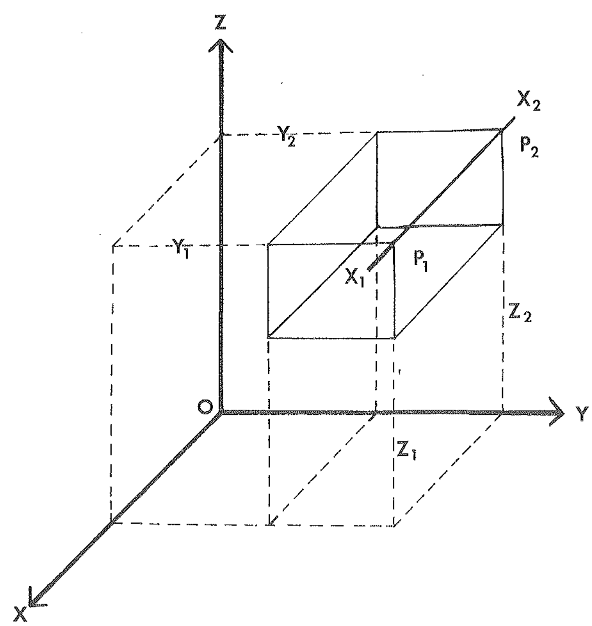


Fig. 12-7. Six coordinates to position a body in space. Three are on one side and three on opposite side. If only three coordinates were used, then marked side could remain fixed and the body in space can move about the coordinates and position will not be fixed.

should also be given, and this would be the time it would take for point P to move to a new position in space (Fig. 12-7).

Mass

The concept of mass is used to characterize and compare bodies on the basis of certain fundamental mechanical experiments. Two bodies of the same mass, for example, will be attracted by the earth in the same manner; they also will offer the same resistance to a change in translational motion.

Force

A force represents the action of one body on another. It may be exerted by actual contact or at a distance, as in gravitation and magnetism. A force is characterized by its point of application, magnitude, and direction; a force is represented by a vector.[1] (See Fig. 12-8.)

• • •

In Newtonian mechanics, space and time are absolute concepts independent of each other. (This is not true in relativistic mechanics, where the time of an event depends upon its position and the mass of a body varies with its velocity.) On the other hand, the concept of force is not independent of the other three. One of the fundamental principles of Newtonian mechanics indicates that the resultant force acting on a body is related to the mass of the body and the manner in which its velocity varies with time.

Newton's three fundamental laws are as follows:

First law: If the resultant force acting as a particle is zero, the particle will remain at rest (if originally at rest) or will move with constant speed in a straight line (if originally in motion).

Second law: If the resultant force acting as a particle is not zero, the particle will have an acceleration proportional to the magnitude of the resultant and in the direction of this resultant force. This law may be stated as F = ma.

To better understand the law, imagine the following experiment: a particle is subject to a force F_1 of constant direction and constant magnitude F. Under the action of that force, the particle will be observed to move in a straight line and in the direction of the force (Fig. 12-9, *A*). By determining the position of the particle at various instances, we find that its acceleration has a constant magnitude, a. If the experiment is repeated with forces F_2, F_3, etc. of different magnitudes or direction (Fig. 12-9, *B* and *C*), we find each time that the particle moves in the direction of the force acting on it and that the magnitudes a_1, a_2, a_3, etc. of the accelerations are proportional to the magnitudes F_1, F_2, F_3, etc. of the corresponding forces.

$$\frac{F_1}{a_1} = \frac{F_2}{a_2} = \frac{F_3}{a_3} = \text{Constant}$$

The constant value obtained for the ratio of magnitudes of the force and accelerations is a characteristic of the particle under consideration. It is called the mass of the particle and is denoted by m. When a particle of mass m is acted upon by a force F_1, the force F and the acceleration a of the particle must therefore satisfy the relation: F = ma.

This relation provides a complete formulation of Newton's second law; it expresses not only that the magnitude of F and a are proportional, but also (since m is a positive scalar) that the vector F and a have the same direction.

Third law: The forces of action and reaction between bodies in contact have the same magnitude, same line of action, and opposite sense.

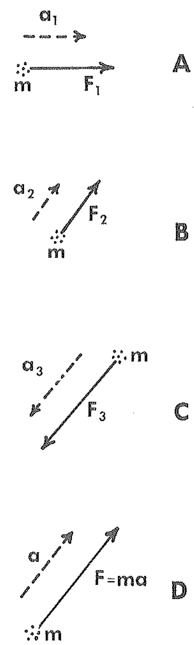


Fig. 12-9. A, A mass is subject to a force F, of constant direction and constant magnitude. The mass moves in a straight line in the direction of the force. **B** and **C,** Experiment repeated with forces F_2 and F_3. Particle moves in direction of force acting on it and magnitude, a_1, a_2, a_3, etc. of accelerations are proportional to magnitudes F_1, F_2, F_3, etc. of corresponding force. **D,** Expressing not only that magnitudes of F and a are proportional but also that vectors F and a have same direction.

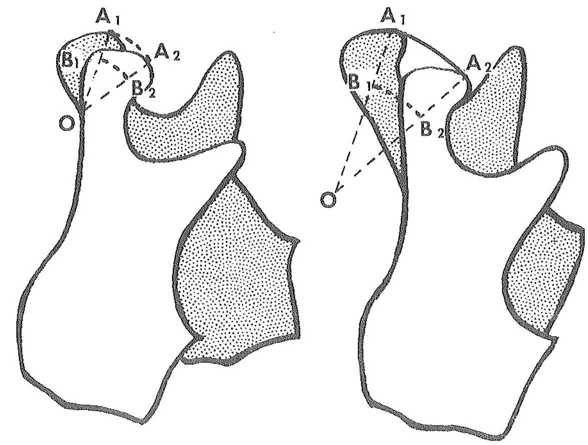
The terms "rotation" and "translation" will be used in the course of this discussion; therefore, a definition of these terms is needed.

Rotation

A motion is said to be rotation when the particles of the representative mass move along concentric circles. If the common center O of the circle is located on the mass, the corresponding point remain fixed. In many cases of rotation, however, the common center is located outside the slab, and none of the points of the mass remains fixed. (See Fig. 12-10.)

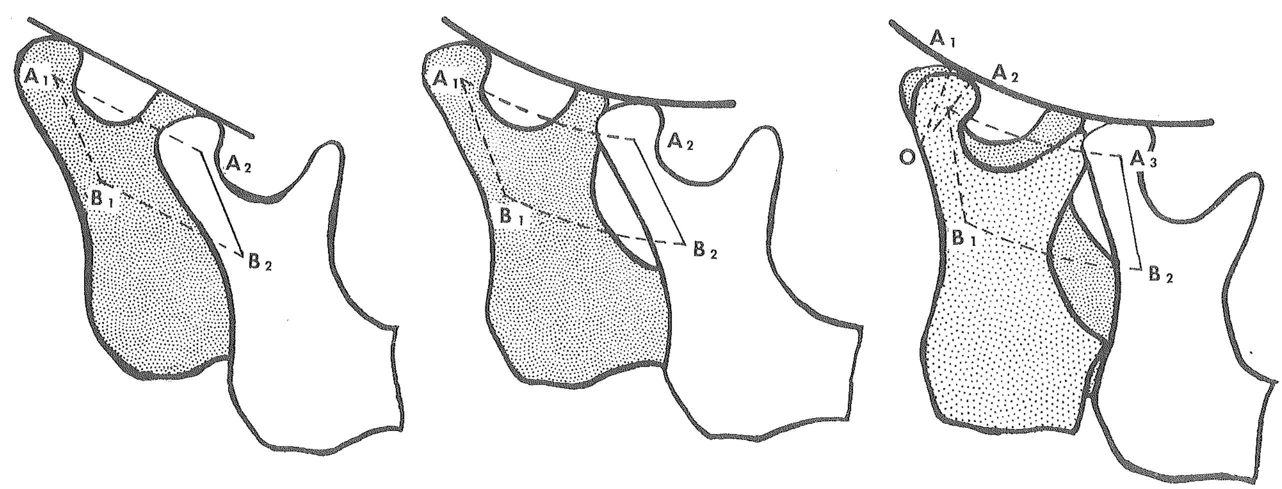
Translation

A motion is said to be translation if any straight line drawn on the body keeps the same direction during the motion. It also may be ob-



A B

Fig. 12-10. A, Here common center O remains on mandible, and corresponding point remains fixed. B, Common center O is located outside mandible, and none of the points on mandible remains fixed.



A B C

Fig. 12-11. A, Rectilinear translation when all particles move along parallel lines. Consider position of two of mandible's particles A_1, and B_1 at time T. At time T $+\Delta t$, the two particles will occupy position A_2 and B_2. From definition of translation line A_2B_2 must be parallel to A_1B_1. Since mandible is rigid $A_2B_2 = A_1B_1$. Then $A_1B_1B_2A_2$ is a parallelogram, and the two vectors representing displacement of the two particles during time interval must have same magnitude and direction. B, curvilinear translation when all particles on mandible as represented by A_1 and B_1 move along parallel circles to position A_2 and B_2 so that any straight line drawn on mandible will maintain same direction. C, Rotation and curvilinear translation occurring at same time.

served that, in a translation, all the particles forming the body move along parallel paths. If these paths are straight lines, the motion is said to be rectilinear translation; if the paths are curved lines, the motion is a curvilinear translation.[2] However, both rotation and translation may occur at the same time. (See Fig. 12-11.)

Mandibular axial centers of rotation

Horizontal axial centers

To locate the horizontal axial centers of rotation on an isolated mandible, the thumb and forefinger are placed on the lateral aspects of the condyles and the incisal region of the man-

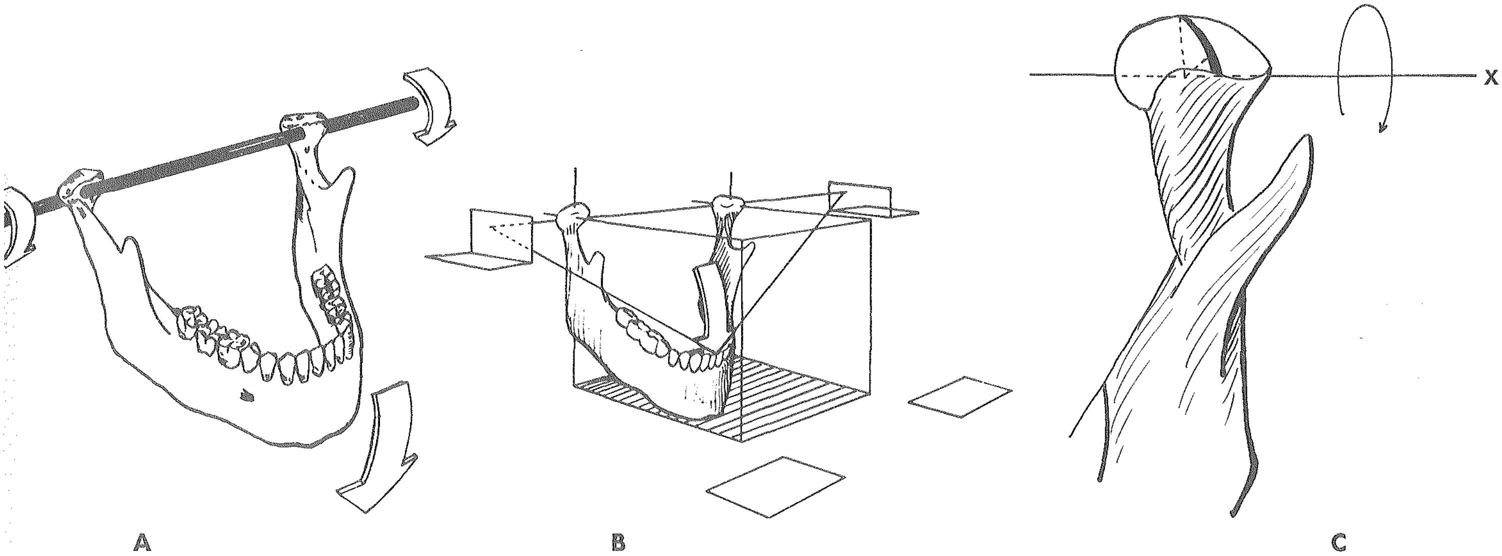


Fig. 12-12. A, Horizontal centers of rotation connected by an imaginary line are termed hinge axis. B, In pure opening movement rotation takes place about hinge, or terminal, axis. C, Anteroposterior segment of convex surface of superior aspect of condylar element that is responsible for horizontal axial center. (A and B from DePietro, A. J.: Dent. Clin. N. Amer., pp. 607-620, Nov., 1963.)

dible is permitted to fall and rise in a vertical plane. Rotation about the horizontal axial centers will be noted. One center is located in each condylar element. The anteroposterior segment of the convex surface of the superior aspect of the condylar element, when permitted to rotate about the articular disk, develops the horizontal centers of rotation. This arcuate surface, when resolved, produces fixed radii—making it possible to take a centric registration at any vertical opening along that arc dictated by the center of rotation. (See Fig. 12-12.)

Sagittal axial center

The sagittal axial center of one condylar element may be located by grasping one condylar element with the thumb and forefinger on the anterior and posterior surfaces and permitting the opposite, or translating, condyle to rise and fall in a vertical plane (a rockinglike motion). Vertical rectilinear translation of this balancing condyle is observed through the sagittal axial center of the held (or rotating) condyle, demonstrating its sagittal axial center of rotation. However, nowhere in mandibular function is *pure* vertical rectilinear translation observed through the sagittal axial center of rotation. By repeating the foregoing procedure with the opposite condylar element, its sagittal axial center can be located. If this function were possible, then the inferosuperior and mediolateral areas of the convex surfaces of the medial and superior aspects of the condylar elements, rotating about the medial aspect of the glenoid fossa, develop the sagittal axial center of rotation in the rotating condylar element. (See Fig. 12-13.)

Vertical axial center

To locate the vertical axial center, one condylar element is held with the thumb and forefinger on the inferior and superior aspects and the opposite, or translating, condyle is moved along the horizontal plane in an anteroposterior manner. This movement, or pure horizontal rectilinear translation about the rotating condylar element, is developed through its vertical axial center.

As in pure vertical rectilinear translation through the sagittal axial center, *pure* horizontal rectilinear translation through the vertical axial center cannot be found anywhere in mandibular function. In this function (if possible) the anteroposterior portion of the convex surface of the medial aspect of the condylar element, which rotates about the medial aspect of the glenoid fossa, resolves into the vertical axial center of rotation in the rotating condylar element. (See Fig. 12-14.)

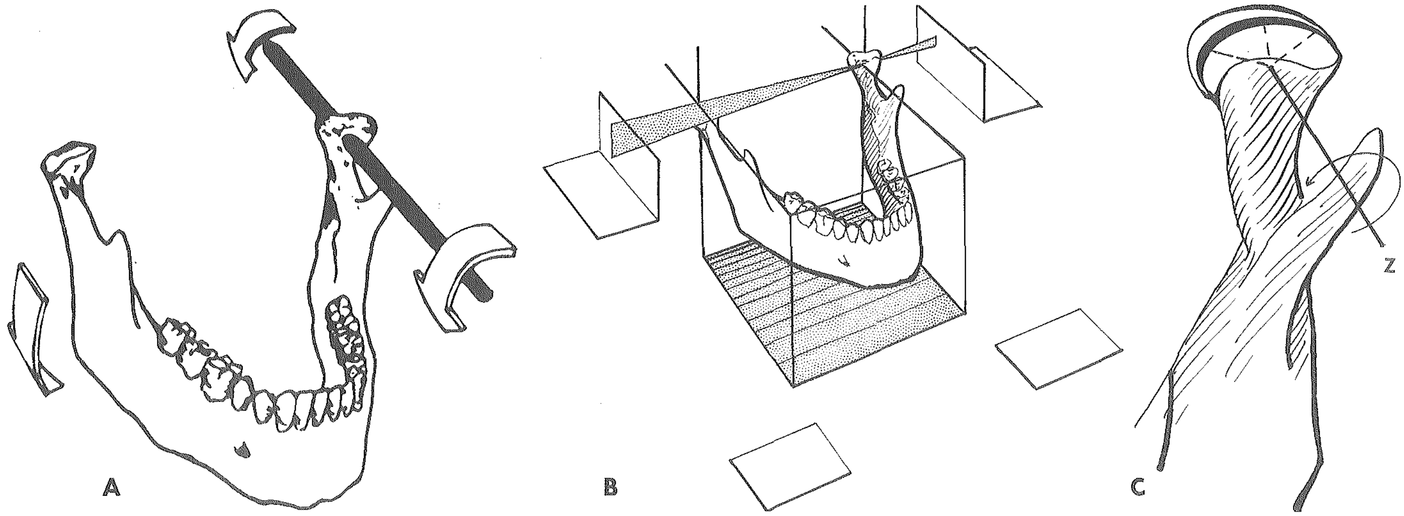


Fig. 12-13. **A,** Sagittal axial center of rotation of rotating condylar element. **B,** Translatory movement of balancing condylar element, when rotating about sagittal axial center of working condylar element, produces a vertical rectilinear tracing on vertical plate and a reciprocal of movement on vertical plate or working side. **C,** Inferosuperior and mediolateral areas of convex surfaces of medial and superior aspects of condylar elements that produce sagittal axial center. (**A** from DePietro, A. J.: Dent. Clin. N. Amer., pp. 607-620, Nov., 1963.)

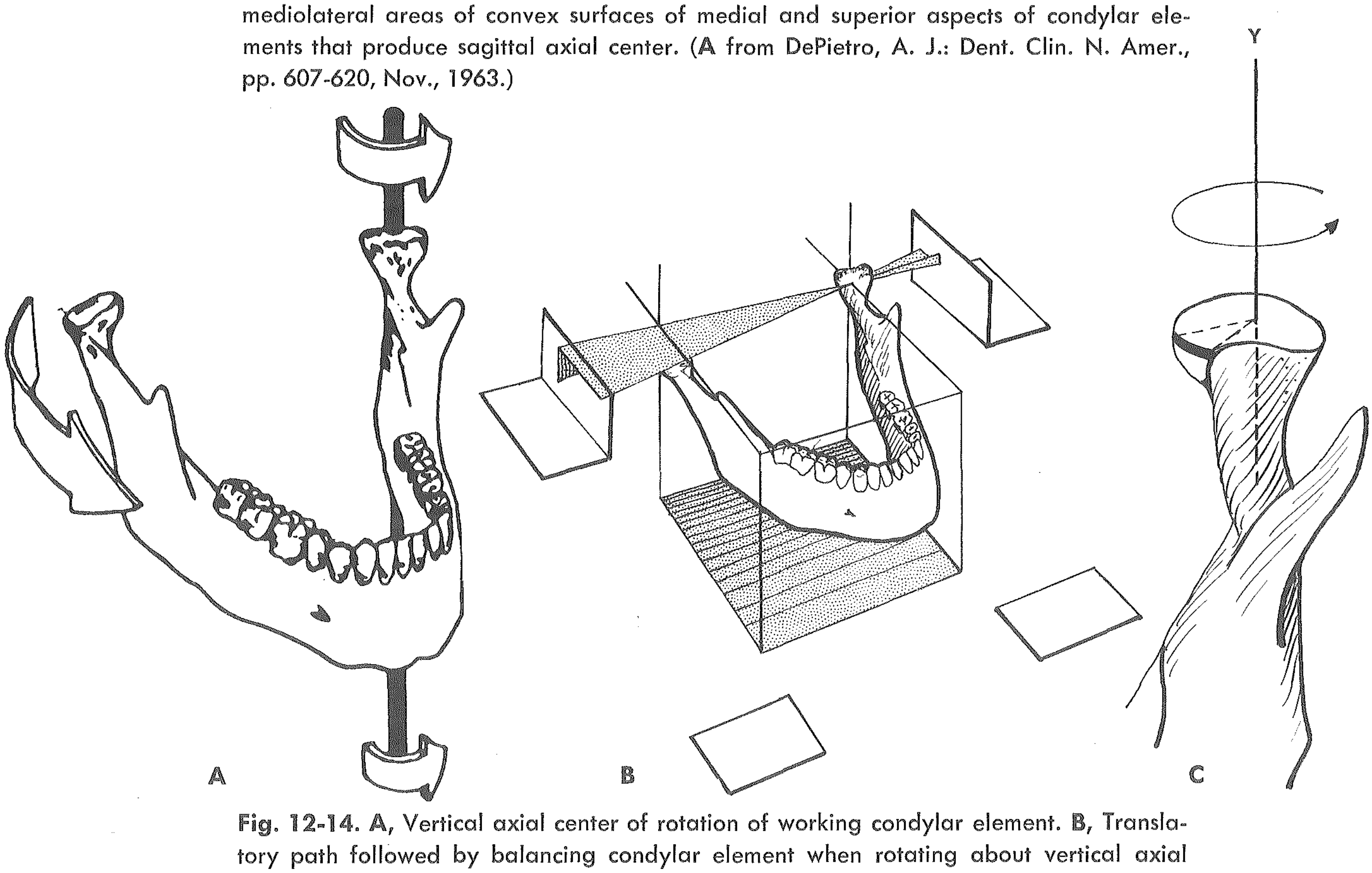


Fig. 12-14. **A,** Vertical axial center of rotation of working condylar element. **B,** Translatory path followed by balancing condylar element when rotating about vertical axial center produces a horizontal rectilinear tracing. Vertical plate on working side traces reciprocal of this movement. **C,** Anteroposterior portion of convex surface of medial aspect of condylar element, which rotates about medial aspect of glenoid fossa, gives rise to vertical axial center. (**A** from DePietro, A. J.: Dent. Clin. N. Amer., pp. 607-620, Nov., 1963.)

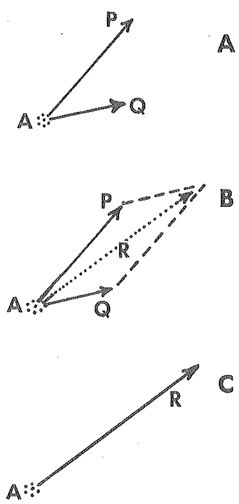


Fig. 12-15. A, P and Q are two forces acting on a particle, A. B, Construct a parallelogram, using P and Q as the two sides of the parallelogram. C, The diagonal, R, that passes through A is the resultant. This is known as the parallelogram law.

Vectors of vertical and sagittal movements

Vectors are defined as mathematical expressions possessing magnitude and direction, which add, according to the parallelogram law, for the addition of two forces. This law is based on experimental evidence; it cannot be proved or derived mathematically. Forces do not obey the rules of addition defined in ordinary arithmetic or algebra. Forces are not the only expressions that follow the parallelogram law of addition. Displacements, velocities, accelerations, and moments are other examples of physical quantities possessing magnitude and direction and are added according to the parallelogram law. All these quantities may be represented by vectors, while those physical quantities that do not have direction, such as volume, mass, or energy, are represented by scalars (ordinary numbers).

Forces acting on a rigid body are governed by the parallelogram law, which states that two forces acting on a particle may be replaced by a single force, called their resultant, obtained by drawing the diagonal of the parallelogram that has sides equal to the given force.[1]

When the mandible in the human masticatory

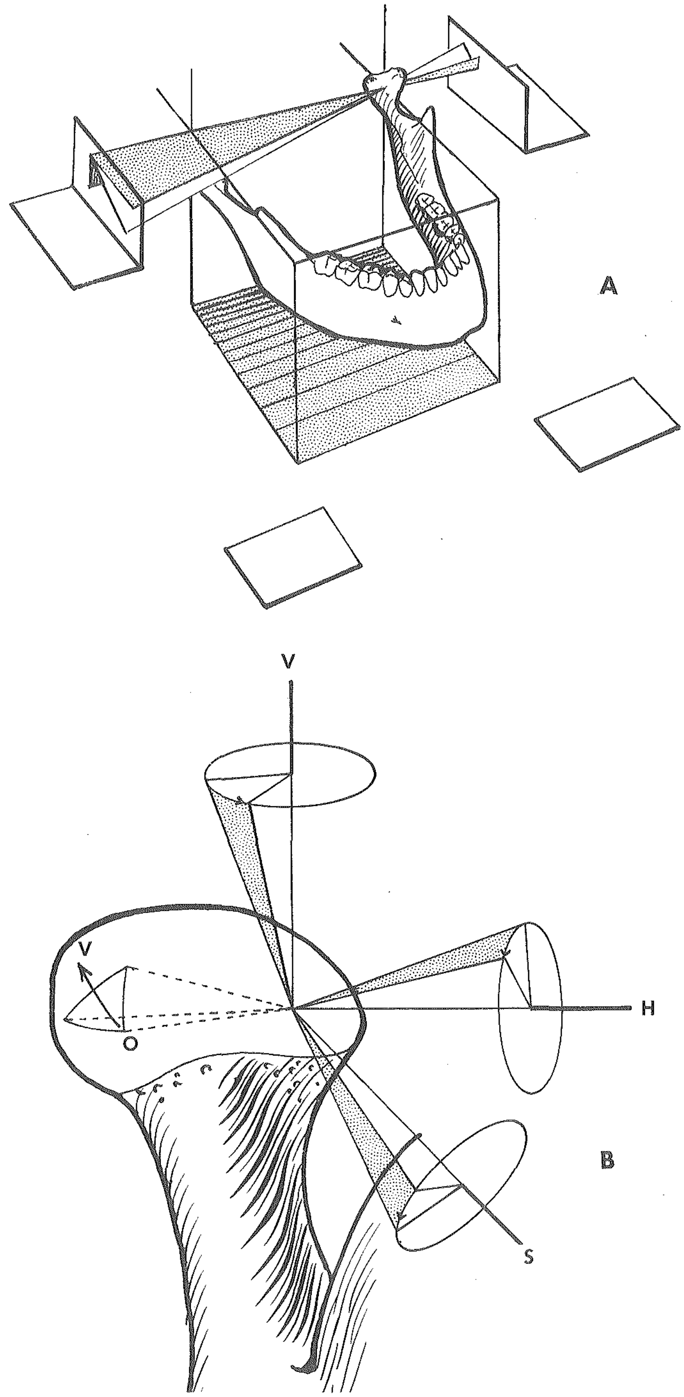


Fig. 12-16. A, Lateral movement showing resulting vector. In lateral movement both vertical and sagittal axial centers are functioning simultaneously. B, Inner aspect of rotating, or working, condylar element produces same vector, and its direction is anteroposteriorly to inferosuperiorly as represented by diagonal OV when O is terminal position. It is therefore the convex surface of medial aspect of condylar element inferoanteriorly to superoposteriorly, rotating about medial aspect of glenoid fossa that results in common axial center.

apparatus performs a lateral movement, the working condylar element rotates, and the path of translation of the balancing condylar vector movement can be called the resultant. It is found to fall between the imaginary angle that would have been formed had the working condylar element been rotating alternately about its sagittal and vertical axial centers. This vector movement can be considered a resultant of the two simple movements generated by pure vertical and sagittal rotation. It becomes quite evident therefore that, in a lateral movement, both vertical and sagittal centers of rotation of the working, or rotating, condylar element are brought into function simultaneously. (See Fig. 12-16.)

In the lateral movement it is the convex surface of the medial aspect of the condylar element, rotating inferoanteriorly to superoposteriorly about the medial aspect of the glenoid fossa that results in the common axial center. This transverse component, which is scribed about the medial aspect of the condylar element, can be resolved into the two simple movements about the sagittal and vertical axial centers.

Simple components of lateral movement in two planes

Mandibular center of rotation

Of interest in connection with the common center of rotation is the horizontal, vertical, and sagittal axial centers that form the one common center of rotation in each condylar element. From this center all rotation arises. For a better understanding of the common center of rotation in a condylar element, the simple components of the lateral movement in the two planes (horizontal and vertical) as related to the horizontal axis must be examined.

The horizontal axis is an imaginary line connecting the horizontal axial center of one condylar element to the horizontal axial center of the other condylar element (Fig. 12-17). The horizontal axial centers are constant to the condylar elements and, in turn, these axial centers are constant to the mandible. Since the horizontal axis is an imaginary line connecting the right and left axial centers, it too is constant to the mandible. Therefore, no matter what translatory movement the mandible may perform, the horizontal axis moves along with it.

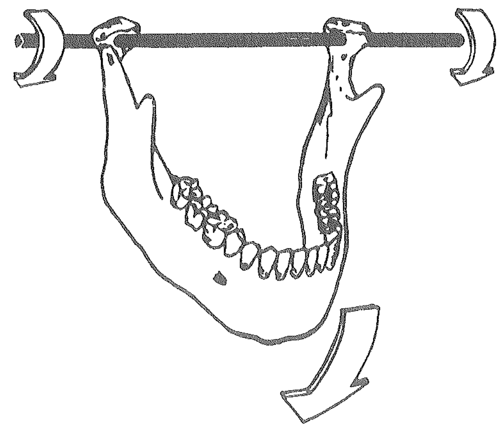


Fig. 12-17. Horizontal axis is an imaginary line connecting one condylar element to horizontal axial center of other condylar element. (From DePietro, A. J.: Dent. Clin. N. Amer., pp. 607-620, Nov., 1963.)

The horizontal plane

In Fig. 12-18 let us consider that line AB represents the horizontal axis. Then the convex surface of the medial aspect of the working condylar element anteroposteriorly, rotating about the medial wall of the fossa (D′D), will demand that the balancing condylar element translate in a horizontal rectilinear path about point O somewhere laterally to the medial wall (D′D). With this movement the horizontal axis follows the condylar elements and moves to a new position (line A′B′).

As the horizontal axis moves to the new position it crosses at point O, the original position occupied by the horizontal axis lines A. Point O designates the vertical axial center of rotation, and at this point the vertical and horizontal axial centers meet to become the common center of rotation. Distance B to B′ on the working side is the reciprocal of the translatory movement A to A′ of the balancing condylar element.

The vertical plane

The vertical plane shows that the horizontal axis is again represented by line AB. The convex surface (arc CD) of the medial and superior surface of the working condylar element, rotating laterally about the medial and superior wall of the fossa about point O, will bring about a vertical rectilinear translatory movement of the balancing condylar element A A′. The working side represents the reciprocal movement B B′,

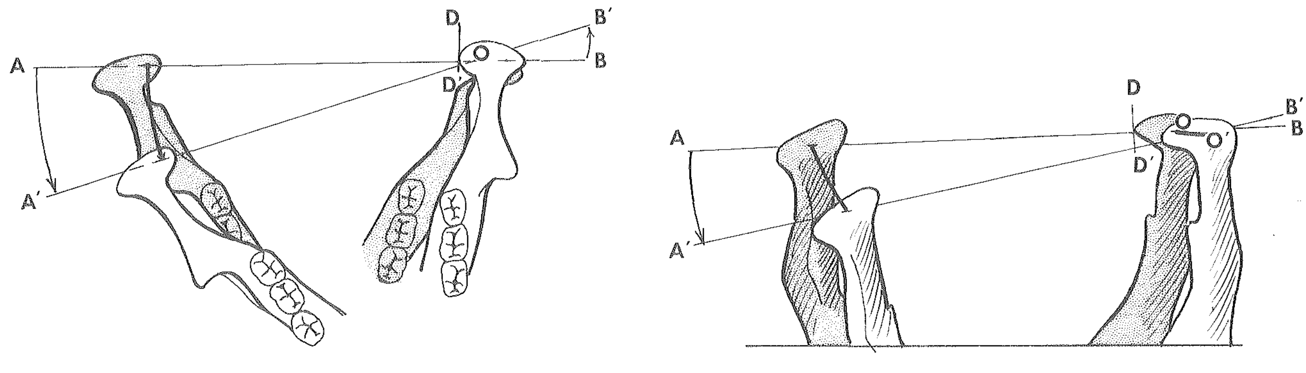


Fig. 12-18. A, Line A'B' crosses line AB. Point of intersection O is where vertical and horizontal axial centers meet to form common center of rotation. **B,** When a Bennett movement is present, rotational center O in working condylar element moves to point O', and again there is a crossing of horizontal axis in vertical plane.

an upward, vertical, rectilinear, translatory movement. The horizontal axis has translated to a new position rotating about point O in relation to the original axis. At point O the original axial center is crossed by the new axial center. The horizontal and sagittal centers now form one common center of rotation. Point O in the vertical plane represents the sagittal center of rotation. (See Fig. 12-19.)

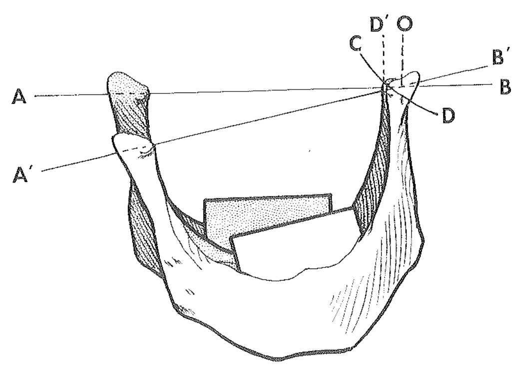


Fig. 12-19. If a Bennett movement was present in vertical plane, point O would move laterally, and again there would be a crossing of horizontal axis.

Lateral movement

In the lateral movement line AB designates the horizontal axis. The convex surface of the medial aspect of the working condylar element, rotating from its inferoanterior to its superoposterior surface about the medial aspect of the glenoid fossa, permits the balancing condylar element to translate in a diagonal rectilinear translatory path. The new position of the horizontal axis, which is dictated by the medial aspect of the working condylar element (arc CD), crosses the original axis (line AB) at point O. A completion of the function by the addition of the vertical and sagittal analysis becomes adequate proof that the three axial centers and the common center of rotation are one and the same. (See Fig. 12-20.)

All lateral movements in the human masticatory apparatus, regardless of magnitude and direction, demand rotation about both vertical and sagittal centers of rotation in the working condylar element.

The mandible, by means of the two condylar projections, positions the vertical, sagittal, and horizontal axial centers of rotation, permitting this structure to rotate in all planes. This is the only function that the mandible can perform, and it can be performed only when one or both condylar elements are braced so that the resultant force (muscle contraction) acting on one point about the body is zero. When the resultant force acting on the body is not zero, then the body will have an acceleration proportional to the magnitude of the resultant and in the direction of this resultant force (translation), and this direction is a function of the glenoid fossae.

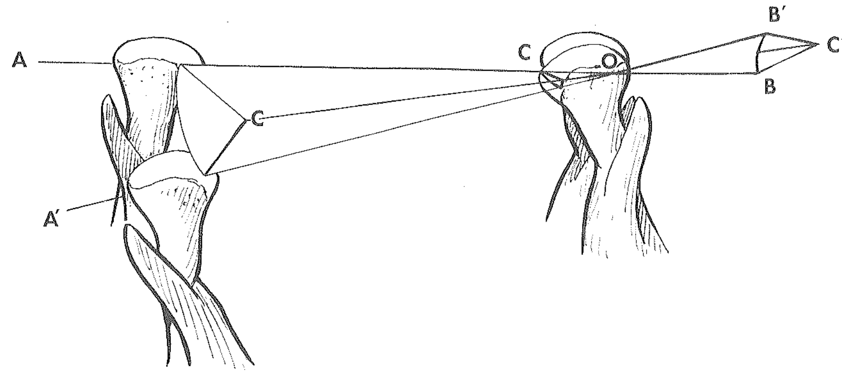


Fig. 12-20. Three-dimensional view representing change in position of horizontal axis from position AB to position A′B′. In order for this to take place, axis rotates on vertical axial center at point O, placing horizontal axis at position CC′; at the same time, horizontal axis rotates about sagittal axial center at point O and horizontal axis moves from position CC′ to position A′B′. Crossing of horizontal axis with original horizontal positions shows common center of rotation at point O on working side.

Structure of ligaments

The mandible is loosely affixed to the glenoid fossae by bands of white, fibrous tissue known as the capsular ligament (Fig. 12-21). This is a thin, loose envelope, which is attached above to the circumference of the mandibular fossa and the articular tubercle and below to the neck of the condylar element. It forms a complete envelope for the freely movable joint.

Ligaments are composed mainly of white, fibrous tissue, placed parallel, or closely interlaced, with one another, presenting a white, shiny, silvery appearance. They are pliant and flexible so as to allow perfect freedom of movement, but strong, tough, and inextensible, so as not to yield readily to applied force. Other ligaments such as the ligamenta flova, which connects the laminae of adjacent vertebrae, may consist of yellow, elastic tissue. These ligaments have elasticity, and this structure is intended to act as a substitute for muscle power.[3] The temporomandibular, sphenomandibular, and the stylomandibular ligaments' prime function is the limiting of the mandible in all its rotary and translatory movements. These structures are responsible for the border paths that are scribed in the gothic arch. (See Fig. 12-22.)

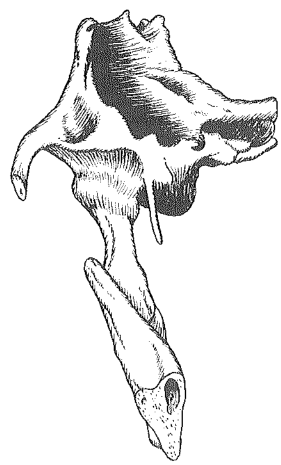


Fig. 12-21. Capsular ligament.

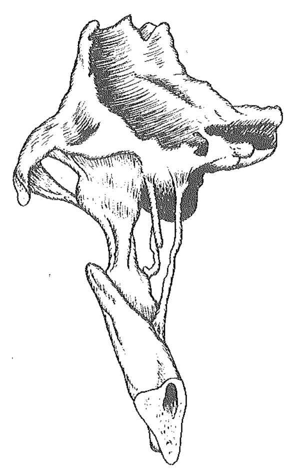


Fig. 12-22. All ligaments of mastication as they may be seen when condylar element is in its terminal position.

Locating horizontal centers of rotation

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 superior and anterior slope of the glenoid fossa and the temporomandibular ligament, can brace itself superiorly, medially, and at its posterior limit and thereby can enable the horizontal centers of rotation to be located. The position of the horizontal axial centers of rotation are dictated by the arcuate area from anterior to posterior of the superior surface of both condylar elements as they rotate within the restricted areas.

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.

In continuing the pure rotary movement of the mandible, translation comes into being when the temporomandibular ligament limits further pure rotation of the condylar element (Fig. 12-23). At this stage of the opening movement the point of inferior attachment of the temporomandibular ligament to the lateral surface and posterior border of the neck of the mandible now becomes the fulcrum, or the new center, of rotation. The condylar elements then translate about this fulcrum and move forward and downward on the fossa to permit further opening of the mouth. This combined rotation and translation gives rise to instantaneous centers of rotation

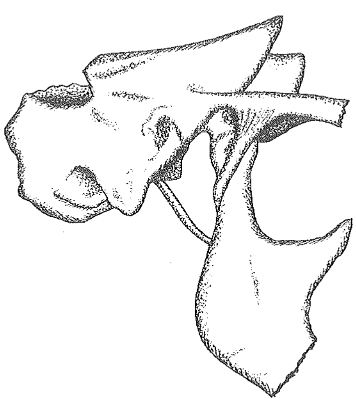


Fig. 12-23. Temporomandibular ligament and its limiting effect on pure rotary movement of mandible.

to the horizontal axial centers located in the condylar elements. Since the combined rotation and translation gives rise to instantaneous centers, this movement must be avoided in the primary location of the horizontal axial centers of rotation.

Instantaneous centers of rotation

Instantaneous centers of rotation (Fig. 12-24) can be shown when at any given instant the velocities of the various particles of the condyle are the same as if the condyle were rotating about a certain axis, the instantaneous center of rotation of the condyle, which is perpendicular to the plane of the condyle.

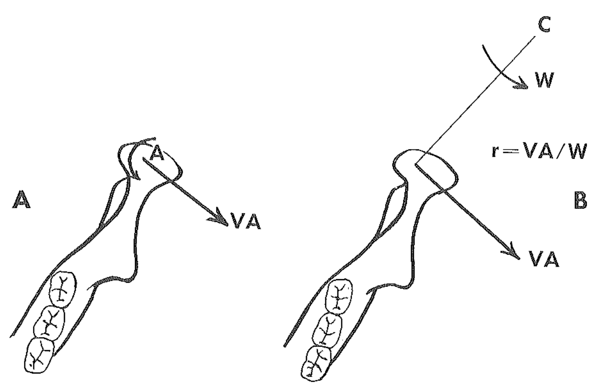


Fig. 12-24. Instantaneous centers of rotation. **A,** Plane motion of condylar element may always be replaced by a translation defined by the motion of an arbitrary reference point A_T and by a rotation about A. Velocities characterized by velocity V_A of reference point A and rotation is characterized by angular velocity W of the slab. Velocity V_A of point A and angular velocity W of slab define completely velocities of all the other particles of the slab. V_A and W are known and they are both different from zero. (If $V_A = O$, point A is itself the instantaneous center of rotation, and if $W = O$, the slab is in translation.) **B,** These velocities could be obtained by letting condylar element rotate with angular velocities W about a point C located on a perpendicular to V_A at a distance $r = V_A/W$ from A. Velocity of A would be perpendicular to AC and its magnitude would be $rw = (V_A/W)W = V_A$. Velocities of all particles on condylar element would be the same as originally defined. Therefore, as far as velocities are concerned, the slab seems to rotate about the instantaneous center C at the instant considered.

Let us assume that V_A and W are known and that they are both different from zero. (If $V_A = O$, point A is the instantaneous center of rotation, and if $W = O$, the condyle is in translation.) These velocities could be obtained by letting the slab rotate with the angular velocity (W) about a point (C) located on the perpendicular to V_A at a distance ($r = V_A/W$) from A. The velocity A would be perpendicular to AC and its magnitude would be $rW = (V_A/W)W = V_A$. Thus the velocities of all the other particles of the condyle would be the same as originally defined. Therefore, as far as the velocities are concerned, the condyle seems to rotate about the instantaneous center (C) at the instant considered.[2]

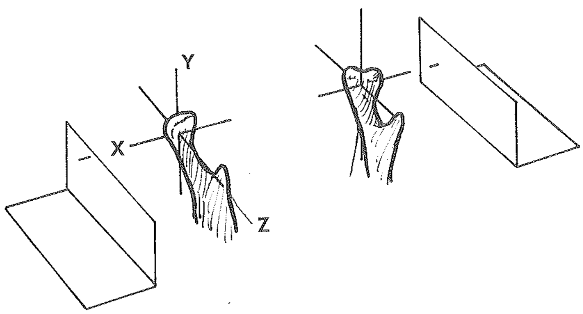


Fig. 12-25. Three coordinates X, Y, and Z needed to establish a coordinate system.

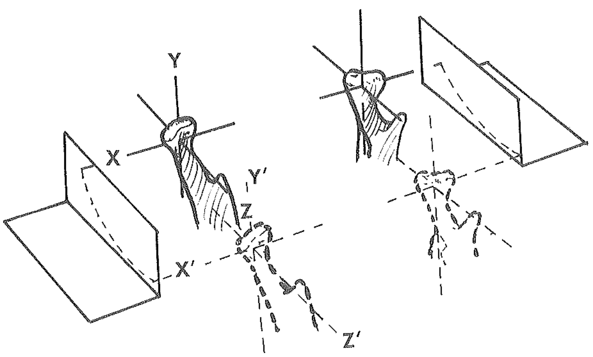


Fig. 12-26. To establish a coordinate system six coordinates are needed to specify configuration—three at right condylar element to give position in space of its particular point and three at left condylar element to position the left point in space. By fixing the two points at the same time there can be no question of the position of a solid body.

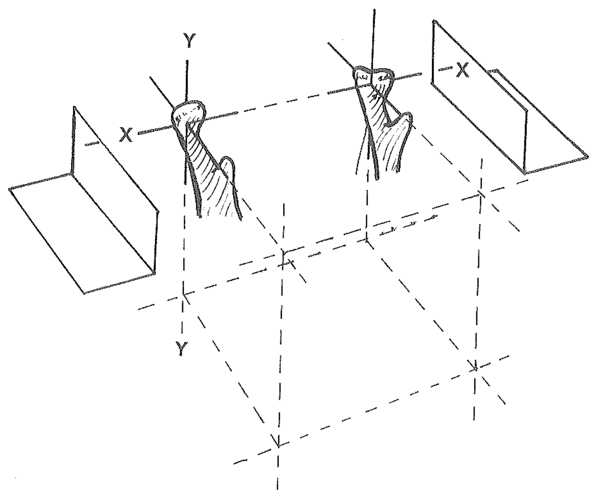


Fig. 12-27. By extending coordinates, mandible can be encased in a cube.

To establish the position of one of the reference points, three coordinates must be supposed (Fig. 12-25). But once point 1 is fixed, point 2 can be specified by only two coordinates, since it is constrained to move on the surface of a sphere centered at point 1. With these two points determined, point 3 has only 1 degree of freedom because it can only rotate about the axis joining the other two points. A total of six coordinates is sufficient (Fig. 12-26). Thus a rigid body in space needs six independent generalized coordinates to specify its configuration. (Three coordinates for rotation and three coordinates for translation.) Clearly, three of the coordinates are needed to specify the coordinates of the origin of this "body" set of axes (from which translation occurs). The remaining three coordinates must then specify the orientation of the prime axis relative to a coordinate system parallel to the external axis, but with the same origin as the prime axis.

To facilitate demonstration of mandibular movements, coordinates are constructed at the origin in both condylar elements. The coordinates represent the horizontal, vertical, and sagittal axial centers that come together to form the common center. By extending and connecting the coordinates, the mandible can be encased in a cube (Fig. 12-27). The cube now completely houses the mandible and acts as a constant in relating translatory and rotary mandibular movements. By extending the horizontal axis beyond the confines of the cube, this can be used to trace the path traveled by the mandible in various movements.

In the pure rotational (opening) movement of the mandible, the vertical and sagittal axes have changed position. They have rotated about the horizontal axis in a backward and downward direction, respectively, while the horizontal axis rotates upon itself. The mandible, therefore, in a limited degree of opening and closing movement, rotates about the horizontal axis. This makes it possible to take a centric registration at any degree of vertical opening up to the point at which translation takes place, and on closure the mandible will remain on the established centers.

A straight protrusive movement

In a straight protrusive movement both condylar elements move downward (vertical component) and forward (horizontal component) simultaneously. The straight protrusive movement gives rise to Christensen's phenomenon (during a protrusive movement, the inclination and curvature of the condylar path cause the spatiotemporal continuum in the molar regions). The path traced by the horizontal axis in this movement is a curved path in 99.3% of the cases. The protrusive path of travel in these cases represents curvilinear translation and demands that a curved path must be standard equipment on a mechanical device if it is to duplicate accurately the protrusive and lateral movements of the mandible.

The limiting factor of the protrusive movement is the combined action of all the ligaments of mastication. The attachment of the temporomandibular ligament to the tubercle and the inferior border of the zygomatic arch becomes the fulcrum point or the center of rotation to this movement. The length of the ligament now becomes the radii, and its attachment to the lateral surface and posterior border of the neck of the mandible becomes the point that scribes the arc.

This movement continues until the two passive ligaments on the right and the left side (sphenomandibular and stylomandibular) become tense. Then the movement stops, and the anterior border path is formed. The ligaments of mastication limit all the function of the mandible.

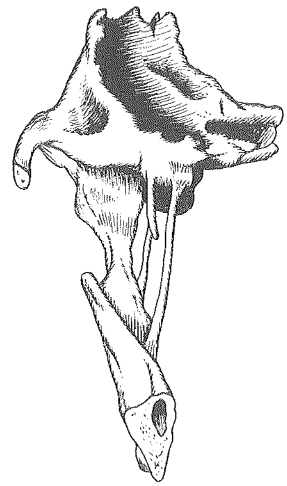


Fig. 12-28. Passive role of the sphenomandibular and temporomandibular ligaments on working side in a lateral movement.

They are responsible for all the border paths with one exception. The sphenomandibular and temporomandibular ligaments play a passive role on the working side of a lateral movement (Fig. 12-28).

Often in the recording of the protrusive movement a deflection of the line to the right or left of center is seen. This deflection in the recording may, in turn, be caused by the difference in length of the sphenomandibular, stylomandibular, and temporomandibular ligaments on the right side as compared to the ligaments on the left side.

To substantiate the foregoing statement, 633 sets of pantographic tracings were examined, totalling 1,266 protrusive paths. On detailed study, the following figures were obtained: 996 paths, or 78.7% of the total number, demonstrated arcs with radii ranging from ⅜ to ¾ inch; 261 paths, or 20.6% of the total, demonstrated arcs with radii ranging from 13⁄16 to 4 inches; 9 paths, or 0.7% of the total number, were straight paths, representing one in every 141 paths examined. The curvature, or character, of the condylar path causes a significant variance in the spatiotemporal continuum in the respective molar regions. To show this effect one must examine a variety of paths that present the same angulation but have a variance in the character of the path.

As the mandible moves in the horizontal plane, the condylar elements are driven down-

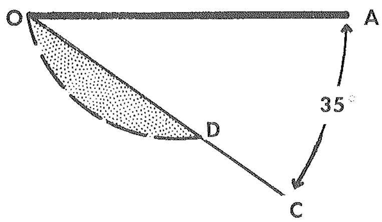


Fig. 12-29. Line OA represents horizontal component; arc AC represents vertical component. Line OD is straight path at a 35-degree angle, and arc OD is curved path at same angulation. Area formed by straight path OC and arc OD represents amount of vertical component that can be lost when straight path is used rather than curved path.

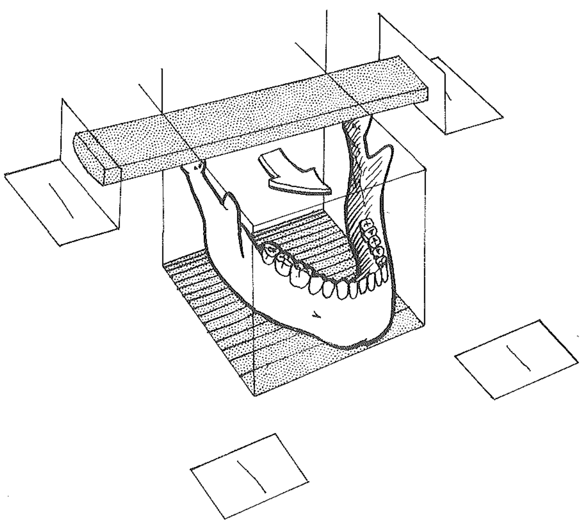


Fig. 12-30. Straight protrusive movement; a two-dimensional movement, accompanied by a constant changing vertical component as dictated by curvature of path.

ward and forward along the glenoid fossa. If the glenoid fossa is constructed so as to present an angulation and no curvature, then the vertical component of this movement becomes the mathematical progression of the horizontal movement. The magnitude and direction of the vertical component is directly proportional to the distance traveled by the condylar element in the horizontal plane. The vertical component of the spatiotemporal continuum in the molar region is directly affected by the straight path. As the mandible continues on with the protrusive movement, the vertical component of the spatiotemporal continuum continues to become larger. A greater interdental space develops. (See Fig. 12-29.)

Where the angulation of the fossa is accompanied by a curvature, the vertical component of the protrusive movement constantly varies in its magnitude and direction with every new position of the condylar element along the horizontal component of the movement. The effect on the vertical dimensions of the area of space in the molar region is an ever-changing one. It may be described as an oscillating change. As the mandible performs a straight protrusive movement along the curved path, the vertical dimension of the spatiotemporal continuum becomes larger as dictated by the character of the path; and as the mandible continues in the movement, the vertical dimension continually decreases. This accounts for a continuous instantaneous change of the spatiotemporal continuum between the maxillary and mandibular occlusal forms.

Since this movement is two-dimensional and is accompanied by a constant changing vertical component, it cannot be registered in toto by a gothic arch. Gothic arch tracings give only the horizontal component of this movement, and no trace of the vertical component can be demonstrated. (See Fig. 12-30.)

The foregoing facts make it mandatory that paths on a mechanical device be of the curved variety. There is no problem in the determination of the condylar character when pantographic tracings are used in the recording of this movement. However, basic condylar curvature can also be determined when a check-bite technique is used. This development can be substantiated by the following analysis of what takes place when multiple protrusive registrations are recorded on the same patient. If the patient possessed a straight condylar path, then all protrusive registrations will record the same condylar angulation when they are transferred to an articular that has a straight condylar path, regardless of the protrusive distance traveled by the condyle to record this movement.

If the patient does not present a straight condylar path but a curved one, we are confronted with one of two possibilities. The single protrusive record cannot aid us in setting the protrusive angulation on a mechanical device as it is; therefore it is of no value. The straight protrusive path used on the instrument is not correct, since the path traveled by the condyle is not straight but curved.

The examination of pantographic tracings clearly demonstrated that 99.3% of all paths traced by the condylar element were curved. Condylar angulation can be duplicated when a straight protrusive path is used only when multiple protrusive registrations are taken at the same extent of protrusive excursion. This would establish only two correct points on a path—the starting point and the recorded point.

If a Gothic arch tracing is used and two points along the protrusive line of the tracing are measured, two protrusive registrations at different predetermined degrees of protrusive excursions can be taken. Setting a straight condylar path on an articulator will naturally give two different condylar angulations, unless of course the patient presented a straight condylar path. By placing the two known protrusive distances and their respective condylar angulations on a graph, the radius of curvature is determined.

In Fig. 12-31 let XX′ and YY′ be two straight lines meeting at right angles. The point of intersection is the coordinate of the graph or centric relation of the patient. Along line XX′ from the coordinate the two degrees of protrusion are recorded (the same protrusive distance marked on the gothic arch). A protractor is placed in such a position that its origin falls on the coordinate, the zero degree registration falls on line XX′, and at the 90-degree position falls on line YY′. With the protractor in the 90-degree

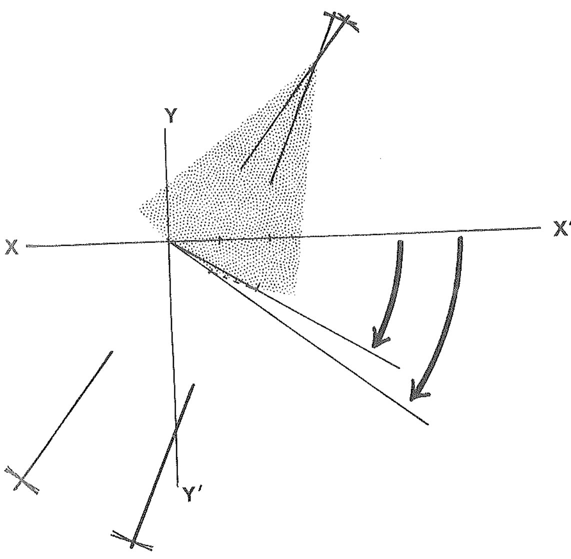


Fig. 12-31. Determination of condylar curvature.

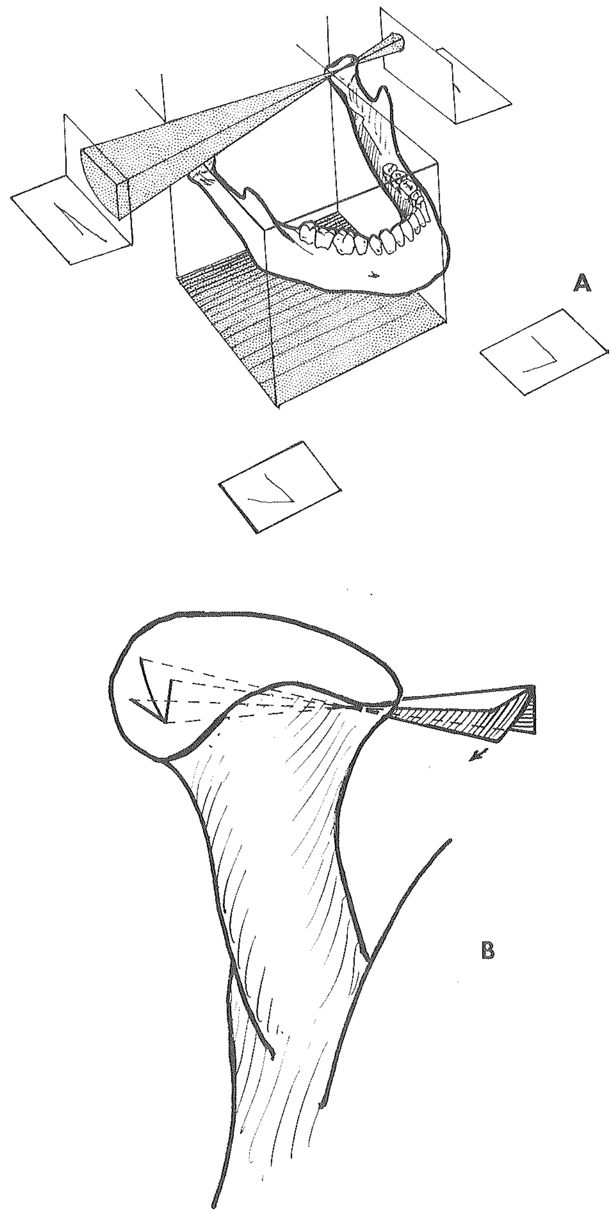


Fig. 12-32. A, In lateral movement balancing condylar element moves downward, forward, and inward while opposite condylar element is rotating and at times moving laterally. A three-dimensional movement. **B,** Change in position of horizontal axis in working condylar element. Common center of rotation may fall within or outside body of condyle.

position the angulations given by the two protrusive registrations are marked. Lines are drawn from the coordinate to the angulation points, and the two points that were marked previously on the XX′ axis are extended to the YY′ axis to intercept the angulation lines. Plotted on the graph are two points and the coordinate (centric relation), a total of three points that do not fall on a straight line. Any three points that do not fall on a straight line can be connected by an arc of a circle, thereby demonstrating a common radius and center. This arc, with determined radius, is the path followed by the condyle in the protrusive movement.

Lateral movement

In a lateral movement, one condylar element (the balancing or translating condyle) moves forward, downward, and inward while the opposite condylar element is rotating (Fig. 12-32, *A*). This working or rotating condyle, depending on its configuration and the position of its rotational center, may give rise to pure rotary movement or to a combination of pure rotation with lateral translation (Fig. 12-32, *B*). This lateral translatory movement of the working condylar element is called the Bennett movement. This movement is influenced by the rotation of the working condylar element and therefore cannot be completely detached from it. The movement on the balancing or translating side in the horizontal plane accounts for the Bennett angle, and in the sagittal plane, the Fisher angle.

Role of ligaments

The role of the temporomandibular ligament in this function can best be observed in the horizontal plane. Again, as in the protrusive function, the attachments of the temporomandibular ligaments to the tubercle and inferior surface of the zygomatic arch become the fulcrum points, or the centers of rotation. The length of the ligaments becomes the radii. The attachment of this ligament to the lateral surface and posterior border of the neck of the mandible directs the lateral aspect of the condylar elements to translate outward and forward. On the balancing side, it permits the condylar element to move more inward. The limiting effect of the temporomandibular ligament gives the border path of the lateral movements but may not be responsible for the limit of the movement.

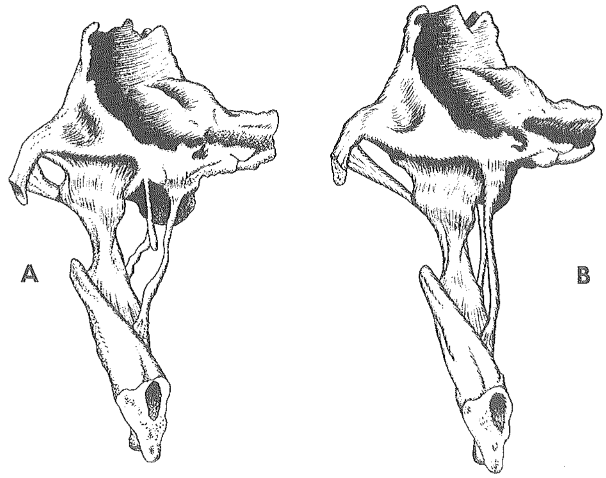


Fig. 12-33. A, Role performed by ligament on working side. **B,** Role performed by same ligament on balancing side.

On the balancing side, the sphenomandibular and stylomandibular ligaments at the end of this movement become tense and stop the movement. On the working side, the sphenomandibular and stylomandibular ligament remain passive. (See Fig. 12-33.)

Bennett movement

Bennett movement is the lateral translatory movement of the working condylar element to permit rotation of the element. It can be demonstrated that three factors play an important role in the amount of lateral translatory movement exhibited by the working condyle. Lateral translatory movement gives the fine adjustment to the functions of the rotational centers in all translatory and rotary movements. The three factors that influence the amount of this translatory movement are as follows:

1. The symmetry of the medial surface of the condylar element (Fig. 12-34).
2. The degree of deviation of the medial aspect of the condylar element from the horizontal axis (Fig. 12-35).
3. The position of the vertical and sagittal centers in the condylar element (Fig. 12-36). The more medial and anterior these centers are placed to the condylar ele-

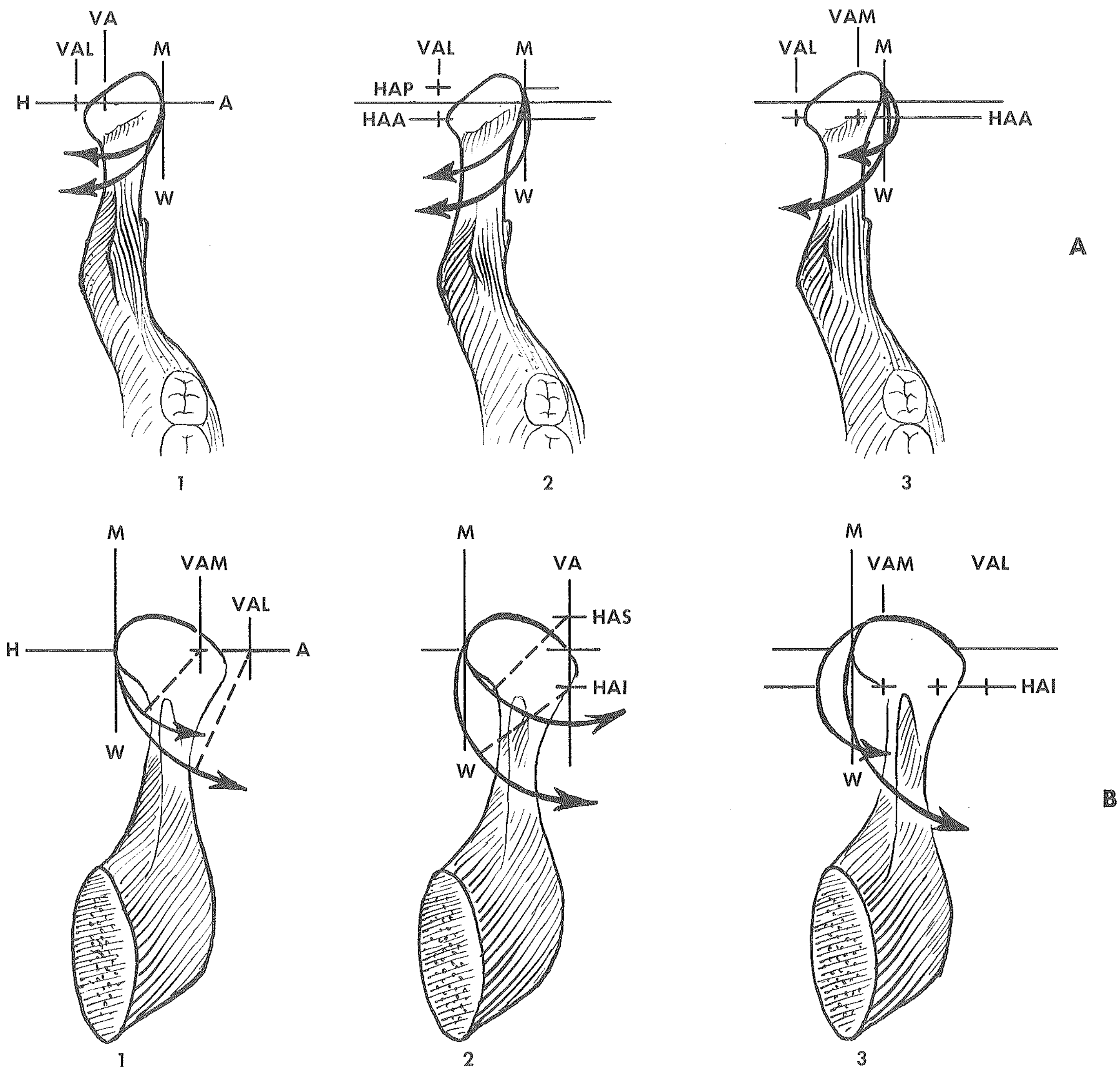


Fig. 12-34. A, In horizontal plane, when a symmetrical condylar element has a normal horizontal axial center regardless of position of vertical and sagittal axial centers, there is no Bennett movement. When horizontal axial center is placed posteriorly, as in **2**, and vertical and sagittal axial centers are placed laterally, no Bennett movement; since horizontal axial center is placed more anterior, Bennett movement develops. In **3** the more medial the vertical and sagittal axial centers are placed, the more Bennett movement develops. **B,** A symmetrical condylar elment is viewed in a vertical plane. In **1**, which has a normal horizontal axial center regardless of position of vertical and sagittal axial center, no Bennett movement is needed. As horizontal axial center is placed inferior, Bennett movement devlops as in **2**. The more medial the vertical and sagittal axial centers are placed, as in **3**, the greater the need for lateral translatory movement becomes.

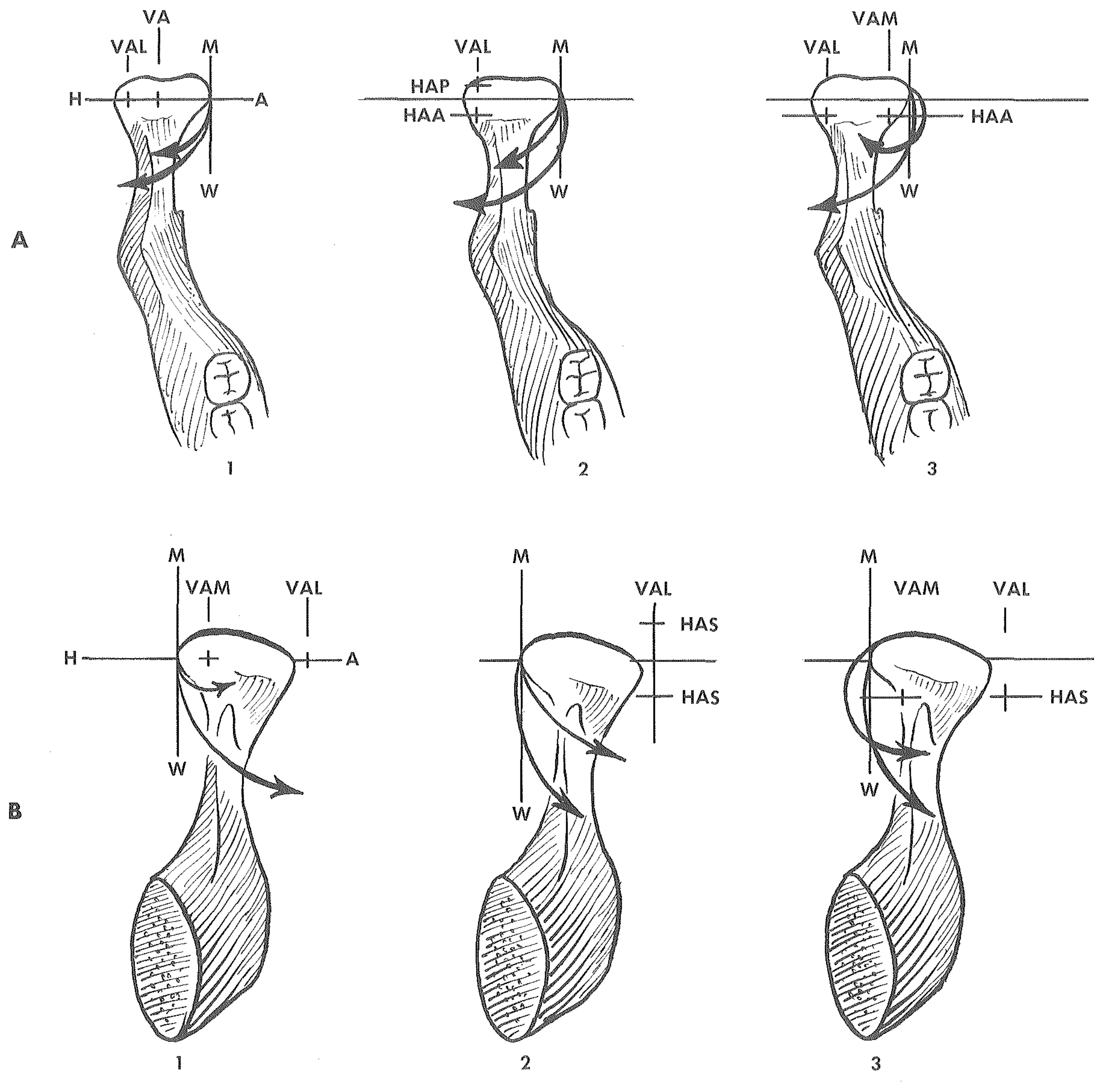


Fig. 12-35. A, In horizontal plane, when condylar element is parallel to horizontal axial center regardless of position of vertical and sagittal axial centers as in **1**, no Bennett movement is needed. As horizontal axial center is moved anterior as in **2**, a degree of Bennett movement is needed. With anterior positioning of horizontal axial center and medial positioning of vertical and sagittal axial centers as in **3**, more Bennett movement is needed. **B,** Vertical plane presents a condylar element parallel to horizontal axis (**1**). As vertical and sagittal axis is placed more laterally and horizontal axis more inferior, Bennett movement develops as in **2**. The more medial the vertical and sagittal center are placed (**3**) the greater Bennett movement is demanded.

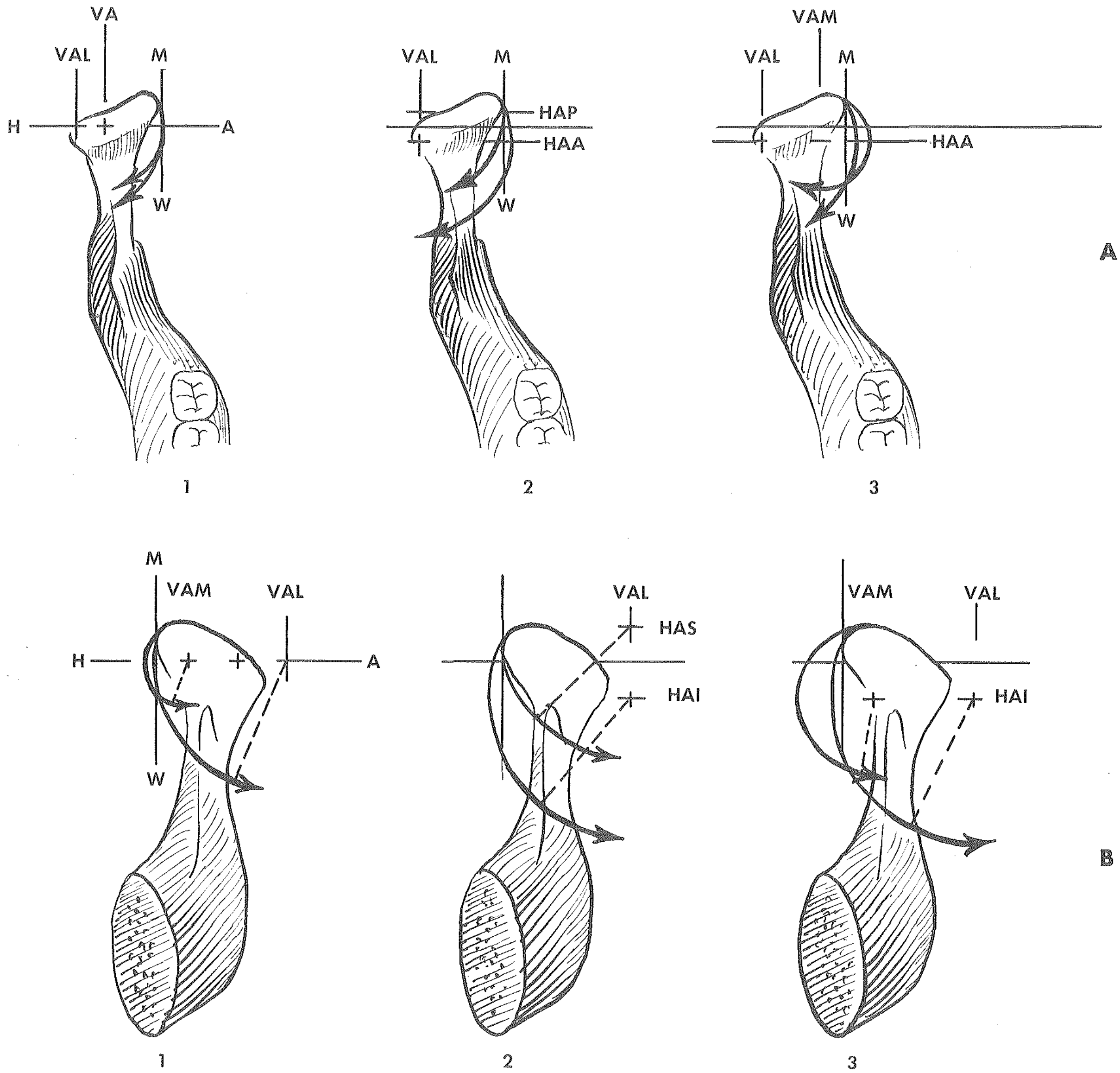


Fig. 12-36. A, An asymmetrical condylar element is placed more oblique to horizontal axis, and, regardless of where horizontal axial center is placed in relation to vertical and sagittal axial centers, Bennett movement is needed. The more anterior and medial the centers are placed as in **3** the greater the amount of Bennett movement. **B,** In vertical plane same set of conditions are present. As centers are placed more inferior and more medial, the greater becomes the demand for Bennett movement as shown in **3.**

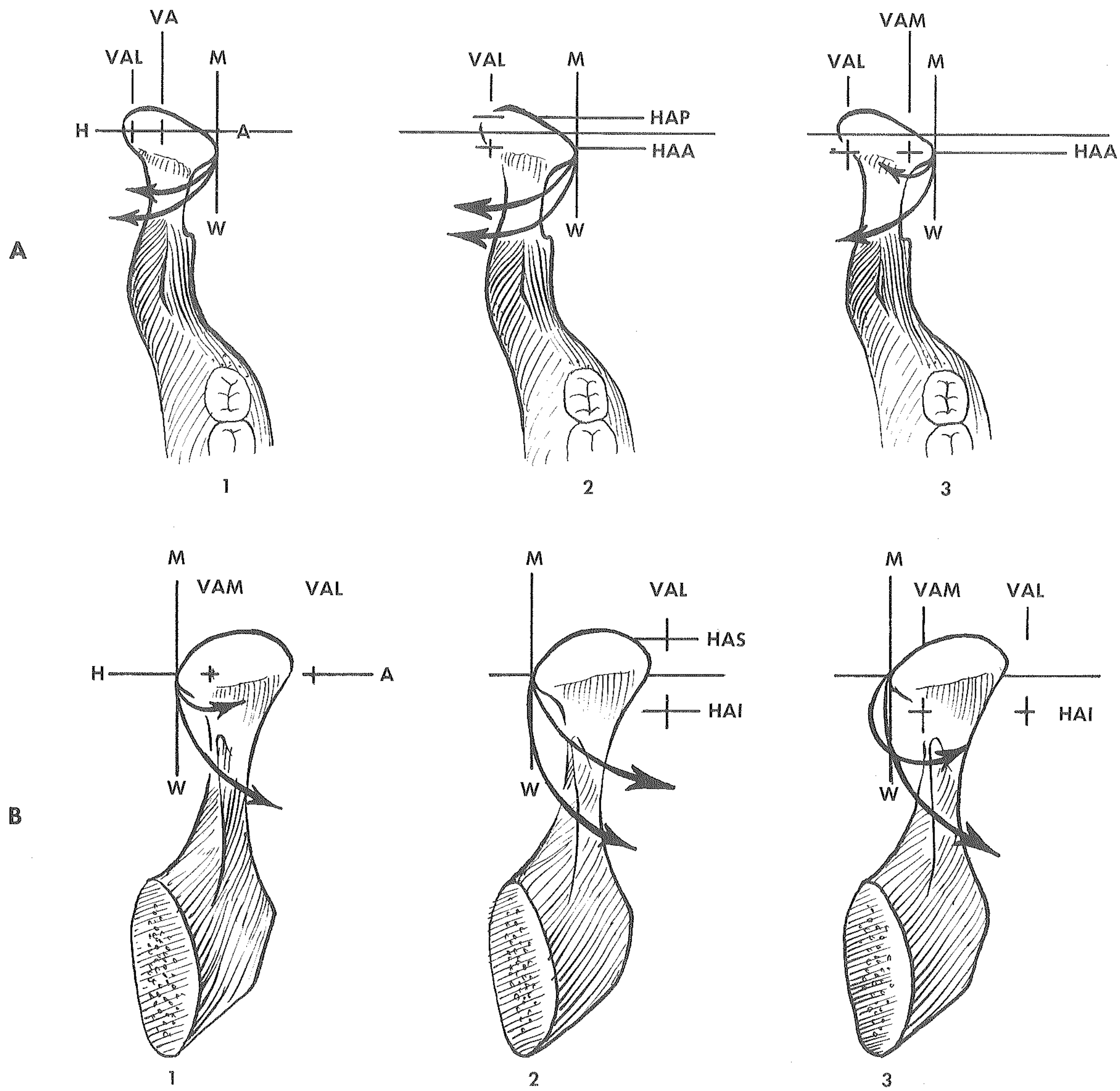


Fig. 12-37. A, In horizontal plane the medial aspect of condylar element is placed in anterior version in relation to condylar element. Regardless of position of horizontal, vertical, and sagittal axial centers, no Bennett movement develops, as seen in **1** to **3**. **B,** In vertical plane same conditions are constructed. As horizontal axial center is moved more inferior as in **2** no Bennett movement. As vertical and sagittal centers are moved more medial, a slight Bennett movement develops as in **3**.

ment, the more Bennett movement is needed to permit rotation of the element. The more lateral and posterior these centers fall in relation to the condylar element, the less Bennett movement is needed to permit rotation.

The effect in the vertical plane is the same as in the horizontal plane. The more medial and inferior that the horizontal and vertical centers are placed, the more Bennett movement is needed to permit rotation. The more lateral and superior the centers may fall, the less Bennett movement is needed to permit rotation of the condylar elements. (See Fig. 12-37.)

In a symmetrical condylar element, the configuration of its medial aspect permits no interference with the medial wall of the fossa. All radii from the common center of rotation to every point that comes in contact with the medial wall of the fossa in the vertical and sagittal planes are the same length; hence, no Bennett movement is needed to permit rotation of structure. When the element is shaped irregularly and its long axis is aligned obliquely to the horizontal axis in the horizontal plane and the medial aspect lies superiorly to the horizontal axis in the vertical plane, the condylar element (and the common center of rotation) must move laterally to free itself from the medial aspect of the fossa so that rotation can take place. In this case, all radii from the common center of rotation to every

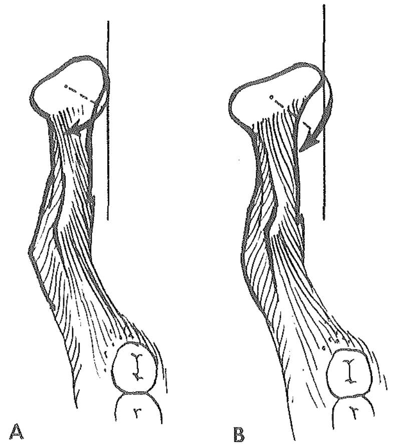


Fig. 12-38. A, Symmetrical condylar element; no Bennett movement needed to permit rotation. **B,** Irregular condylar element; lateral translation required to permit rotation. (From DePietro, A. J.: Dent. Clin. N. Amer., pp. 607-620, Nov., 1963.)

point that makes contact with the medial wall of the fossa in this movement are not the same in length; hence, a Bennett movement is needed to permit rotation. (See Fig. 12-38.)

Relation to horizontal axis

Rotation of the condylar element in the lateral movement takes place in the horizontal and vertical planes. Fig. 12-39 shows four different working condylar elements having the same configuration, the same vertical and sagittal axial centers, and the same radius, but varying deviations in the relation of the long axis of the condylar element to the horizontal axis.

In Fig. 12-39, *A*, the long axis of the condyle is constructed parallel to the horizontal axis in the horizontal plane, and in Fig. 12-39, A_1 the long axis is constructed parallel to the vertical axis. As the condylar element rotates in both figures, the medial surface of the fossa does not interfere with the arc formed by the surface of the rotating condylar element, and therefore no Bennett movement is needed to permit rotation about the common center.

In Fig. 12-39, *B*, the long axis of the condylar element is constructed at a slight deviation from the horizontal axis in the horizontal plane, and the long axis of the condylar element is again constructed at a slight deviation from the horizontal axis in the vertical plane. Since, in this case, the medial surfaces of the fossa in both planes will interfere with the arc formed by the surface of the rotating condylar element, the condylar element must translate laterally as it rotates in order for complete rotation to take place. In this instance a slight amount of Bennett movement is necessary for completion of the function.

In Fig. 12-39, *C*, the long axis of the condylar element is constructed at a greater posterior direction from the horizontal axis in the horizontal plane, and the condylar element is constructed at a greater superior deviation from the horizontal axis in the vertical plane. In this case the medial surface of the fossa will interfere grossly with the arc formed by the medial surface of the rotating condylar element, and for rotation to take place a greater lateral translatory movement is demanded (Bennett movement).

In Fig. 12-39, *D*, the long axis of the condylar element is constructed at an anterior deviation from the horizontal axis in the horizontal

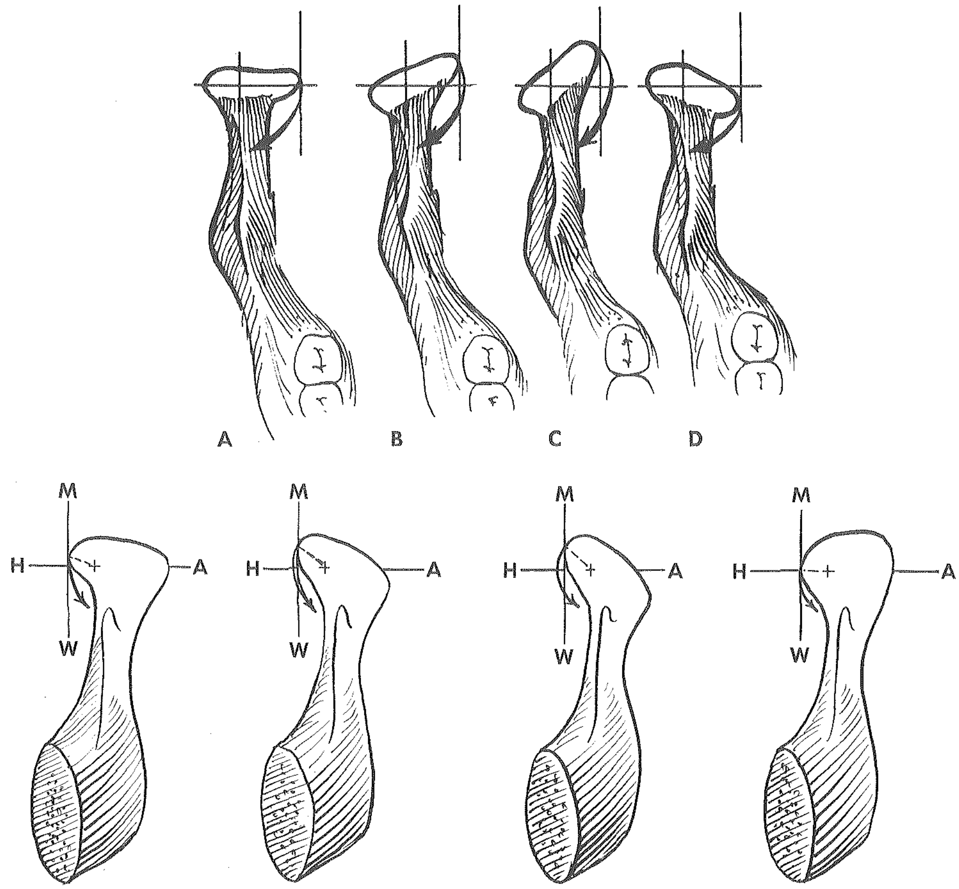


Fig. 12-39. Four different working condylar elements with same configuration and same vertical and sagittal axial centers of rotation, but varying in relation of long axis to horizontal plane. (**A** to **D** from DePietro, A. J.: Dent. Clin. N. Amer., pp. 607-620, Nov., 1963.)

plane, and the condylar element is constructed at an inferior deviation from the horizontal axis in the vertical plane. In this case the medial surface of the fossa could not offer any interference in the rotary movement, and therefore, no Bennett movement is needed.

Relation to common center of rotation

Fig. 12-40 represents a condylar element having its medial surface, in the horizontal plane, in contact with the medial wall of the fossa line, represented by line EF. The common center of rotation is represented by O, the vertical axis of rotation; line CD, the sagittal axis of rotation; and line AB, the horizontal axis of rotation. When the mandible rotates, the medial aspect of the condyle scribes an arc, O. This slight arcing across line EF dictates the amount of Bennett movement needed for this asymmetric condylar element. If the common center of rotation in both planes were located at O′, the greater amount of arcing across lines EF (as represented by arc O′) would demand greater lateral movement of the condyle to permit its rotation and, hence, greater Bennett movement.

At position O″, the common center of rotation of the condyle is again moved laterally in the horizontal plane and inferiorly in the vertical plane, thereby further increasing the radii of the scribed arcs. Arc O″ demands a greater lateral translation of the condyle elements to permit rotation, hence a greater Bennett movement than was necessary in the previous case.

These factors, or any possible combination of the foregoing factors, will determine the magni-

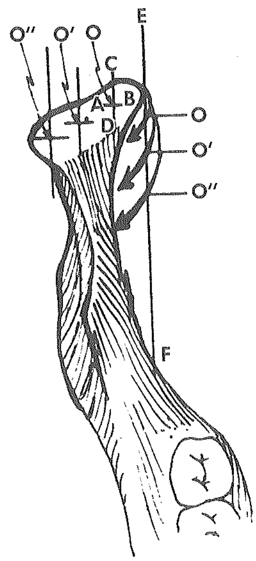


Fig. 12-40. Relation of Bennett movement to position of vertical and sagittal centers in condylar element having medial surface in contact with medial wall of fossa. (From DePietro, A. J.: Dent. Clin. N. Amer., pp. 607-620, Nov., 1963.)

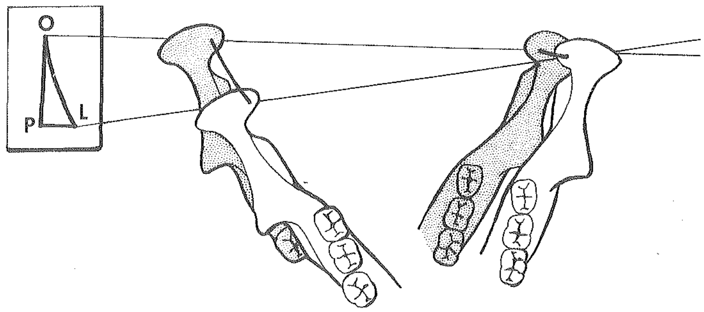


Fig. 12-41. Angle formed by recording of two movements is referred to as Bennett angle.

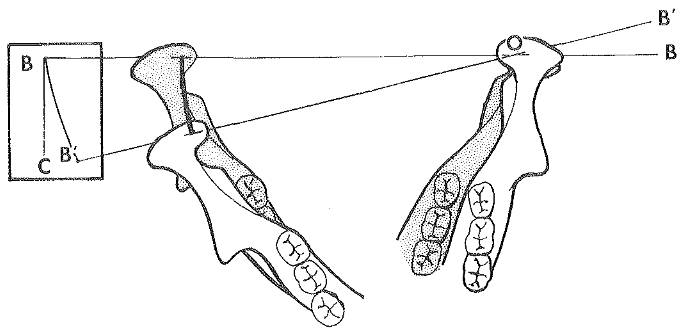


Fig. 12-42. Bennett angle, result of pure rotation.

tude, duration, and direction of the Bennett movement.

Bennett angle

In a straight protrusive movement, both condylar elements translate downward and forward, but in the horizontal plane (a two-dimensional recording) the only motion recorded is the forward movement. In a lateral movement, the balancing condylar element translates downward, forward, and inward; in the horizontal plane, the only motion recorded is the forward and inward movement of the balancing condylar element. The angle formed by the recording of the two movements is referred to as the Bennett angle (Fig. 12-41).

Bennett angle may be the product of pure rotation of the working condylar element, or the product of pure rotation and lateral translation of the working element.

Pure rotation

In Fig. 12-42, line BB represents the horizontal axis extended to fall upon plates that are positioned in the horizontal plane. In the straight protrusive movement, the extensions of the horizontal axis will scribe the path BC on right and left plates. When a lateral movement is performed by rotation about the vertical axial center point O in the working condylar element, the axial extension on the balancing side scribes line BB′, thereby forming the angle CBB′. The angle thus formed is called the Bennett angle. The inward movement represented by line BB′ is not a product of the Bennett movement in this case but is produced by the change in position of the fixed radius. Therefore the inward movement is the product of pure rotation.

The same figure that was used to explain the Bennett angle can be used to show that the Bennett angle may be the product of pure rotation with lateral translation (Fig. 12-43). For the working condylar element to rotate, it must translate laterally; therefore, the common center of rotation (O) travels to position O′, and in so doing moves the balancing condylar element medially to position BB″. The reciprocal on the working side is moved laterally to establish a new path, which is represented by BA′.

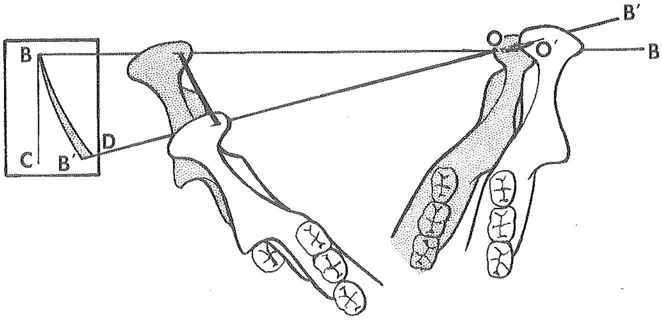


Fig. 12-43. Bennett angle, product of pure rotation and lateral translation.

Fisher's angle

In a straight protrusive movement both condylar elements translate downward and forward in the sagittal plane (at most a two-dimensional record) and complete protrusive movement of the right and left side is recorded. In the lateral movement, the balancing condylar element translates downward, forward, and inward; but in the sagittal plane, the only motion recorded is the downward and forward movement of the balancing condylar element (Fig. 12-44). In the majority of cases the recorded lateral movement falls below the protrusive record, and the angle recorded by the two movements is called Fisher's angle (Fig. 12-45).

In a small percentage of cases, the protrusive record and the lateral record of the balancing condylar element fall one upon the other, and there is no Fisher angle. An even fewer number of cases has the lateral record of the balancing condylar element recorded superiorly to the protrusive record on the sagittal plane. This may be designated as an "inverted Fisher angle."

Since all translatory movement is the function of the glenoid fossa, the variance in the Fisher angle must be caused by the anatomic configuration of this fossa.

In the discussion of Fisher's angle, three distinct relationships were described. They can be shown best when the anatomic configuration of the glenoid fossa is related to the horizontal and sagittal recording plates.

In Fig. 12-46 point O on the horizontal plate represents centric relation, and from this point all translatory movement originates, as represented by angle POL, the Bennett angle. On the sagittal plane, point O′ represents the centric relation, and again all translatory movement originates from this point, as represented by angle L′O′P′, the Fisher's angle. Centric relation becomes the origin of all mandibular function and must be considered a point of function rather than an area.

The tracings recorded on the horizontal and sagittal planes represent a two-dimensional view of half the functions of the mandible. To reconstruct the anatomic configurations of the glenoid fossa, both tracings must be combined to give the three-dimensional picture of the one condylar fossa.

To begin the reconstruction of the fossa, the triangle POL is duplicated with the same length of line P′L′ at the point of angle OLP. Arc O′L′ is connected to point O and point L′. Arc O′P′ is transferred to points O and P. Point P is connected to point L′ with a straight line.

The fossa now presents a three-dimensional object with height, width, and length (Fig. 12-

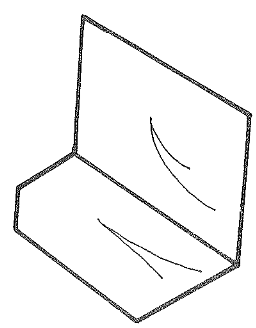


Fig. 12-44. Recordings of protrusive and lateral movement on sagittal and horizontal plates in region of condylar element.

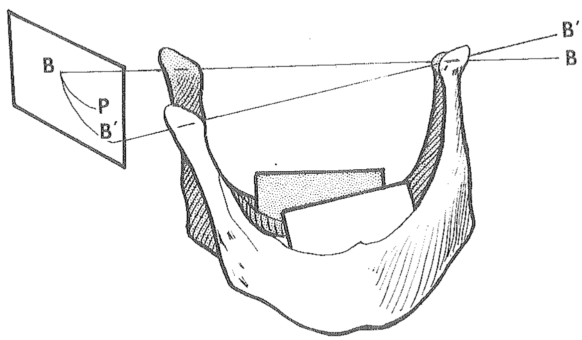


Fig. 12-45. In lateral movement path traced on sagittal plate is downward and forward. Angle B′BP is formed and is Fisher's angle.

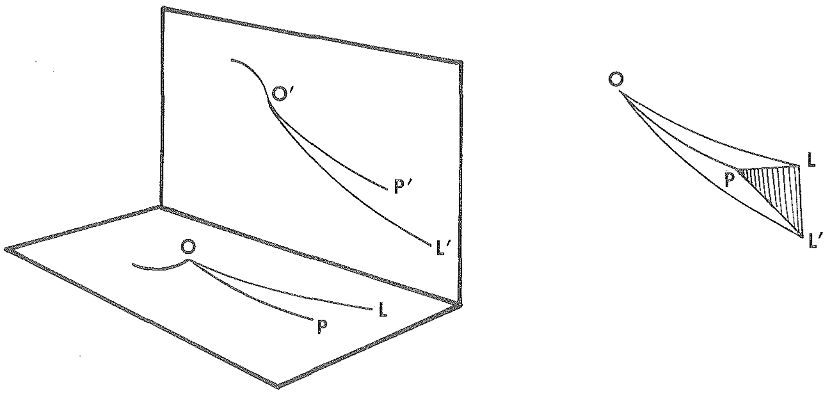


Fig. 12-46. Possible contour of glenoid fossa when this series of tracings are presented.

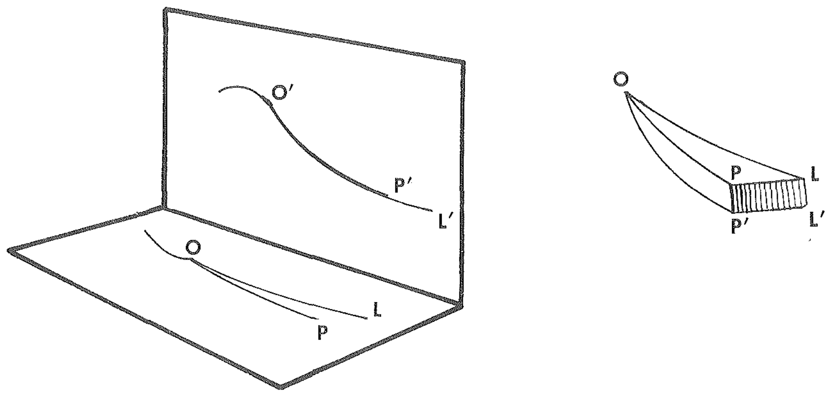


Fig. 12-47. When lateral path coincides with protrusive path, this is possible configuration of fossa.

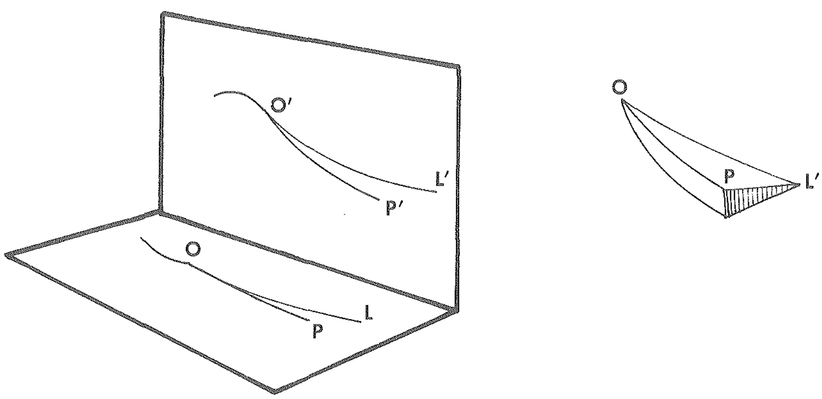


Fig. 12-48. Balancing path is superior to protrusive path on sagittal plate, suggesting this possible fossa contour. Variations in horizontal plate along with sagittal plate are capable of presenting numerous combinations of contours.

47). The condylar element is capable of translating about the entire triangular area (P′OL′) of the inferior surface of the constructed fossa. This surface accounts for half of all mandibular function. The same surface on the opposite side completes the entire envelope of motion. The medial aspect of the fossa is inferior to the lateral aspect.

In the second relationship to be considered the lateral path coincides with the protrusive path. By following the same procedure described in the first relationship, the configuration of the fossa can be constructed (Fig. 12-48). The medial and lateral aspects of the fossa are on the same plane.

The third relationship in the sagittal plane places the lateral path of the balancing condylar element in a superior relationship to the protrusive record. By combining the records on the horizontal and sagittal planes the medial aspect is directed superiorly to the lateral aspect of the fossa.

Character of the lateral curve

To determine the type of curve the translating condylar element scribed in the lateral movement, ten complete sets of pantographic tracings were examined. The right and left sagittal record plates were removed from the set, photographed, and enlarged six times. The curves were traced on graph paper in such a manner that the beginning of the curve fell on the y axis. The end of the curve was so placed as to approach the x axis but never to make contact with the x line or the x axis is an asymptote. Three tangents were constructed from the curve to the x line, and all tangential lines that were constructed were found to be of equal length. From these findings the assumption was made that the curve in question was a tractrix. (Fig. 12-49).

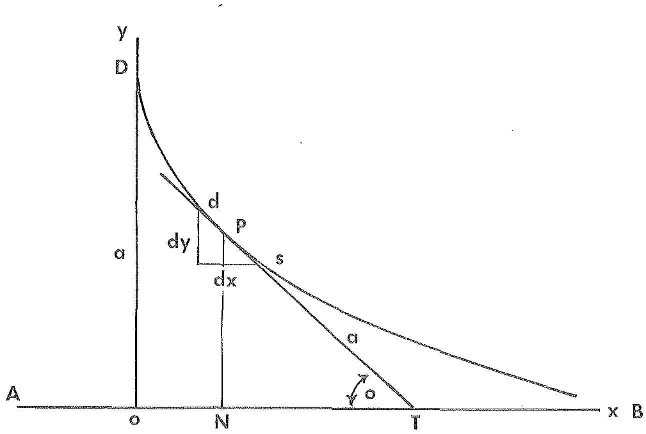


Fig. 12-49. A curve is such that length of tangent at any point P, from P to intersection T of tangent with a fixed line AB is a constant length; a is a tractrix.

A *tractrix* is defined as a curve whose tangent is always equal in length to a given line. It may be described by a small weight attached to a string, the other end of which is moving along a straight line or curve. It is a curve of equal *wear* and of the same *resistance*.

If we consider a small portion (ds) of the curve at P, then the sin $\Theta = \frac{dy}{ds} = \frac{-y}{a}$. (The reason for the minus sign before the $\frac{y}{a}$ is because the curve slopes downward.)

Then

$$ds = -a\frac{dy}{y} \text{ and } s = -a\int\frac{dy}{y}$$

that is

$$s = -a \log y + c; \text{ when } x = \Theta,$$
$$S = \Theta, y = \Theta$$

so that

$$\Theta = -a \log a + c, \text{ and } c = a \log a,$$
$$\therefore S = a \log a - a \log y$$

then

$$S = a \log \frac{a}{y}$$

This is the length of the curve without a knowledge of the equation of the curve. This is sometime impossible.

To get the length of an arc between two points given by their abscissa, however, it is necessary to know the equation of the curve.

This is obtained as follows:

Since

$$PT = a$$

$$\frac{dy}{dx} = -\tan\Theta = -\frac{y}{\sqrt{a^2 - y^2}}$$

Then

$$dx = -\frac{\sqrt{a^2 - y^2}}{y}dy$$

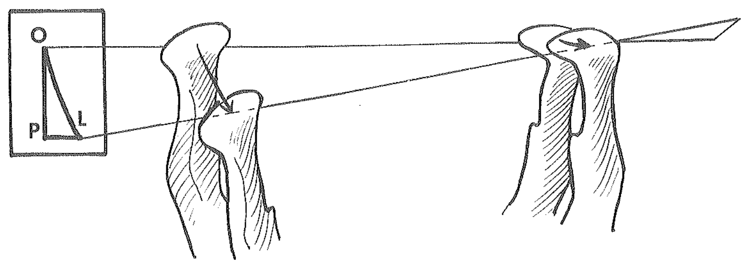


Fig. 12-50. On horizontal plate triangle POL is formed by protrusive and lateral movement, OP is height of triangle, PL is base, and OL is hypotenuse. Both OL and OP come to rest at same distance on plate, as represented by point O and line PL, but in lateral movement OL, being the hypotenuse, shows that distance of travel is greater.

The integration will give us a relation between x and y, which is the equation of the curve.

$$dx = \frac{\sqrt{a^2 - y^2}}{y}\,dy$$

$$dx = \frac{i\,\sqrt{y^2 - a^2}}{y}\,dy$$

put

$$\sqrt{y^2 - a^2} = a \tan \Theta$$

$$y = a \sec \Theta$$

$$dy = a \sec \Theta \tan \Theta \, d\Theta$$

$$\therefore dx = \frac{i\,\sqrt{a^2 - y^2}}{y}\,dy = \frac{i\,a \tan\Theta \sec\Theta \tan\Theta\, d\Theta}{a \sec \Theta}$$

$$= i\,a \tan^2 \Theta\, d\Theta = i\,a\,(\sec^2 \Theta - 1)\,d\Theta =$$

$$i\,a \tan\Theta + a \log(\mathrm{Cos}\,\Theta - i \sin\Theta) + C$$

$$y = i\,a \tan\Theta - i\,a\Theta + C =$$

$$i\,\sqrt{y^2 - a^2} + a \log\left(\frac{a - i\,\sqrt{y^2 - a^2}}{y}\right) + C$$

$$x = a \log \frac{a + \sqrt{a^2 - y^2}}{y} - \sqrt{a^2 - y^2}$$

The measured values from graph	*The calculated values from formula*
$t_1 = 1.000$ $y = .72$ $X = .23$	$t_1 = 1.000$ $y = .6480$ $X = .2384$
$t_2 = 1.187$ $y = .55$ $X = .42$	$t_2 = 1.187$ $y = .567$ $X = .3595$
$t_3 = 1.625$ $y = .36$ $X = .8$	$t_3 = 1.625$ $y = .370$ $X = .6997$

The foregoing represents data from one lateral translatory path. The remaining paths were treated in the same manner, and the results were approximately the same—strong evidence to support the fact that a lateral path is a tractrix.

If the lateral path is examined in the horizontal plane, it will help explain how a radius of an arc can remain unchanged and still give rise to a tractrix-type path.

In the straight protrusive movement the condylar element translates from point O along arc OP, which has a fixed radius. In the lateral movement the condylar element translates from O to L, cutting across arc OP on a diagonal and forming the Bennett angle POL; point P should be connected to point L by a perpendicular line drawn from point P to meet line OL (Fig. 12-50). The triangle POL is formed where line PL is the base (b), line OP the altitude (a), and line OL the hypotenuse (h). The mathematical equation $h = \sqrt{b^2 + a^2}$ shows that h is always greater proportionately than b, and, as the value of a increases, h becomes still larger than b so that, in the lateral movement, the balancing condylar element may travel the same horizontal distance along the path as in the protrusive movement. However, the distance covered in the lateral movement is greater. The arc, so to speak, is being elongated: the greater the Bennett angle, the more elongation to the arc.

Mandibular fossae

The mandibular fossae are not functional areas for the condylar elements, since the temporomandibular articulation presents essentially a tubercle-to-tubercle relationship. However, the most superior, distal, and medial position of the condylar elements as they encroach upon the fossae acts as the initial point of all function; that is, it is a positional relationship from which all mandibular function begins, and this includes

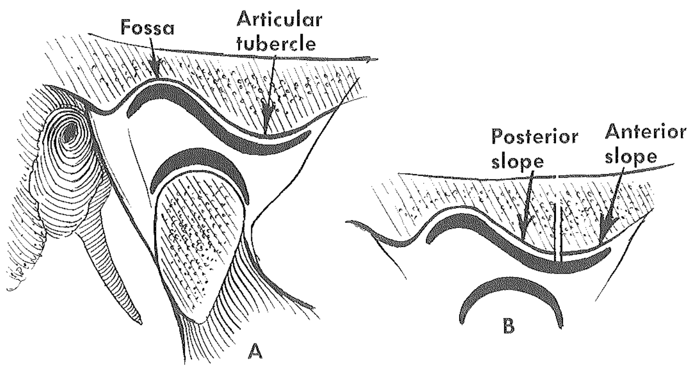


Fig. 12-51. A, Cross section of temporomandibular articulation. Glenoid fossae are divided into fossa and articular tubercle. B, Articular tubercle is divided into posterior slope and anterior slope.

the many varied rotary and translatory movements occurring independently of, or in combination with, one another.

Anatomically, there is no definite differentiation between the articular tubercle and the glenoid fossa. However, it is said that the articulation is with the articular tubercle and the fossa. How far into the glenoid fossa the articulation exists can be determined only by dissection and observation of the position of the meniscus, which varies from individual to individual but rarely goes past the base of the fossa. This observation seems to indicate that the anterior portion of the fossa may indeed be the functional surface. This term, anterior portion, is based on the premise that the temporomandibular articulation can be divided arbitrarily into a posterior section, the mandibular fossa, and an anterior section, the articular tubercle (Fig. 12-51). For the sake of discussion, the articular tubercle can be divided into a posterior slope and an anterior slope. The dividing line of the tubercle is the point of contact when the tubercle of the condylar element is positioned most superiorly, distally, and medially in relation to the articular tubercle. Therefore, it can be said that all mandibular function takes place along the dividing line and the anterior slope of the articular tubercle.

In the protrusive movement the tubercle of the condylar element translates and rotates forward and maintains contact with the inferior surface of the anterior slope of the articular tubercle through its entire range of function. In this specific translatory movement two characteristics of the articular tubercle are noted: (1) the degree of angulation, which may range from a minus angle to any degree of plus angulation when related to a plane of reference (the axis orbital plane, the Frankfort plane, etc.), and (2) the amount of curvature presented by the anterior slope, which may vary from a straight path to a curved path that may present radii that range from ⅜ to 4 inches.

The lateral function on the balancing side is closely allied to the protrusive movement, and its function is derived from the translatory movement of the tubercle of the condylar element with the more medial portion of the anterior slope of the articular tubercle. It differs from the protrusive movement in that it is a forward and inward translatory movement.

The mandibular tubercle, moving inward, travels along the anterior slope of the articular tubercle in a diagonal direction, producing a new expression of the slope. Since the inward movement demands a greater distance of travel in comparison to the protrusive movement over the same forward distance of translation, an elongation or a stretching of the arc results. This lateral surface of the slope in a lateromedial plane may produce the same angulation as in the protrusive movement; it may produce a greater angulation or a lesser angulation, indicating that its plane may lie on the same level, on an inferior level, or on a superior level.

In most anatomic articulators this registration can be reproduced by adjusting the inclination of the condylar element. The inclination setting is also used to adjust for the working function. When and if this registration is satisfied, a loss of the lateral setting will result.

In the working function the mandibular tubercle moves laterally between the posterior slope and the anterior slope of the articular tubercle and, depending on its position and contour, is capable of directing the mandibular tubercle in four basic directions. These primary directions are superior, inferior, posterior, and anterior, or any variety of combinations of these four primary directions.

The Bennett movement, or the amount of lateral translation, is completely dependent on the anatomic configurations of the medial and

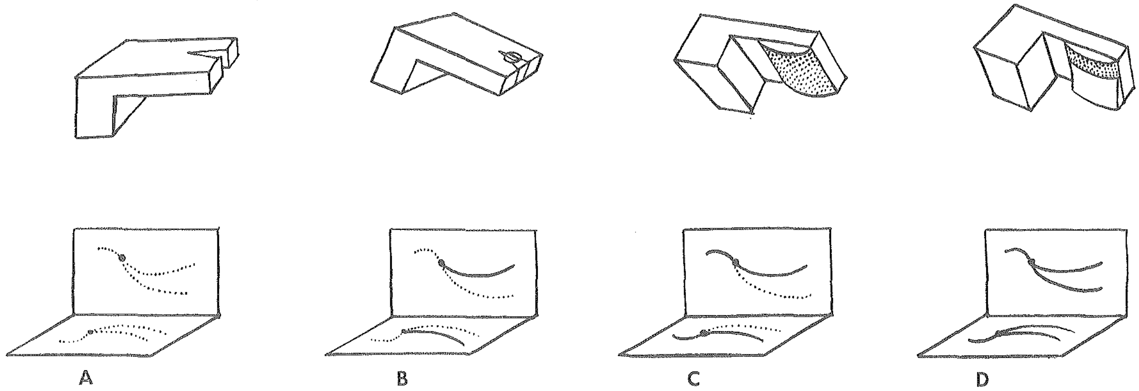


Fig. 12-52. **A,** Vertical and horizontal recording plates are shown. **B,** Setting of protrusive angulation and curvature as recorded on plates. **C,** Working function is now set, as designated on plates, by reciprocal movements. This is done by inclination setting. **D,** Inclination setting cannot be altered. Material must be added on medial and anterior portions of slope to follow lateral tracings on plates.

superior surfaces of the mandibular tubercle and the anatomic configurations of the inferior and medial surfaces of the glenoid fossa. In many cases this movement produces no lateral translatory movement of the condylar elements in the horizontal plane, which is pure rotation. In other instances varying degrees of horizontal translations are needed to permit rotation of the working condylar element.

All translatory paths are the function of the articular tubercle, whereas all axial centers of rotation are functions of the mandibular tubercle. To duplicate the temporomandibular articulation by a mechanical device it is well to follow the same pattern. The mandibular member is constructed so as to carry the spherical bodies that produce the axial centers of rotation, and the maxillary member is constructed to house the simulated fossa. The fossa must be constructed so as to reproduce the angulation and variety of curvatures that are demanded by the protrusive movement. The inclination adjustment must be present to allow for the lateral setting of the balancing side. (See Fig. 12-52.)

The setting for the working function now presents a problem. If the inclination setting is changed to accommodate the working function, then the setting for the lateral movement is lost. To recapture the lateral balancing movement a change must be made in the path. If a new path is inserted, then this would alter the protrusive setting. The method now in use to establish the lateral path is to add or take away part of the path and by so doing maintain the protrusive and working settings. If the lateral balancing path is in superior version to the protrusive path, then the simulated tubercle must be cut; if it is in inferior version, plastic material must be added. To connect this phase of the setting a simulated fossa must be constructed so that the working component is free and capable of independent movement. Since the working portion of the path has an independent inclination setting, it can be adjusted and in no way will this adjustment alter the inclination of the path.

Intercondylar distance

Intercondylar distance can be defined as the distance from the common rotational center of one condylar element to the common center of rotation of the opposite condylar element. This factor often is confused with the recording of an interfacial distance as recorded by the hinge-bow when performing a hinge-bow transfer. Interfacial distance is the distance from the point of the right stylus to the point of the left stylus. Its only function is to record and transfer the horizontal axis to a mechanical device.

Intercondylar distance is responsible for many of the mandibular functions, but this factor is so closely allied to the common centers of rotation that it becomes extremely difficult to separate the individual functions of one from the other.

In the discussion of the rotational centers it was shown that a lateral movement brings into

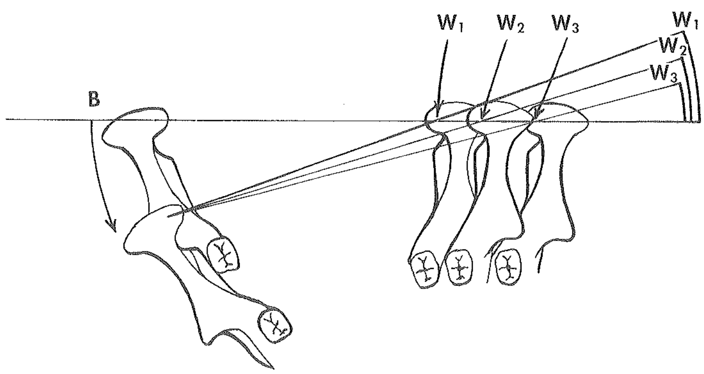


Fig. 12-53. Position of common center of rotation on working side has a marked effect on reciprocal movement in both horizontal (shown) and vertical planes. In pantographic tracings a slight variation of end point of either working or balancing tracing can severely alter intercondylar distance of working condylar element. Translatory distance on balancing side has remained fixed. Reciprocal distance on working side has changed. When reciprocal distance of travel is recorded from point B to W_3, the common center of rotation of working condylar will fall at point W_3. When recorded distance is from B to W_2, change in common center to point W_2, the same can be seen for BW_1 to center W_1.

function simultaneously both the vertical and sagittal axial centers of rotation. These centers function as one and cannot be separated into their simple components of rotation.

To simplify this treatise of these centers in the functional lateral movement, the Bennett movement will be disregarded. However, it is worth noting that, although the Bennett movement is a lateral translation and does not actually affect the rotational centers per se, it does permit these centers to perform the same function in a different position in relation to the glenoid fossa.

When the mandible performs a lateral movement, the balancing condylar element translates downward, forward, and inward a fixed distance, whereas the working condylar element rotates about its common center. As has been shown previously, an extension of the horizontal axis on the working side results in a reciprocal movement that appears to be upward, backward, and inward. In a specific unit of time (that is, in a given number of seconds), the balancing condylar element has traveled a fixed distance downward, forward, and inward, while an extension of, or the lateral aspect of, the rotating condylar element in the same unit of time has given rise to a definite reciprocal distance of travel (i.e., the upward, inward, and backward movement). The effect of intercondylar distance, or the positional relationship of the common centers of rotation to one another, can best be viewed in the horizontal and vertical planes.

One method of observing the influence of the common center of rotation of the working condylar element in the horizontal plane would be to place one center more medially (W_1) and another more laterally (W_3) to the original center (W_2), as shown in Fig. 12-53. A balancing condyle element and three imaginary working condyles are positioned at different intercondylar distances. The balancing condyle (B) has moved a definite distance in a specific period of time, the reciprocal movement of the working condyle (W_1) has moved a greater distance than when rotation occurred about the original center (W_2). When the balancing condylar element (B) translates about the more lateral center (W_3), a small distance of travel at the same unit of time is noted in the reciprocal movement. It becomes apparent now that to achieve a correlation of rotation and translation per given unit of time, a mechanical device must be capable of an intercondylar distance adjustment to set the correct position of the vertical and sagittal centers of rotation.

The time-distance factor has a definite effect on the occlusal forms to be constructed. When this factor is correct on both the working and the balancing sides, the buccal cusp tips of the mandibular teeth will travel on the balancing side from the central fossa to the tips of the maxillary lingual cusps which is seen when rotation occurs about the medially placed center (W_1). The path followed by the mandibular buccal cusps is represented by arc L_1 in Fig. 12-54. This is the most distal of the arcs formed and has the greater length. When rotation occurs about center W_2, arc L_2 is formed; this arc is shorter and more anteriorly placed than arc L_1, even though the balancing condylar element has translated the same distance in both cases. Arc L_3 represents the path of travel of the mandibular buccal cusp tip when the condylar element translates the fixed distance about the most lat-

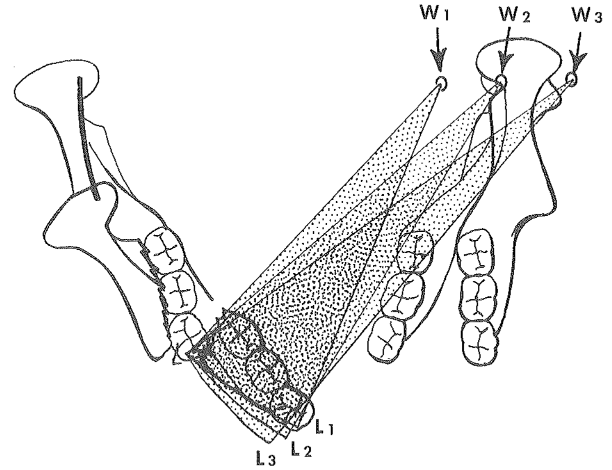


Fig. 12-54. In horizontal plane rotation about W_1 forms arc L_1, rotation about W_2 forms arc L_2, and rotation about W_3 forms arc L_3. Arcs formed represent path followed and distance traveled by mandibular buccal cusp on balancing side.

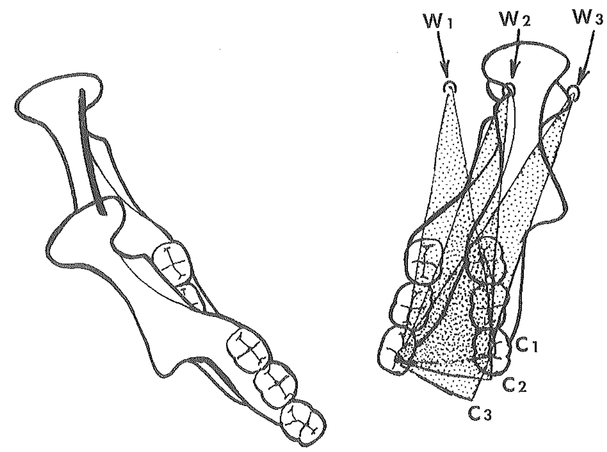


Fig. 12-55. In horizontal plane rotation about W_1 forms arc C_1, rotation about W_2 forms arc C_2, and rotation about W_3 forms arc C_3. Arcs formed represent paths followed and distance traveled by mandibular buccal cusps on working side.

eral rotational center. The arc formed is still shorter than arc L_1 and arc L_2.

Simultaneously, on the working side, the mandibular buccal cusp tips will pass through the buccal grooves and embrasures of the maxillary teeth and the maxillary buccal cusp tips will pass through the buccal grooves and embrasures of the mandibular teeth. They will come to rest at the buccal edges of the maxillary and mandibular posterior teeth. When rotation occurs about center W_1, arc C_1 is the path followed by the mandibular buccal cusp tip, as shown in Fig. 12-55. This arc is the most posteriorly placed and the longest formed, even though the translating condylar element has moved the same fixed distance. Arc C_2 is the path followed when the translating condylar element moves a fixed distance about center W_2. This path of travel is more anteriorly placed and is much shorter in length than path C_1. Rotation about the most lateral center (W_2) forms arc C_3. This arc is the most anteriorly placed, and is the shortest in distance traveled.

In the horizontal plane, when the working condyle becomes the balancing condylar element, translation may take place from the most lateral center (B_3), the medially placed center (B_2), or the more medial center (B_1) (Fig. 12-56). This change in the translating center has no effect upon the placement of the paths but only upon the distance the balancing and working cusps will travel in relation to the maxillary teeth. The time factor and the distance traveled by the balancing condylar element from centers B_1, B_2, and B_3 are kept constant, but a change in intercondylar distance changes the angular displacement on the working side. An increase occurs in the angular displacement by shortening the intercondylar distance. This factor increases the dis-

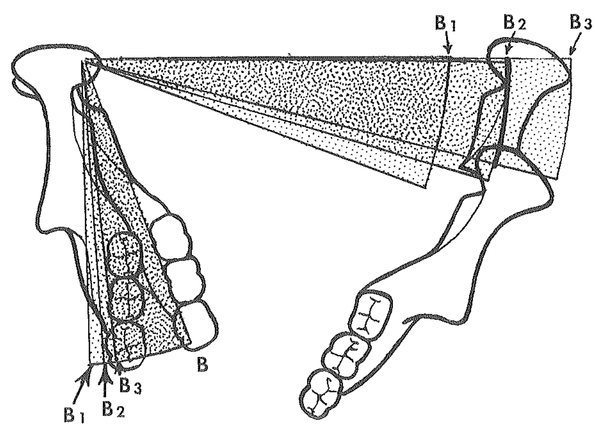


Fig. 12-56. In horizontal plane balancing condylar element in varying positions B_1, B_2, B_3, moving a fixed distance produces arcs BB_1, BB_2, and BB_3. On working side this has a marked effect on width of tooth from central groove to buccal contour.

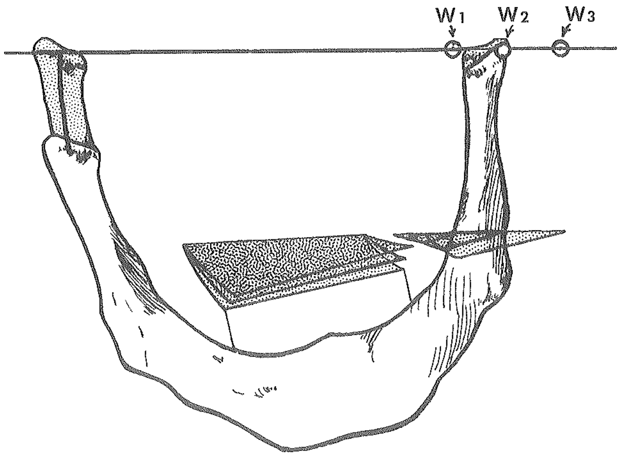


Fig. 12-57. In vertical plane as common center of rotation is moved from position W_2 to W_3, vertical component of spatiotemporal continuum on both balancing and working sides is increased.

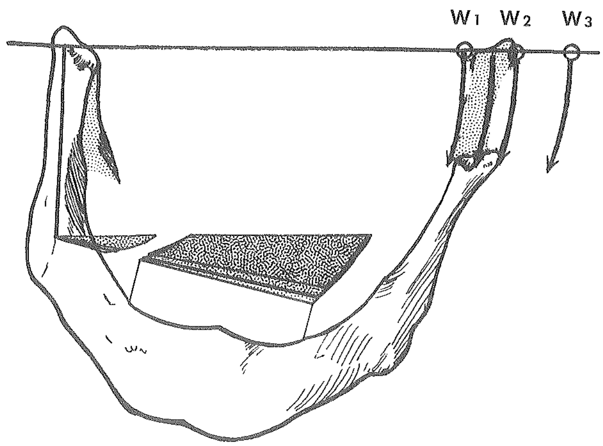


Fig. 12-58. Loss in vertical component of spatiotemporal continuum, as the common center of rotation of balancing condylar element is moved from position W_2 to W_3.

tance the mandibular buccal cusps will travel. As the intercondylar distance is increased (by moving the balancing center laterally), the angular displacement becomes less and the distance of travel of the cusps becomes shorter.

The lateral movement, in the vertical plane, shows the balancing condylar element moving inward and downward and the reciprocal movement, on the working side, upward and inward. This function plays a major role in the vertical dimension of the spatiotemporal continuum formed between the maxillary and mandibular ridges. The change in the centers of rotation in this plane has an effect on the vertical dimension on both the working and balancing side.

In Fig. 12-57 the mandible is shown in the vertical plane, and the balancing condylar element in this plane appears to translate downward and inward. When this function occurs about the common center of rotation (W_1), the reciprocal movement of the working condylar element presents the greatest amount of upward and inward movement. It also is responsible for the least amount of vertical distance in that position of the spatiotemporal continuum on the working and balancing side of the occlusal forms.

By moving the common center of rotation more laterally with the same amount of translatory movement by the balancing element, a smaller reciprocal movement (upward and inward) on the working side occurs. The vertical dimension of that portion of the spatiotemporal continuum on the working side increases considerably (about four times).

As the common center of rotation is moved more laterally than in the previous two examples and with the same amount of translatory movement of the balancing condylar element, much less upward and inward movement of the reciprocal on the working side develops. The vertical component of the spatiotemporal continuum is still greater on the balancing side and about one-third larger on the working side.

When the working condyle becomes the balancing condylar element and translatory movements are performed from the most medial (W_1), the medial (W_2), and the lateral (W_3) common centers of rotation, a constantly changing spatiotemporal continuum is developed because of the changing of the vertical dimension.

In Fig. 12-58, the three centers (W_1, W_2, W_3) are viewed in the vertical plane. These centers have been changed from the working function to the balancing function and are permitted to rotate about the common center point a fixed distance. As the balancing center is changed along the horizontal axis, the angular displacement on the working side is also changing and, in effect, the changing of the angle accounts for the vertical changes.

Translation of the condylar element from W_1 about the common center is responsible for the greatest amount of vertical change in the spatiotemporal continuum. As the balancing center is moved more laterally to position W_2, a significant decrease on the vertical dimension of the spatiotemporal continuum is noted; as the balancing center is moved laterally, a greater change is observed. It also may be noted that the position of the teeth to the common centers of rotation will play a major role in this continuum. The more medial the teeth, the farther they are placed from the center, and an increase or decrease in the vertical component may develop, depending on the function of the condylar element.

The time factor assumes a major role in the problem for the simple reason that teeth are placed on the right and left side of the dental arch. This factor in the spatiotemporal continuum is present on one side of the arch because of the buccal-lingual width of the teeth. It becomes magnified when the opposite arch is involved and, if the time factor is incorrect (because of the intercondylar distance), the working side will complete its movement while the balancing side presents a partially completed movement; or the situation may be reversed, depending upon the decrease or increase in intercondylar distance. This is but one consideration; changes in this factor and all the fixed factors of articulation are capable of developing many variations in response to the variations in the formation of the teeth.

Variable factors of occlusion

The variable factors of occlusion are anterior guidance, plane of occlusion, and curve of Spee. These are definite determinants in the formation of the spatiotemporal continuum. This effect manifests itself primarily in the anterior region, and there is a gradual diminution of this control toward the posterior region. The fixed factors are Bennett movement, lateral angulation and curvature, protrusive angulation and curvature, intercondylar distance, and the horizontal axis. They exert the greatest amount of control in the formation of the continuum in the posterior portion of the dental arch, and their effect diminishes gradually toward the anterior portion of the arch. Therefore the variable and fixed factors of occlusion, functioning simultaneously, from the complete spatiotemporal continuum in all excursions, which directly influences the construction of the posterior occlusal forms.

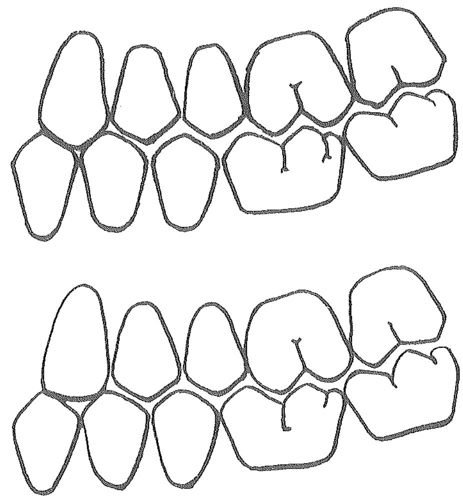


Fig. 12-59. A, Tracking effect of the cuspid. B, Blunting of cuspid tip, eliminating tracking effect.

Anterior guidance

The main function of anterior guidance is the harnessing of the mandibular movements that are the product of the fixed factors of occlusion. By so doing anterior guidance, with a few exceptions, completely negates in the anterior region the effect of the fixed factors of occlusion and exerts its effect upon the continuum.

The tip of the maxillary cuspid may, on the working side, pull the condylar element forward along its functioning position.

On the working side, the tip of the maxillary cuspid passing through the distal slope of the mandibular premolar may force the movement of the working condylar element out of the fossa and forward onto the slope (Fig. 12-59, *A*). By slightly blunting the maxillary cuspid tip the tracking effect can be eliminated with no loss of cuspid function (Fig. 12-59, *B*). This variable

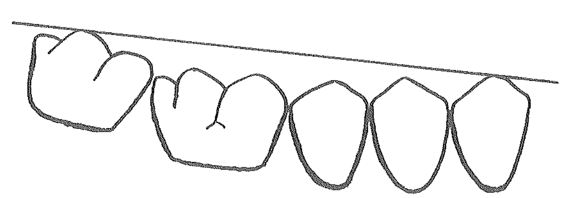


Fig. 12-60. A plane of occlusion is defined as an imaginary line drawn from tip of cuspid to tip of distobuccal cusp of mandibular second molar.

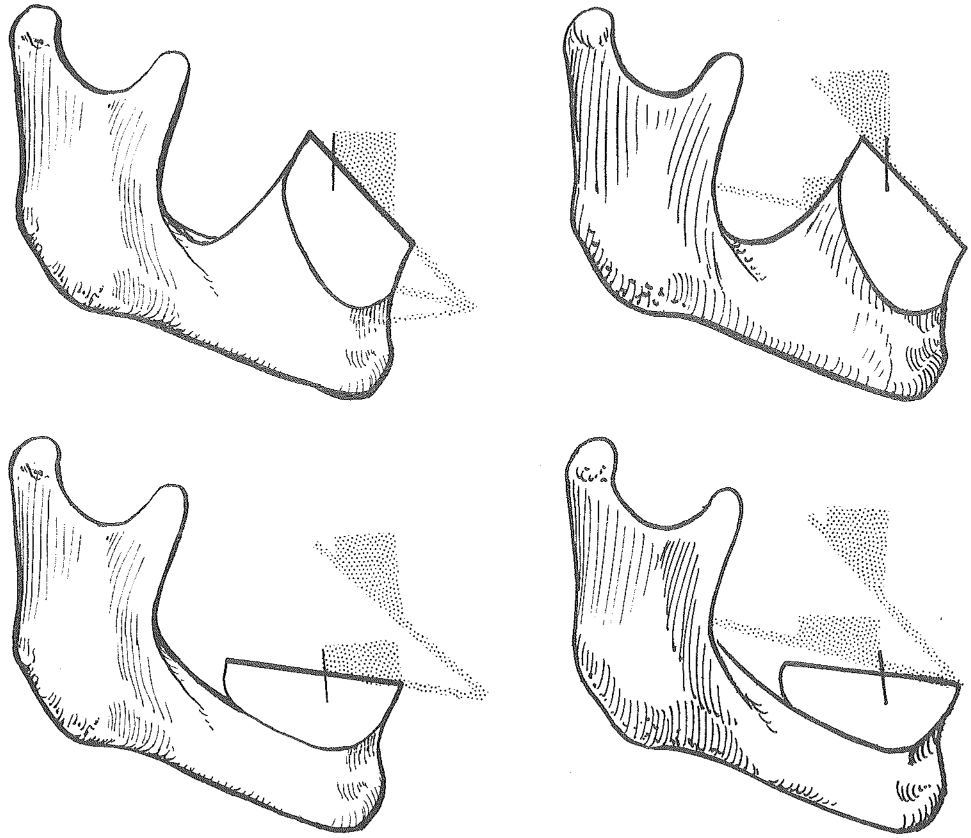


Fig. 12-61. A, Plane of occlusion is constructed parallel to a condylar angle, and the mandibular plane of occlusion is made to fall upon constructed plane in the centric position. **B,** Condylar element moves a fixed distance in protrusive, and there develops no vertical component to spatiotemporal continuum. A fixed anteroposterior size is established to a tooth. **C,** A new plane of occlusion is constructed more perpendicular to condylar angle. Mandibular plane is made to fall on constructed plane in centric position. **D,** With same fixed distance of protrusive travel a vertical component to the continuum develops, and a larger tooth size anteroposteriorly is evident.

factor has a two-dimensional influence on the vertical and horizontal components of the spatiotemporal continuum. The horizontal component (horizontal overlap) limits the protrusive function by the positioning of the mandibular incisors, but it has no effect upon the protrusive movement. As the mandible translates from the centric position to the limit of the protrusive function, the vertical component of the movement (vertical overlap) is constantly developing a new vertical dimensional change with every degree of horizontal translation of the mandible. This changing of the vertical component affects the vertical dimension of the spatiotemporal continuum in the zones of the continuum that are controlled and influenced by anterior guidance.

In the right and left lateral movements, the cuspids, by their location in the dental arch, account for the anterolateral guidance. Anterior guidance is a factor that embraces all mandibular function, and its effect is the same in the lateral movements as described in the straight protrusive movements. It limits the lateral function but not the lateral movement. It accounts for the constantly changing vertical dimension in the spatiotemporal continuum in the zones under the control and influence of anterior guidance.

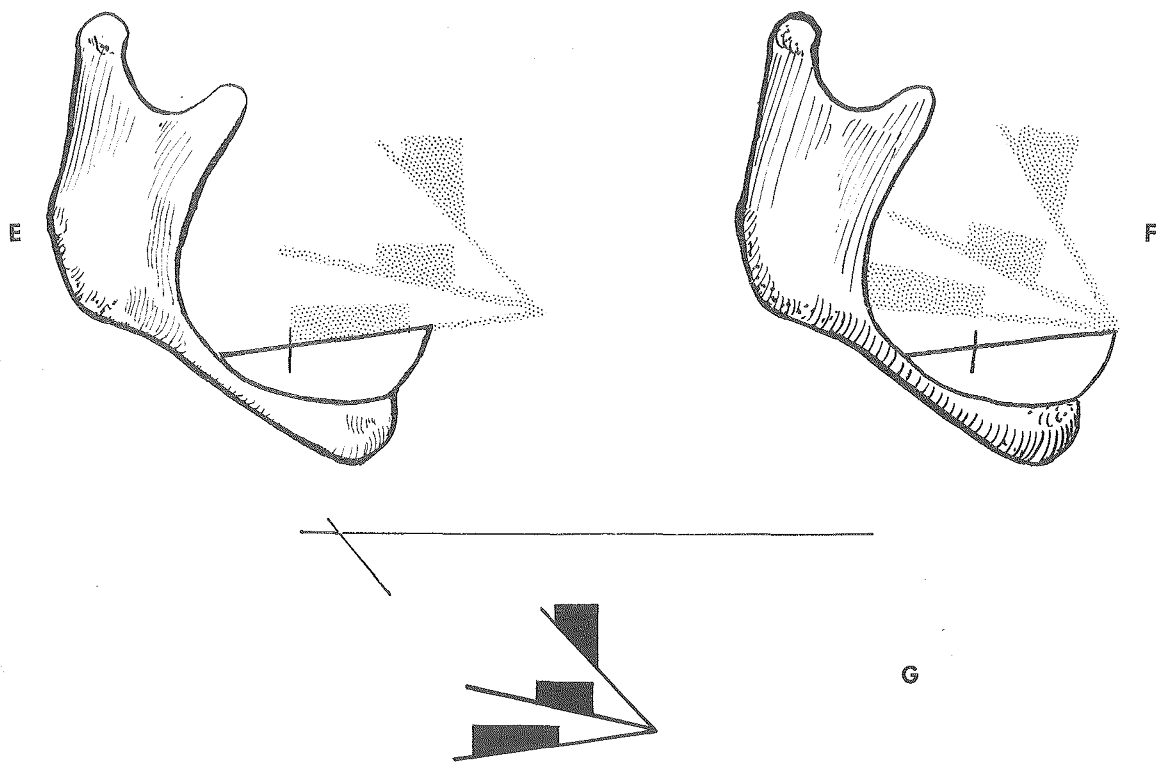


Fig. 12-61, cont'd. E, Plane of occlusion is even more perpendicular than previous illustrations in centric relation. **F,** Same fixed distance of protrusive movement and a greater vertical component to continuum is noted, and a larger tooth anteroposteriorly is formed. **G,** Variance in planes of occlusion, and change in anteroposterior size of teeth with a fixed distance of protrusive travel.

Plane of occlusion

The plane of occlusion is defined as an imaginary line drawn from the tip of the mandibular cuspid to the tip of the distobuccal cusp of the mandibular second molar (Fig. 12-60). When a plane of occlusion is constructed parallel to the condylar angle and the mandible is permitted to translate from the centric position to the protrusive position, no change is noted in the vertical dimension of the spatiotemporal continuum and only a slight change is noted in the horizontal dimension of the continuum.

The more perpendicular the plane of occlusion is constructed to the condylar angle, the larger the vertical and horizontal dimensions of the spatiotemporal continuum become. The plane of occlusion, as it relates to the condylar angle, will increase or decrease the cuspation of the teeth and also the overall dimension of the tooth from mesial to distal surface. A given plane of occlusion related to the condylar angle will yield a definite mean cuspation and a fixed distance from the tip of the mandibular cuspid to the distobuccal cusp of the mandibular second molar. The only method that can be employed to change the overall distance and the mean cuspation is to change the plane of occlusion. The more perpendicular the plane of occlusion is constructed to the condylar angle, the longer

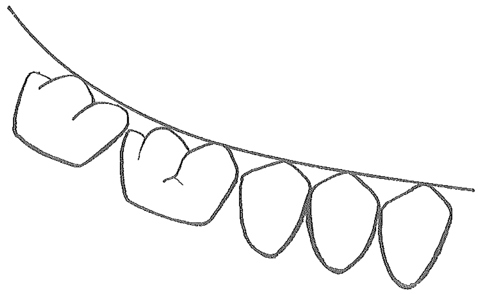


Fig. 12-62. Curve of Spee: a curvature of occlusal alignment of teeth beginning at tip of lower cuspid and following cusp of natural premolars and molars, continuing to distobuccal cusp of second molar.

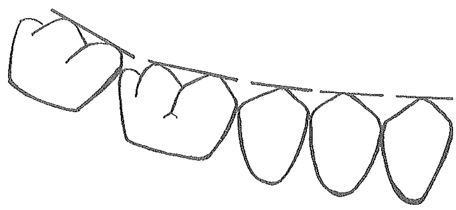


Fig. 12-63. Curve of Spee may be treated so that each tooth may present its own plane of occlusion.

the mesiodistal distance and the larger the average cuspation. As the plane of occlusion approaches a more parallel relationship to the condylar angle, the overall mesiodistal length (from mandibular cuspid tip to the disto-buccal cusp of the second molar) becomes shorter and a lesser mean cuspation results. (See Fig. 12-61).

Curve of Spee

The curve of Spee may be defined as a curvature of the occlusal alignment of teeth beginning at the tip of the lower cuspid, following the buccal cusps of the natural premolars and molars, and continuing to the distobuccal cusp of the second molar (Fig. 12-62). Upon a given plane of occlusion, many curves of Spee can be constructed. In relation to the curve of Spee the plane of occlusion may be defined as the chord of the arc of the curve of Spee.

The curve of Spee accounts for the individual size of the tooth mesiodistally and the cuspation of each tooth, but it never alters the overall distance mesiodistally or the average cuspation as dictated by the plane of occlusion. Since the curve of Spee follows the buccal cusps, then each tooth can be said to have its own plane of occlusion (Fig. 12-63). By connecting the distobuccal and mesiobuccal cusps of a molar with a straight line, an individual plane of occlusion can be constructed for each of the molars. The construction of a tangent to the curve of Spee that is perpendicular to the long axis of the cusps of the teeth will develop individual planes of occlusion for each of the premolars. All posterior teeth are capable of presenting their own plane of occlusion, and they are segments of the curve of spee.

These individual planes of occlusion behave in the same manner as the chord of the curve of Spee behaves in its relationship to the condylar angle. When the individual plane of a tooth is nearly parallel to the condylar angle, the tooth is smaller in size mesiodistally, and little or no cuspation is developed. As the plane is placed more perpendicularly to the condylar angle, the larger the mesiodistal size becomes and a greater cuspation is developed. It may be stated that the cuspation and size mesiodistally of a tooth is developed. It may be stated that the cuspation and size mesiodistally of a tooth is directly proportional to the angle formed between the individual plane of occlusion and the condylar angle.

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Chapter 13

Step-by-step procedures of a case from practice

Objectives

It is felt that a chapter covering step-by-step procedures of a case from my practice would be of value at this time. It is not easy to find a patient who is willing to be subjected to the taking of a great number of photographs and other inconveniences during the rehabilitation; therefore the selection of a case for this purpose is not always as ideal as may be desired. However, the procedural steps in this case are the same as in the majority of cases that I have executed with the additional importance of the need of changing the plan somewhat in "midstream" because of unforseen psychologic considerations.

I have been rewarded richly by having had the opportunity to rehabilitate many mouths, making use of the various known concepts of occlusion in my stages of development, and I feel that the one to be presented at this time has given me the gratifications that are so necessary for one trained not only in operative and prosthodontic procedures but also in the research method. Despite the fact that my successes have been many and gratifying, the failures have been my mentor. I do not look upon a failure as a total disappointment; it is a challenge to know why the restoration failed and whether it was of a technical nature or caused by some unknown or overlooked etiologic factors. Our methods would not pass the scrutiny of the pure scientist, but by basic and clinical research we must endeavor to reach that state.

Modern restorative dentistry must satisfy definite mechanical and biologic demands. Should extensive restorative dentistry be needed, all the component parts of the oral cavity must be taken into consideration if they are to function in harmony with each other. The entire mouth must be studied and treated as an integral unit.

The aim of restorative dentistry is the fabrication of an articulation that is nontraumatic, that protects the periodontal tissues, and that functions efficiently. This necessitates that the proximal contacts of the teeth in each arch be supported properly, that occluding surfaces be arranged so that forces applied at the final closure are distributed along the long axes of the teeth, that unnecessary torque is not exerted from fixed or removable partial dentures, that forces applied to artificial teeth on a removable partial denture are properly directed to the underlying bone of the residual ridge. All this should be done with the teeth, the temporomandibular joints, the neuromuscular mechanism, and the periodontium in functional balance.[1]

An accurate method of recording and transferring mandibular movements to an adjustable articulator will be used so that an accurate occlusal analysis for diagnostic and treatment planning and all laboratory work can be done on the instrument.

The purpose of instrumentation used in our method is to reproduce the functional paths of the joints so that occlusal surfaces that will permit a benign harmony of teeth, joints, periodontium, and muscles can be constructed.

To create occlusal surfaces that will function without clashing and injury, it is necessary to (1) locate the centers about which the condyles rotate, both vertically and horizontally, and (2) reproduce the paths that these centers follow as they glide the cusps past each other without colliding and without lateral stresses on the teeth.[2]

After the rotational centers of the condyles have been determined and transposed to the rotational centers of the instrument, we then can begin to understand and visualize[3] "the interplay of the articulative factors found in the joints with the factors of articulation found in the dental portion of the oral mechanism. The factors of articulation issuing from the joint are fixed and could not be changed by the hand of man or the misfit of teeth, but that the correspondent factors associated with the teeth and their curves of arrangement could be altered to a great degree. Thus we see the sliding movements of the condyles serve to move the lateral vertical axis and the opening-closing axis of rotations, and to put them in positions so that the mandible can make all of its complicated movements."*

The type of occlusion desired is a "mutual-protective occlusion." This means that the bicuspids and molars, when in centricly related closure, protect the incisors and cuspids, in the protrusive position the anterior teeth protect the posterior teeth, and in the lateral position the cuspids protect the incisors and the cusps of the bicuspids and molars.[4]

We must establish a correct centric position, definite eccentric paths (protrusive, lateral protrusive, lateral), which the cusps follow in excursive movements and which also incorporate the Bennett movement, eliminate balancing side contacts, and prevent traumatic contacts of the cuspids.

*From 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.

Flat surfaces or planes in opposition to each other are not effective in triturating food and are more traumatic since they require more force. To facilitate the incising, tearing, and triturating that are essential for proper mastication, it is necessary to develop cusps, ridges, grooves, and sulci in the anatomy of the occlusal surface of bicuspids and molars and the proper anatomy in the anterior teeth. Arch form and placement of restorations in proper relation and alignment to the other teeth in the arch should not be overlooked or minimized.

The previously mentioned material emphasizes the fact that, for a mouth to be restored to good function successfully, the dentist must know how a mouth functions and how the various components of mandibular movement enter into the functional relations of the teeth. He must be able to recognize and distinguish between normal and abnormal occlusion and joint function and must understand the relation between functional demand and metabolic rate. The influence of systemic and psychogenic factors must not be minimized.

In other words, the dentist must realize that the gains of occlusal rehabilitation in the preservation of teeth are inextricably linked to a good knowledge of occlusion, articulation, oral anatomy and physiology, etc. Form and function go hand in hand. The possession of a high degree of skill in the field of prosthodontics and an understanding of the various tools and instruments at his command are "musts." All of this covers a wide range of knowledge, intelligence, judgment, and skill.

We have all seen the results of the destructive forces of malarticulation, but despite this we see patients with a strong alveolar bone and possessing a high metabolic rate tolerating flat cusps, cusps in malrelation, etc. As mentioned in Chapter 5 adaptability of the patient has been a crutch on which so-called successful restorations have been supported, but it always should be remembered that many times there are limits of adaptibility even in the most adaptable of patients.[5]

Examination

A thorough examination of the patient and an evaluation of all available data are the essential elements for comprehensive diagnosis and treatment planning, and they determine to a great extent the success or failure of extensive restorative dentistry.

The data should include (1) vital statistics, (2) chief complaint, (if any), (3) medical and dental history, (4) clinical examination, (5) complete mouth roentgenograms, (6) accurately made and mounted study casts on an adjustable articulator, (7) preoperative photographs, (8) a study of possible psychogenic factors, and (9) roentgenograms of the temporomandibular joints (if indicated).

Vital statistics

The patient is a female, a housewife, and 45 years of age.

Chief complaint

The patient complained of radiating facial pain extending to her head and neck on the right side and of what seemed like a proprioceptive sense of discomfort. An ill-fitting upper removable partial denture was very uncomfortable, and she seemed to have a great desire to be rid of the removable appliance but it was felt that a well-adapted, good-fitting appliance would resolve this difficulty. This was bad judgment on the part of the operator because this feeling was so deeply seated that it was necessary to change the plan of treatment in the last stages of the rehabilitation. Another complaint was that she could not get the dentist to diagnose and evaluate her mouth as an integral unit and to do something about it.

Medical history

The patient was in good general health with no unusual past medical history and no nutritional or diet problems. No obvious psychogenic factors were evident. She was not aware of a bruxism, which was suspected. Although psychogenic factors are never minimized in this type of condition, it was believed that the bruxism was probably caused by an interference in the centric relation—centric occlusion pathways.

Dental history

The patient had had rampant caries in her early years. She was very conscientious in keeping her dental appointments, which were spaced at frequent intervals, and home care was stressed and carried out properly. Despite this type of care she lost a number of upper teeth. Esthetics, especially of the upper teeth from bicuspids on the right side around the arch to the bicuspids on the left side, became a problem, causing what appeared to be a controlling of the lips and cheeks. Sometime after insertion of the upper removable partial denture she became aware of sensitivity and bleeding around the clasped teeth.

Clinical examination

The contour of the face had a normal appearance, although somewhat strained at times, probably caused by fear of the upper removable partial denture dropping during speech and mastication and also the poor esthetics of the anterior teeth.

Because of the radiating facial pain extending to the head and neck on the right side, a functional examination was made of the temporomandibular joints. Observation revealed no clicking of joints, no limitation of motion, no trismus or tinnitus, no subluxation, and maybe a slight deviation of the mandible on opening and closing. Muscle tone seemed to be good, interocclusal space was not a problem, the joints were not tender on palpation, and no history of muscle spasms was elicited. Roentgenograms of the joints were not taken in this case because this procedure was not warranted.

Intraoral examination revealed (1) a normal buccal mucosa, palate, and tongue, (2) gingival tissues to be injected in a number of areas, (3) some pocket depth, (4) attrition and abrasion facets, (5) recession and cervical erosions, (6) some teeth with a limited degree of mobility and a few with a mobility pattern of 2 and 3 degrees, (7) prematurities in a centric closure, with heavy stress on anterior teeth and few occlusal contacts posteriorly, (8) gliding movements that were not what was required for a "mutual-protective" occlusion, and (9) missing teeth, which included upper right and left lateral incisors, upper left second bicuspid and first and second molars, and upper right second bicuspid and first molar. It was felt that the loss of these teeth was the result of occlusal trauma.

Dental care was adequate as far as removal of caries and pulpal protection was concerned, but the restorations were contoured poorly. The coronal form in relationship to gingival tissues was not good, thereby causing periodontal dis-

Fig. 13-1. Preoperative roentgenograms.

turbance. The upper removable partial denture showed lack of proper adaptation and fit, which created a great deal of torque, causing the loss of a few teeth just prior to her appearance in our office, inflamed swollen tissues, and severe loosening of the upper left abutment tooth.

Pulp test response was within the range of normal.

Because the patient maintained a high level of mouth cleanliness, she was comparatively free of calculus, food impaction, etc. Excellent and proper oral hygiene procedures on the part of the patient gave her a very good positive rating in considering the undertaking of treatment in this case.

Roentgenographic examination

A complete set of roentgenograms, including bite-wings, were taken at this first appointment (Fig. 13-1). This procedure is an adjunct to diagnosis, and it must not supplant diagnosis.

The roentgenograms must be good from a diagnostic as well as a photographic standpoint and must be studied and related to the case at hand because they are meaningless unless correlated to the clinical findings in the oral cavity.

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

Cast orientation

Value of study casts

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 emphasizes 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

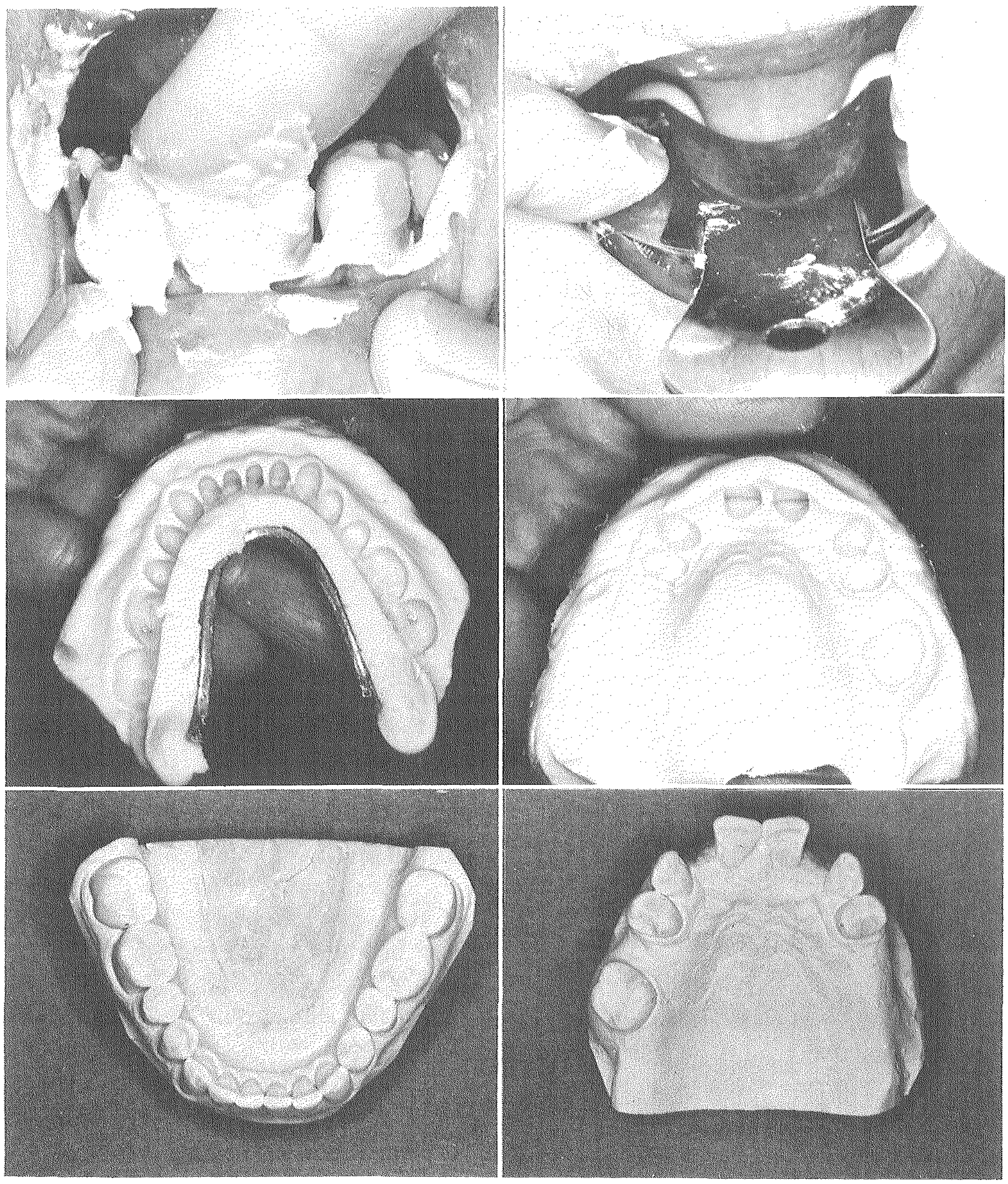


Fig. 13-2. Accurate study casts of patient's mouth were made from well-taken impressions, using an alginate material.

studying them in connection with clinical findings and roentgenograms.

Mounted casts on an articulator must reproduce proper mouth relations so that the correct movements of the mandible can be reproduced. Stallard[3] 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.

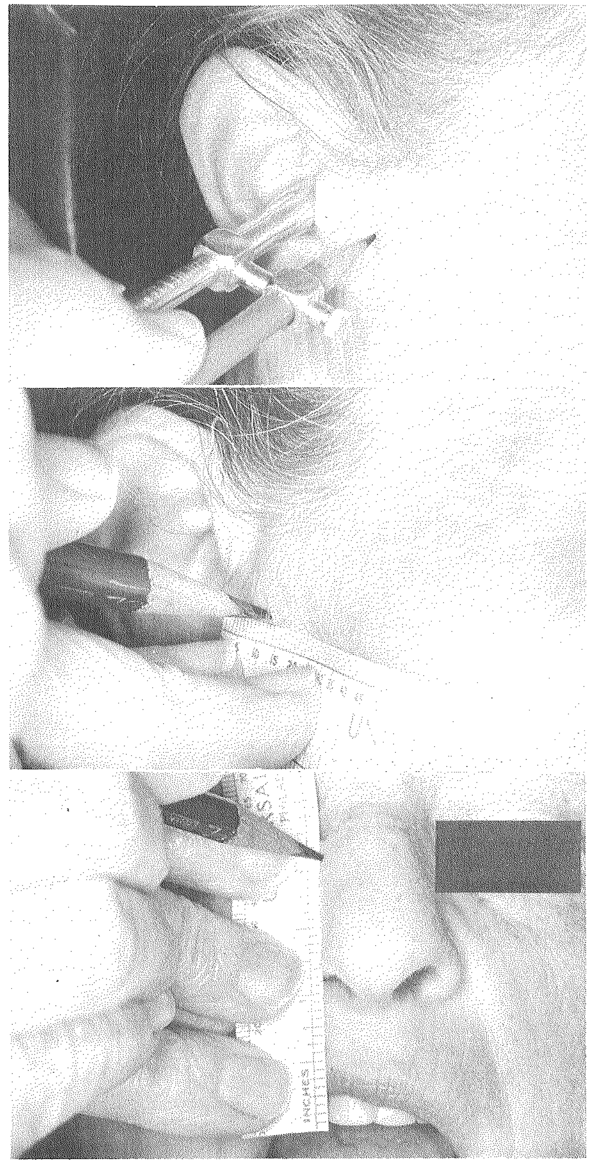
Impressions and casts

Accurate study casts of the patient's mouth were made from well-taken impressions using an elastic impression material, in this case alginate (Fig. 13-2). This type of an impression should be poured immediately for accuracy, using a hard artificial stone.

If possible, two sets of impressions are taken to be able to have (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, necessary in the location of the hinge axis and in the recording of a three-dimensional pantographic tracing of the controlling mandibular axes, and (3) a set for preoperative study—for the determination of types of tooth preparations, for location and amount of tooth structure to remove, and for the development of the articulation in wax, which is required to properly restore the mouth under consideration to good function. However, with great care, second and third sets of casts can be poured from the original impression when alginate material has been used. Be very careful in the removal of the first and second sets of casts to prevent tears and distortion.

Face-bow transfer

In addition, a conventional face-bow mounting and a centric relation record, which will enable us to mount the study casts in a fairly ac-



A

B

C

Fig. 13-3. Locating arbitrary axis points and third point of reference on nose. **A,** Ritchey pencil. **B** and **C,** Flexible millimeter rule.

curate relationship to each other, must be taken. The face-bow transfer is taken to orient the upper cast on the adjustable articulator to the same plane of occlusion that is found in the patient's mouth. A simple method to locate the arbitrary axis points is to find 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, or by making use of the Thomas method, to locate the arbitrary axis points (Fig. 13-3). To use the face-

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*From 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.

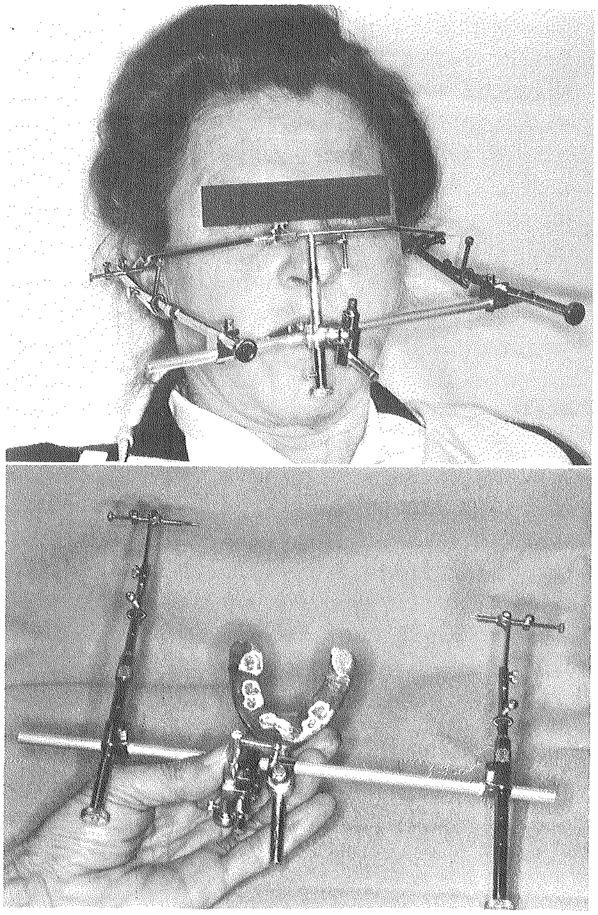

Fig. 13-4. Face-bow transfer. A wash of zinc oxide–eugenol paste (Kydac) was used to accurately register cusp tip indentations to verify fidelity of upper cast—it must seat without rocking.

bow transfer properly, a third reference point must be present to establish a plane of reference, the axis-orbital plane. This third point is marked on the right side of the nose 2⅜ inches from the incisal edge of a central incisor tooth or is located on the inferior border of the orbit on the right side, and for convenience a mark is recorded on the same plane on the side of the nose (Fig. 13-4).

Centric relation record

Next 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 some form of anterior resistance that tends to overcome the translating contractions of the external pterygoid muscle.

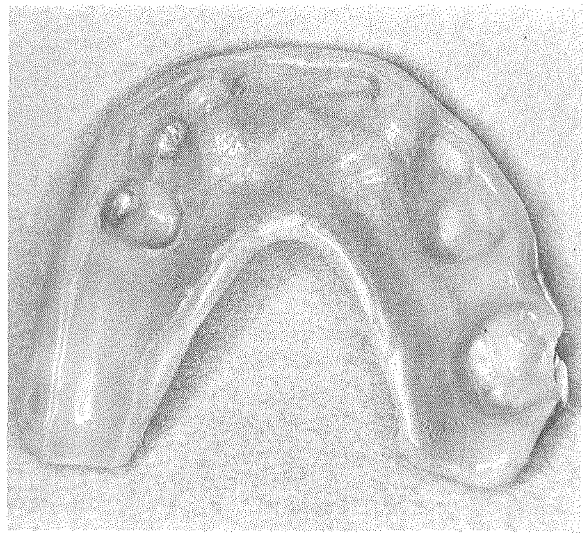

Fig. 13-5. Wax form used in registering centric relation record for mounting study casts on an adjustable articulator. It seats firmly and definitely on upper teeth.

This centric relation record must be registered at an increased vertical dimension (within the limits of pure rotation of the condyles) to remove the guidance provided by the teeth. Some form of anterior resistance must be provided. This resistance tends to act as a fulcrum that aids in obtaining a registration of the condyles in the posterior and superior position—rearmost, uppermost, and midmost.

In all preliminary diagnostic procedures a wax form (made with Sure-Set wax*) is adapted accurately 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 provides a wax form that can be seated firmly and definitely on the upper teeth. (See Fig. 13-5.) Then use is made of a piece of "air chamber metal"† to provide the anterior resistance and act 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.

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*Kerr Mfg. Co., Detroit, Mich.
†Dixon Mfg. Co., Newark, N. J.

During the exact positioning and adjustment of the metal form to the wax form for proper contact with a few lower teeth and posterior clearance for the recording material, the patient is not allowed to bring the teeth together so that the proprioceptive reflex can be avoided. A saliva ejector is inserted into the mouth every time the wax form is removed for adjustment of the metal form.

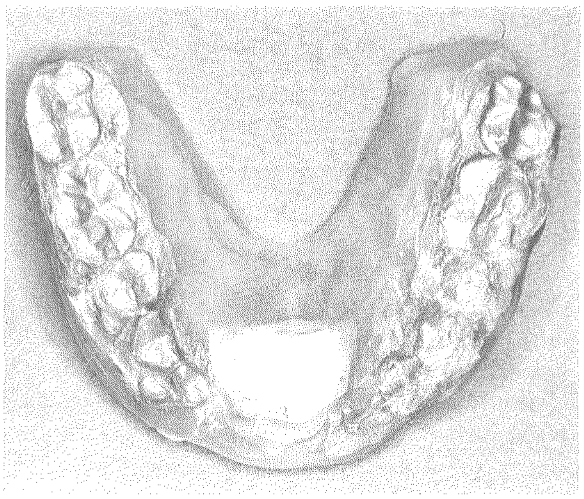


Fig. 13-6. Completed interocclusal record for mounting study casts on an adjustable articulator.

Use is made of a soft wax, Aluwax,* for the recording of shallow occlusal indentations. The well-adapted wax form with the softened Aluwax on the underside is seated on the upper teeth and 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. The mandible is guided, not pushed or forced, into repeated closure. The wax record is removed and placed in cool water. Excess wax is removed with a knife,† leaving only the cusp tip indentations so that the cast may be seated accurately when the mounting is made. (See Fig. 13-6.) Again this wax record is seated on the upper teeth and the patient closes the mouth, the operator guiding the mandible into 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 dis-

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

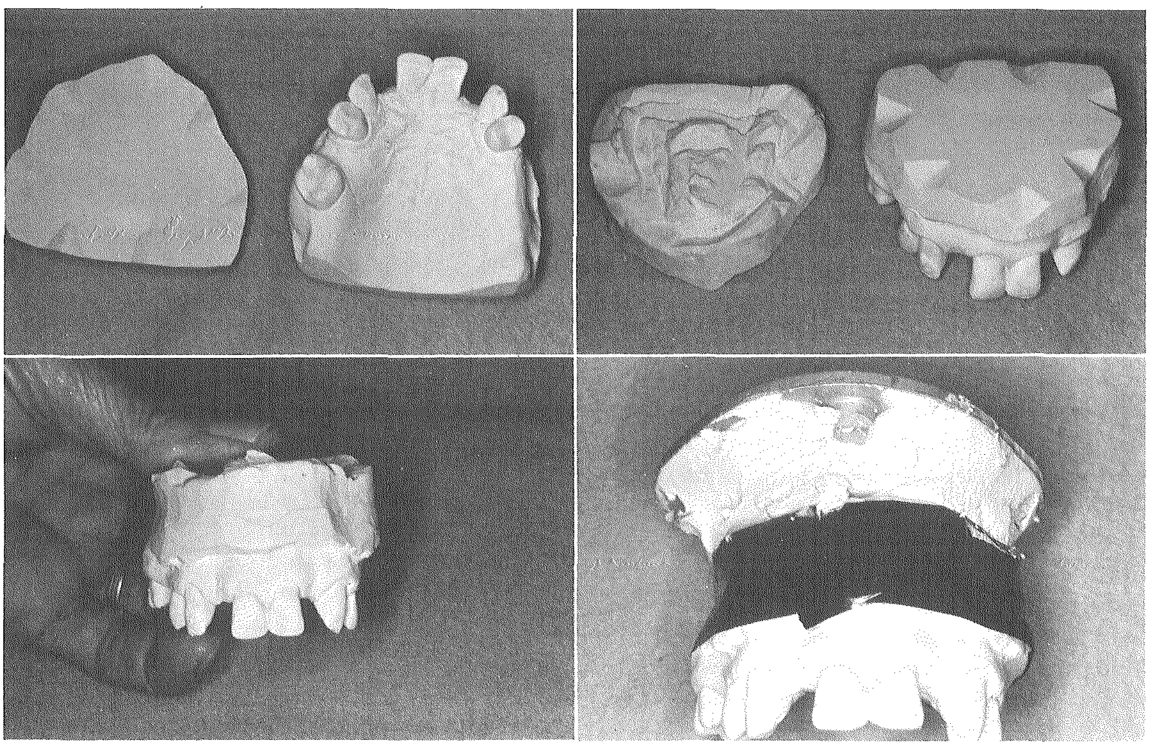


Fig. 13-7. Upper cast, which has been prepared for split-cast method, is mounted on an adjustable articulator with face-bow transfer record.

tortion can be detected on closure, the record is accepted. Two other centric relation records are taken to verify the accuracy of the record by checking one record against the other, making use of the Lauritzen split-cast method.

Mounting the casts on articulator

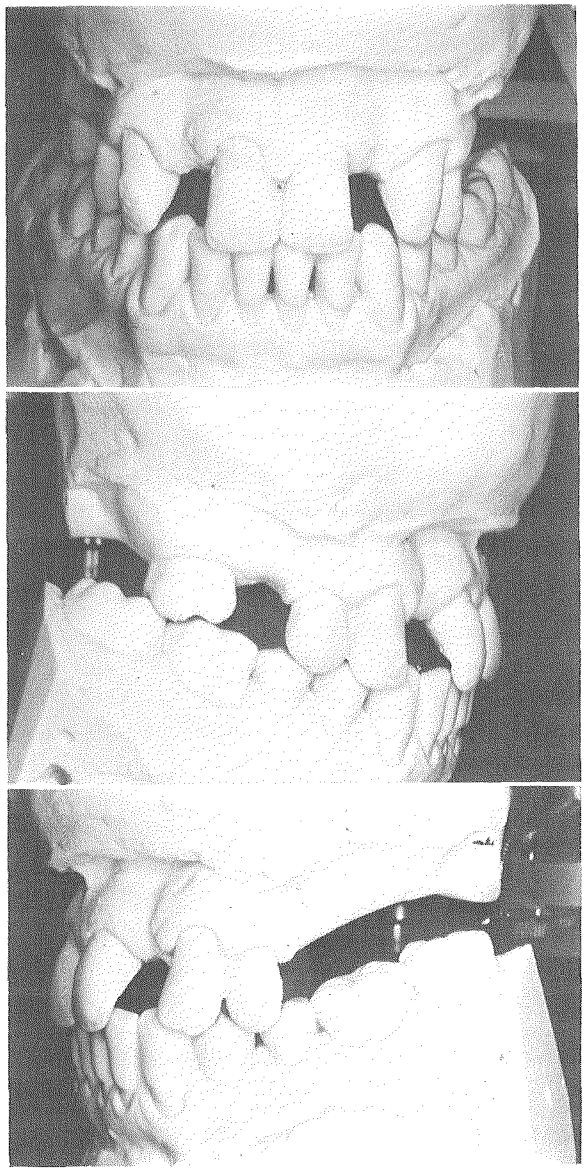
The upper cast, which has been prepared for the split-cast method, is mounted on an adjustable articulator with the face-bow transfer record (Fig. 13-7). After this step has been completed, the articulator is inverted on a mounting block, and the centric relation record is placed on the occlusal surface 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 Fig. 13-8.)

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 held carefully 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 mounted correctly in terminal hinge relation.

In this type of cast orientation, in which an arbitrary axis has been located for preliminary study of occlusal relations and the construction of clutches for the recording and transferring of mandibular relations, some discrepancies will result. However, the discipline 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.

Recording and transferring of mandibular relations

There is no one arbitrary cusp form and relation that is best for all persons. It is a problem of determining which cusp forms and contacts best suit all the conditions in a given mouth. Therefore the importance of the hinge



A

B

C

Fig. 13-8. Relation of upper and lower teeth. **A,** Anterior relation. **B,** Relation of teeth on right side. **C,** Relation of teeth on left side.

axis, eccentric paths, centric relation, vertical dimension, plane of occlusion, etc. must be recognized because it is the only logical method for ascertaining the facts for a proper cast analysis that will be of great help in our diagnosis, treatment planning, prognosis, and therapy.

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. We must try to create functional relations that will make it possible for the natural metabolic processes of the body to come to our aid.

First, a set of clutches must be made using the casts of the preliminary mounting. By means of these clutches, a hinge-bow, and a pantograph, the hinge axis will be located, registrations or "jaw writings" taken, the articulator adjusted to these registrations, and the study casts remounted to the correct axis.

Clutch construction

The purpose of clutches is to attach the recording apparatus firmly to the teeth. The most ideal situation would be to construct individual aluminum clutches for each patient.

After the study casts have been mounted correctly on the articulator (by means of an arbitrary hinge axis mounting and good centric interocclusal record, the importance of which will be evident when registrations are secured), look for worn facets on the occlusal surfaces of the casts. These facets should be utilized to set the instrument for synchronization with these markings before constructing the clutches.

Preparation of casts

In preparing the wax relief and wax trays on the study casts for the clutches it is important to do so in such a way that the increasing of the vertical dimension is kept to a minimum. All edentulous spaces are blocked out with a roll of wax so that the filled-in space is continuous with adjacent teeth (Fig. 13-9).

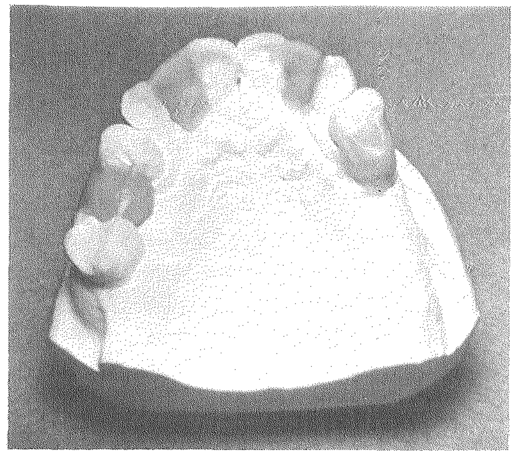


Fig. 13-9. Blocking out of edentulous spaces, wide embrasures, and separations with a roll of wax so that filled-in spaces are continuous with adjacent teeth.

Cover the upper cast with a layer of Tenax wax,* extending facially to the mucobuccal fold and lingually to gingival crests and over the palate, and while it is still soft, close the articulator in centric position, and then move it in all the excursive movements. This will thin out the wax on the occlusal and incisal surfaces to the point where many teeth will show through and the surface will be relatively flat. Ascertain that all the undercuts of the teeth and cast are relieved, and do not wax in excess (See Fig. 13-10.)

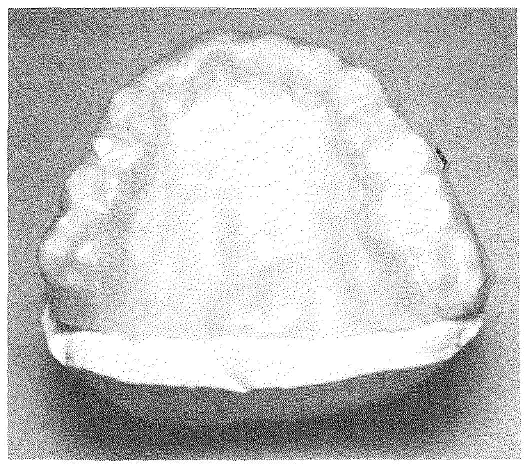


Fig. 13-10. Upper cast covered with a layer of Tenax wax, extending facially to mucobuccal fold and lingually to gingival crests and over palate. While wax is still soft, close articulator in centric position and move it through all excursive movements. This procedure thins out wax on occlusal and incisal surfaces to a point where many teeth will show through and surface will be relatively flat. Relieve all undercuts and do not wax in excess.

Repeat this procedure with the lower cast, wax extending facially to the mucobuccal fold and lingually slightly beyond the gingival crests (Fig. 13-11).

Now cover the upper and lower casts with one thickness of 0.003-inch tinfoil, and burnish them smooth with no undercuts. Apply a film of petroleum jelly over the tinfoil so that the wax

*S. S. White Dental Mfg. Co., Philadelphia, Pa.

Fig. 13-11. Repeat procedure with lower cast.

clutch trays to be constructed will separate easily from the tinfoil. (See Fig. 13-12.)

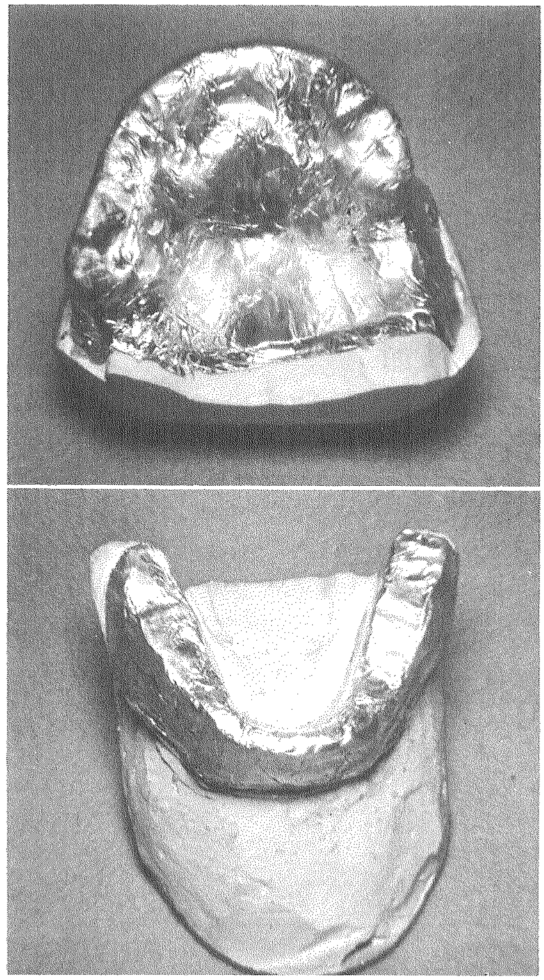


Fig. 13-12. Upper and lower casts covered with one thickness of 0.003-inch tinfoil. Burnish smooth, and then lubricate surface of tinfoil with a film of petroleum jelly to facilitate wax clutch tray removal.

Clutch pattern

Upper cast. A layer of Tenax wax should be adapted over the lubricated tinfoil, extending it facially from incisal and occlusal surfaces about ½ inch, and the palatal area covered. Posteriorly, the wax is carried to the buccal groove of the upper first molar or the buccal groove of the second molar. This will form a kind of wax tray. In the case that is being taken from practice in this chapter, the area distal to the first bicuspid on the left side is edentulous—a short saddle area is advisable to ensure stability of the clutch during the registrations. (See Fig. 13-13.)

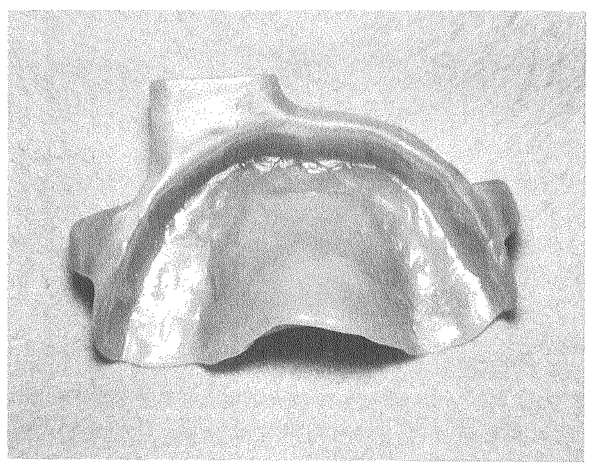


Fig. 13-13. Upper wax clutch tray.

Lower cast. A layer of Tenax wax should be adapted over the lubricated tinfoil, extending the wax facially and lingually ½ inch below incisal and occlusal surfaces (Fig. 13-14). Never impinge on the tissue reflections.

Remember that sturdy clutches must be present so that the parts of the clutches will not bend or distort on removal from the patient's mouth. If it bends, it will be impossible to reassemble parts to their original relationship, and this in turn will interfere with the correct setting of the articulator.

Positioning of wax blocks (posterior). Vertically posed ¼-inch square blocks of Tenax wax

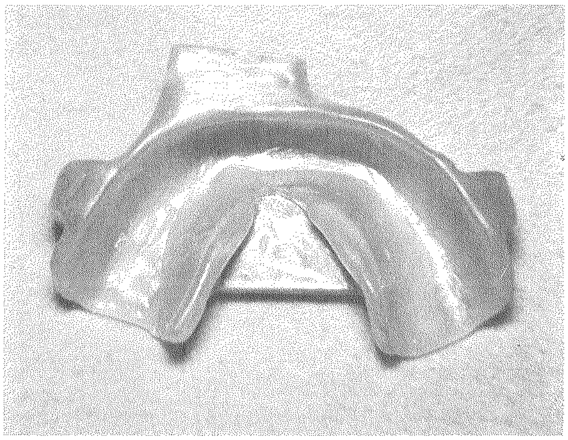


Fig. 13-14. Lower wax clutch tray.

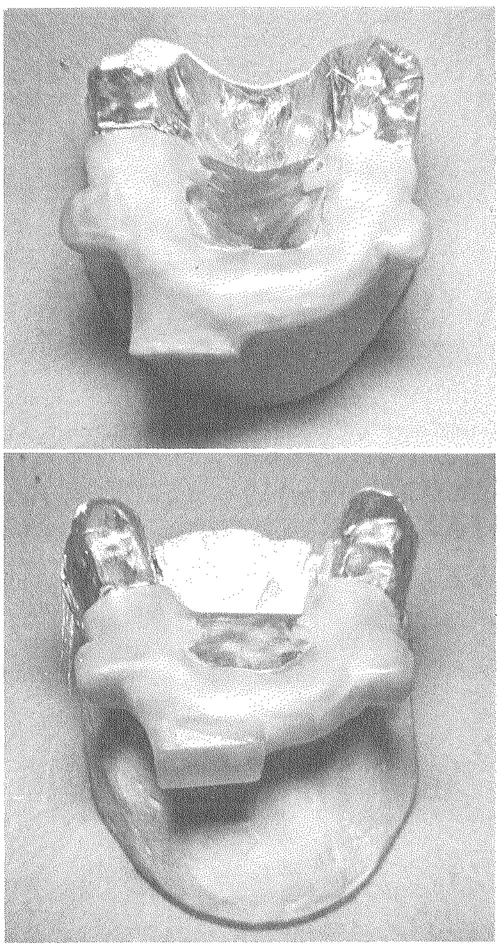


Fig. 13-15. Positioning of wax blocks. These blocks, after the casting process, allow for drilling, tapping, and sawing for hinge-bow and pantograph attachment and clutch removal.

½ inch long are placed over the buccal of the mesial cusps of the first molars (both upper and lower) and luted to the wax pattern with a warm spatula. These blocks should be rounded or tapered posteriorly to prevent patient discomfort. The blocks need this particular thickness to allow for later drilling, tapping, and sawing for clutch removal. (See Fig. 13-15.)

Positioning of labial wax blocks. Wax blocks are placed labially to accommodate the attachment of the studs. The upper labial wax block is placed to the left of the median line and the lower wax block to the right of the midline. This staggered placement of studs provides space for the toggle joint attachment of the recording apparatus.

The separable stud alignment jig is placed in front of the casts on the articulator. Wax is applied to the clutch patterns so that the studs will be placed equally above and below the incisal edge and at right angles to the hinge axis in both the vertical and horizontal planes. Wax is placed between the jig stud plate and the waxed clutch pattern, and then the wax addition is luted down smoothly to the clutch patterns. (See Fig. 13-16.)

This relates the stud blocks in a very exact manner, parallel to each other, to facilitate the positioning of the recording apparatus on the patient so that the locked apparatus can be removed easily from the patient.

Both upper and lower wax patterns are reinforced with a ⅛-inch square strip of Tenax wax placed around the facial area between the posterior and anterior wax blocks.

Bearing devices. Bearing devices are necessary for separating the clutches enough during registrations so that they will not interfere with each other. The only bearing between the two clutches is through the center bearing screw.

Upper clutch. From a piece of 14-gauge nickel silver, or brass a semicircular piece is cut to fit behind and close to the upper anterior teeth. It should be about 1 inch anteroposteriorly and about 1 inch in width. The plate should be bent to present a slight concavity into the upper clutch. The bend will give some vertical lift in the lateral movement of the mandible to aid clearance of the clutches in those movements. (See Fig. 13-17.)

The plate is heated and set into the wax clutch pattern, placing it about ⅛ inch below the

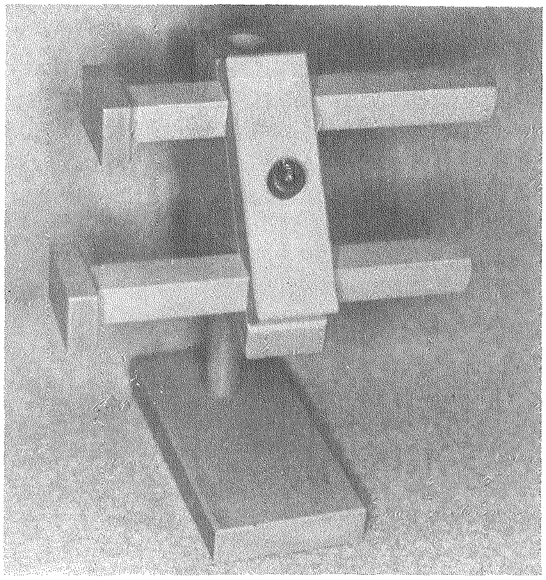


Fig. 13-16. Stuart separable stud alignment jig.

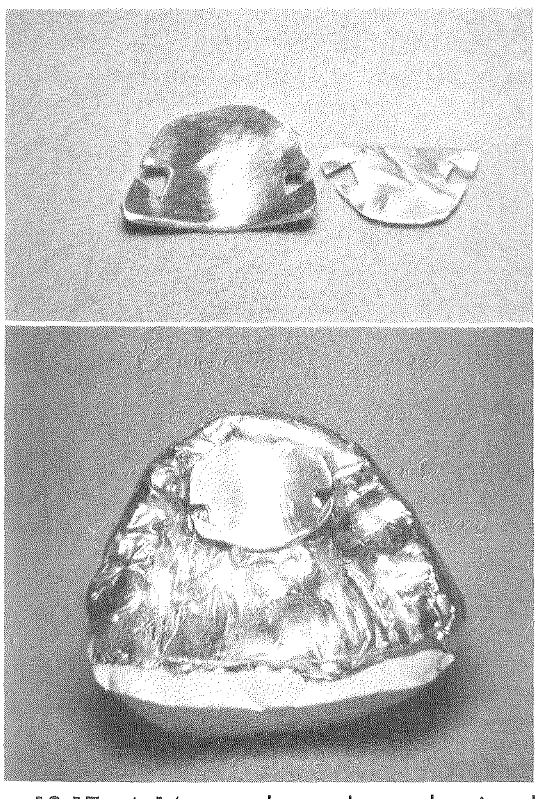


Fig. 13-17. A 14-gauge brass plate, a bearing device for upper clutch. It is bent to present a slight concavity into upper clutch to give some vertical lift in lateral excursion of mandible and thereby aid clearance of clutches in these movements.

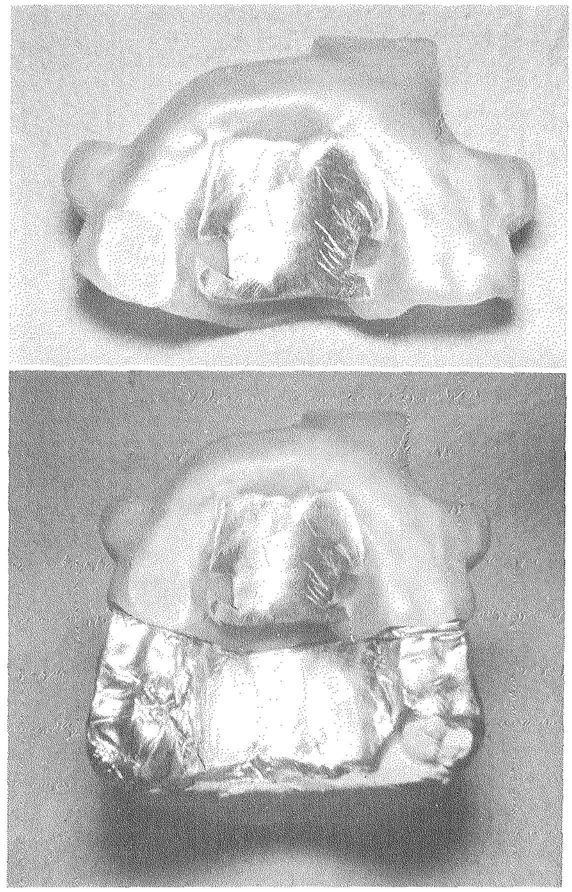


Fig. 13-18. Heat plate and set into wax clutch pattern. Place it ⅛ inch below incisal edge of anterior teeth and slope to about ¼ inch depth below plane of occlusion at its posterior edge. This gives opening to clutches in protrusive movement.

incisal edge of the anterior teeth and sloping it to about ¼ inch depth below the plane of occlusion at its posterior edge. By depressing the posterior edge of the plate an opening to the clutches in the protrusive movement is provided.[6] (See Fig. 13-18.)

Lower clutch. From a piece of 14-gauge nickel silver, or brass a semicircular piece is sawed out to fit the inner curvature of the lower anterior teeth. It should be about ½ inch wide at its maximum width.

The plate is heated and set into the wax clutch pattern behind the lower anteriors, keeping it parallel to the plane of occlusion and about ⅛ inch below this plane (Fig. 13-19). Avoid impingement on tongue to any great degree.

Then patterns are removed from the casts

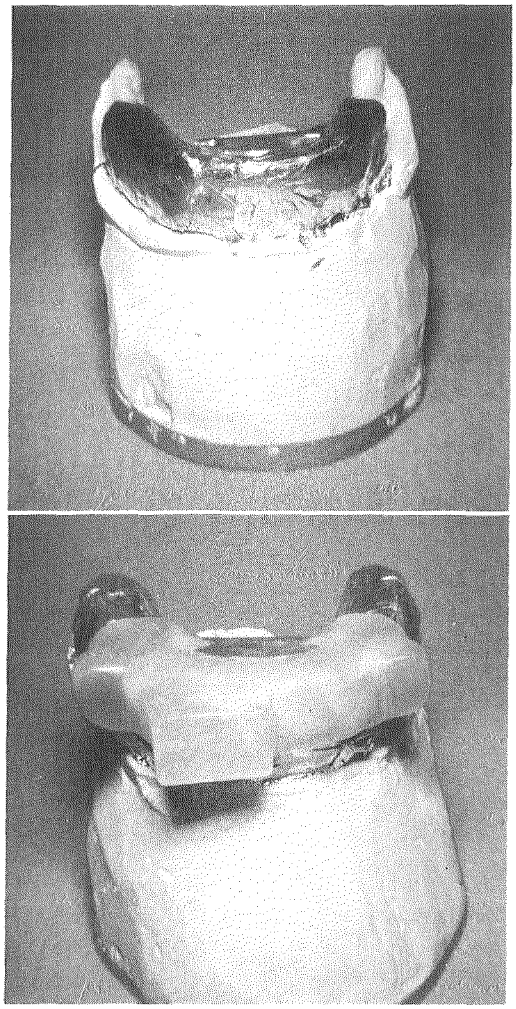


Fig. 13-19. Piece of 14-gauge brass (a semicircular piece) is fitted to inner curvature of lower anterior teeth. It is heated and set into wax clutch pattern behind anterior teeth, keeping it about ⅛ inch below plane of occlusion and parallel to it.

and the borders trimmed to eliminate as much material from the edges as is consistent with adequate strength.

Many times a large hole about ¾ inch in diameter is cut in the palate of the upper wax pattern, leaving about ¼-inch border across the posterior edge.

Replace patterns on the cast and check for fit and adaptation.

Spruing, investing, and casting

Spruing. The type of spruing is dependent on the type of casting machine that is used—pressure, vertical centrifugal, or horizontal centrifugal.

Flat sprues made of three layers of Tenax wax are attached at the anteriormost portion of each clutch pattern and at each heel. The three sprues are waxed together at a convenient intersection and made into a sprue former. Various types of spruing designs can be used.

Investing. Casting investment,* Cristobalite,† or aluminum investment‡ should be mixed according to manufacturer's instructions, the proper size ring filled, the wax pattern painted very carefully, and the wax pattern inserted into the ring filled with investment. After the investment has set enough crucible capacity should be created for the considerable amount of aluminum needed to complete the casting.

Burnout. The wax pattern should be eliminated by placing the flask into boiling water with the sprue holes facing up, thereby removing the bulk of the wax. The flask should be transferred to a burn-out oven for complete elimination of the wax residue, heating to 1300° F., then removed from the furnace and allowed to cool to 500° F. or, what is still better, to cool until it can be picked up with the hand. The aluminum will cast best in a cold mold.

Casting. In melting the aluminum it should not be overheated, but should be cast as soon as it is fluid to avoid brittleness. The metal should be covered with a large brush flame in a reducing atmosphere. Aluminum casting ingots should be used§ (Fig. 13-20), using a new batch of casting ingots for each casting—used buttons should not be remelted. After casting, allow the flask to bench cool before quenching it in water.

After the castings are cleaned of investment, the sprues are removed with carborundum disks or the gold saw. Sprue ends and nodules are smoothed with heatless stones, and a wire-brush finish is given to the clutches (Fig. 13-21).

Drilling and tapping of clutches

To facilitate removal of the clutches after completion of the registrations, it is necessary to separate each clutch into two parts, which is accomplished with a gold saw. However, before

*Modern Materials Mfg. Co., St. Louis, Mo.
†Kerr Dental Mfg. Co., Detroit, Mich.
‡Whip-Mix Corp., Louisville, Ky.
§Hammond Dental Mfg. Co., Santa Monica, Calif.

this is done the block areas must be drilled and tapped for screws so that the two parts can be held together during the recording procedures and for setting the articulator.

A No. 49 airplane type of drill (or a No. 50 drill) is used in a chuck* on a lathe, and two holes are drilled in each block at the first molar areas above and below the ⅛-inch square reinforcing rib. This is followed with a No. 2-56 machine tap in a hand wrench to tap or thread the holes for screws. Turpentine is used as the lubricant for aluminum tapping. (See Fig. 13-22.)

*Jacobs Mfg. Co., Hartford, Conn.

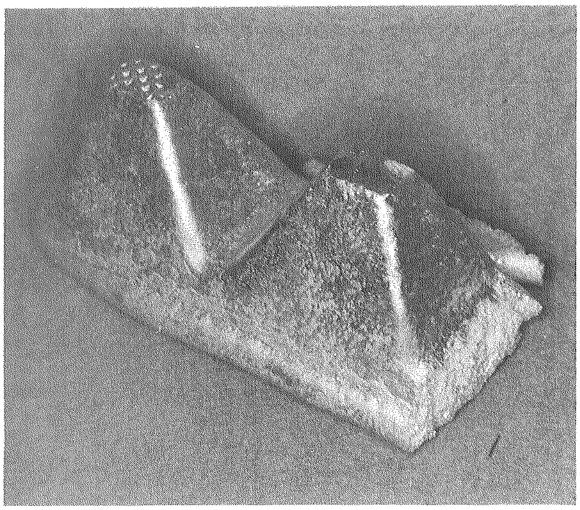


Fig. 13-20. Aluminum casting ingots for making clutches.

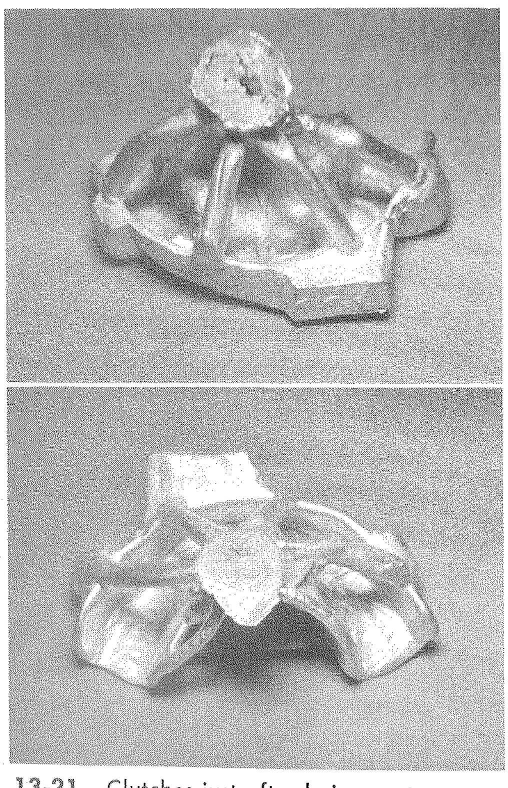


Fig. 13-21. Clutches just after being cast.

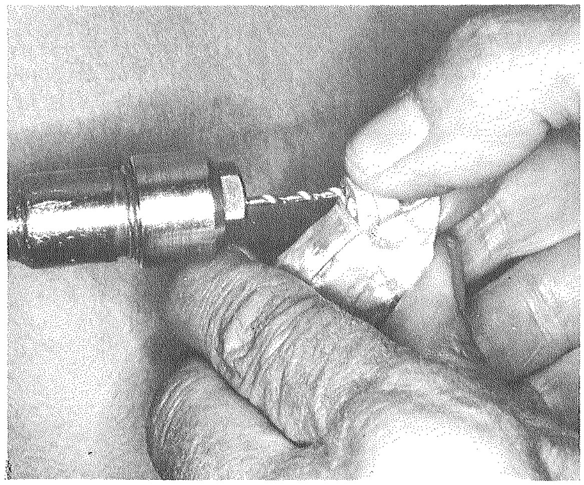


Fig. 13-22. Holes being drilled in block at first molar area. Two holes are also drilled into stud block, and they must be positioned correctly in relation to stud plate so that this plate can be fastened securely to stud block.

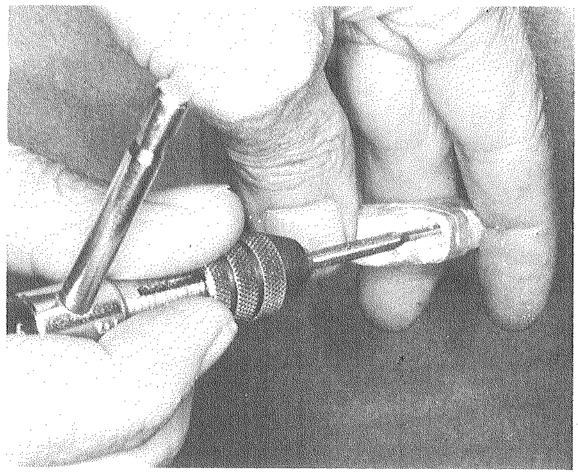


Fig. 13-23. After drilling of holes follow with a No. 2-56 machine tap in a hand wrench to tap or thread holes for screws. Turpentine is used as lubricant for aluminum tapping.

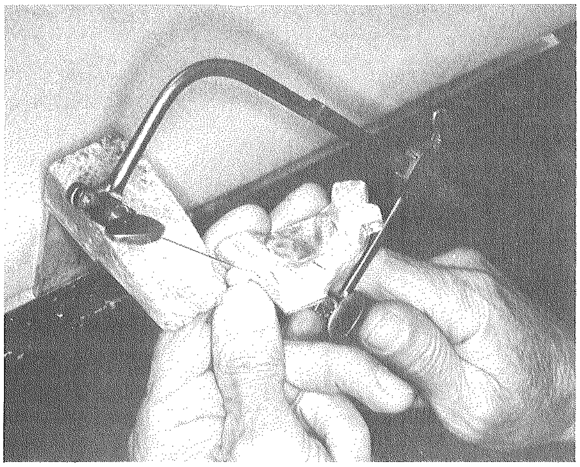


Fig. 13-24. Separate each clutch into two sections by cutting vertically through posterior block at its center, and continue cut through occlusal and incisal surfaces in a zigzag manner until it joins cut through posterior block on other side. Use a thin saw blade for cutting, and use No. 2-56 machine screws or Allen screws for joining the two sections.

Fig. 13-25. Small pry slot (arrow) is cut on outside of each molar block with a crosscut fissure bur for separation of two sections by insertion of a small screwdriver.

Two holes are drilled into the stud block (No. 49 airplane type of drill or No. 50 drill), care being taken that the holes are positioned correctly in relation to the stud plate, so that it can be fastened securely to the stud block. These holes are tapped for No. 2-56 screws, and the separable stud plates then can be attached to the clutches. (See Fig. 13-23.)

Separation of clutches

The next step is to separate each clutch into its two sections by using a gold saw. Studs are screwed onto the plates on the clutches which provide a convenient handle while the casting is cut. The clutch is placed in a vise to hold it tightly.

With a thin saw blade cut vertically through the block (molar area) at its center (leaving about ⅛ inch on each side of cut) and continue the cut through the occlusal and incisal surfaces in a zigzag manner until it joins the cut through the block (molar area) on the other side. Zigzag

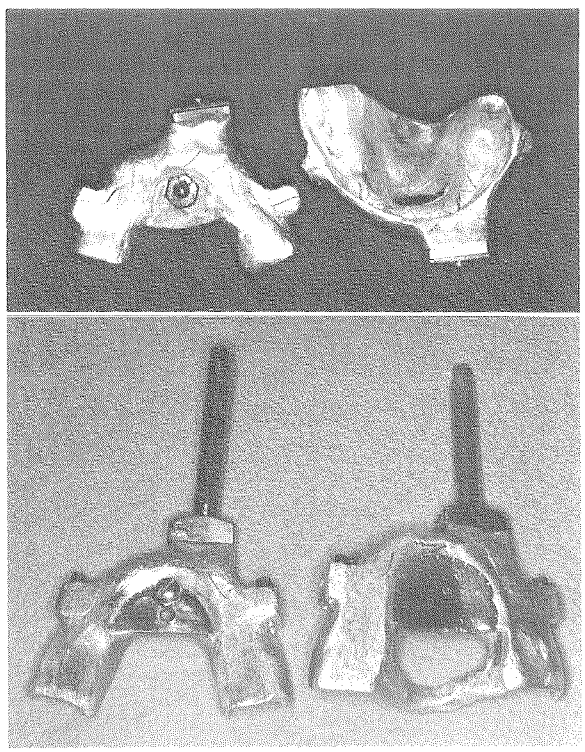


Fig. 13-26. Drill hole for center bearing screw with a No. 36 drill and tap with a No. 6-32 tap. Tip of center bearing screw should be rounded, or a No. 6-32 screw and lock nut can be placed in tapped hole to serve as bearing point.

cutting provides better locking of the two parts of the clutch. After sawing, the clutch will be separated into two sections, to be joined with No. 2-56 machine screws or Allen screws. (See Fig. 13-24.)

With a crosscut fissure bur a small pry slot is cut on the outside of each molar block in the saw cut line between the two screws to allow for the insertion of a small screwdriver to pry apart the two sections of the clutch when it is removed from the mouth (Fig. 13-25).

The clutch sections should be reassembled by placing screws in position, and the clutches examined for any sharp or rough areas that might cause discomfort to the patient.

The clutches should be placed on casts on the articulator and the location of the center bearing screw determined. The hole is located so that the bearing screw will fall in the middle of the upper plate from side to side and as far forward as the lower anterior teeth will permit. The hole is drilled with a No. 36 drill and tapped with a No. 6-32 tap. The tip of the screw, if it is to be used as a bearing point, should be rounded (so that it will slide freely on the plate without cutting into the plate, which tends to guide the pa-

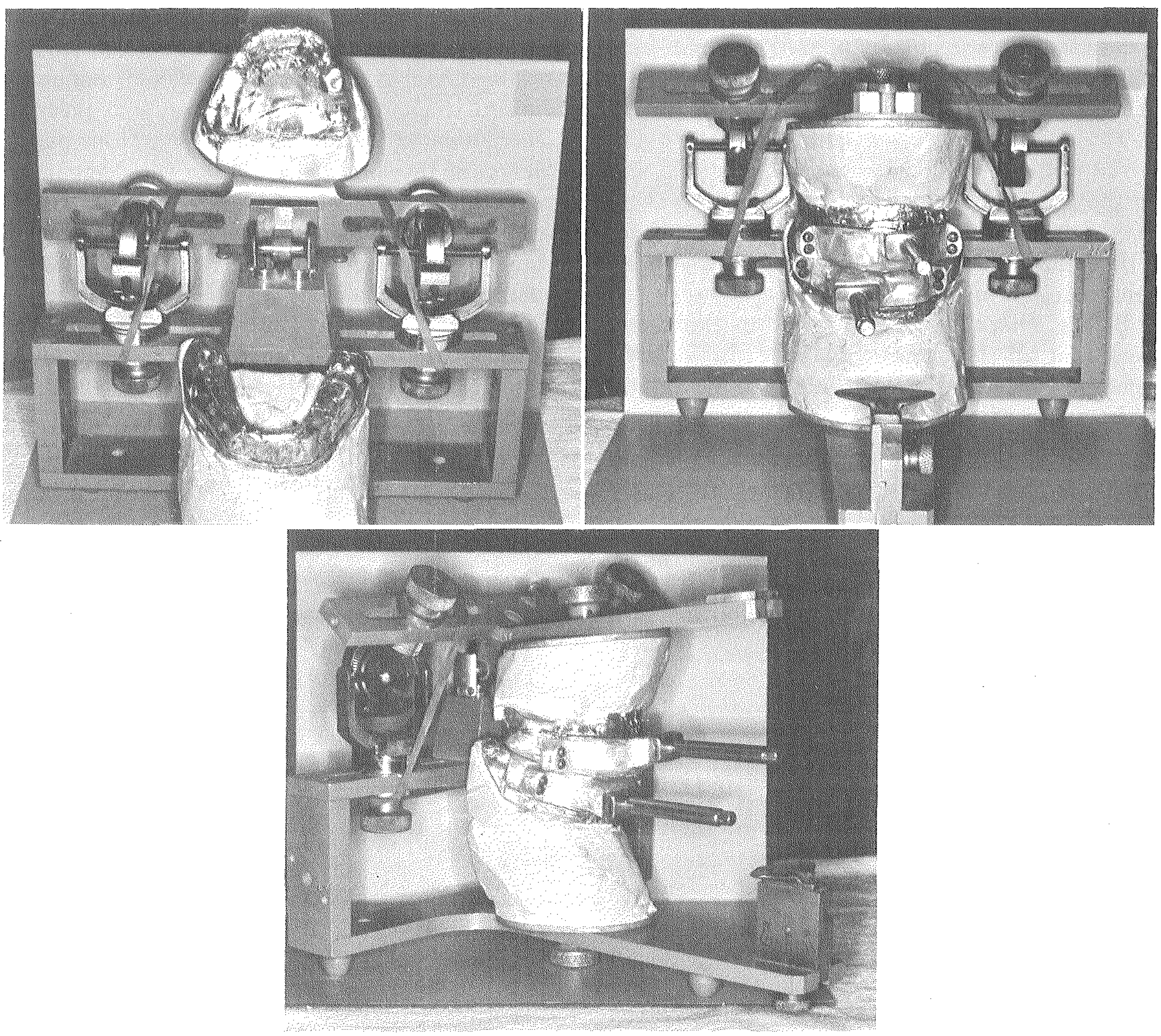


Fig. 13-27. Clutches are placed on mounted casts and center bearing screw adjusted so that no contact exists in centric, protrusive, and lateral positions except on screw. Increase of vertical dimension must be minimal.

tient), or a No. 6-32 screw and lock nut can be placed in the tapped hole and serve as the center bearing point (Fig. 13-26).

Again place the clutches on the casts (which still have wax and tinfoil on them), and raise the center bearing screw so that no contact exists in centric, protrusive, and lateral positions except on the screw. Because any increase of the vertical dimension must be kept at a minimum, it may be necessary to machine the clutches to bring them as close together as possible without creating very thin areas. (See Fig. 13-27.)

Now the recording apparatus can be assembled on the articulator in the laboratory preparatory to placing it on the patient (Fig. 13-28). This is an important step because the lining up of the various parts of the apparatus prior to the appointment saves time, aggravation, and patient inconvenience.

The upper and lower lateral arms are removed from the front bars, and the screws holding the separable studs together are withdrawn, leaving the studs of the separable studs attached to the front bars and the separable stud attachment plates on the clutches.

Before cementing the clutches to the teeth check that all screws are tightened properly to avoid movement, and then try them in the mouth to determine if the center bearing screw alone makes contact in centric position and all excursive movements. If all the previously described steps have been executed carefully, this will be the case.

Small strips of wax can be placed on the separable stud plates, to avoid interference with the proper seating of the male doweled part created by small particles of cement, and also on screwheads. In patient's mouth, all wide and open interproximal areas, around and under pontics in the gingival third area, or any undercuts should be blocked out with a soft pliable wax. Be especially careful to have enough relief around any teeth showing a high degree of mobility. In most cases I attach an extra pair of separable studs to the stud plates so that it is possible to "eye" the studs to be sure they are parallel to each other during cementation of the clutches.

The clutches are now dried, and a mix of a zinc oxide–eugenol paste such as Ackerman's* or Coe-Flo† is made, placed in appropriate amount in the clutches (do not use excess amounts), carried to the mouth, and seated into position. The patient is told to close on cotton rolls placed on top of the lower clutch until the cement has set, being sure to check parallelism of studs from front and side views, after which all surplus cement is removed over the borders or through small cracks in zigzag cut areas. Again centric position and excursive movements are checked to make sure that only the center bearing screw contacts between the jaws. (See Fig. 13-29.)

Now the front bars are attached to the clutches; then the flags with graph paper on them are positioned by placing them on the

*Ackerman Dental Co., Santa Monica, Calif.
†Coe Laboratories, Inc., Chicago, Ill.

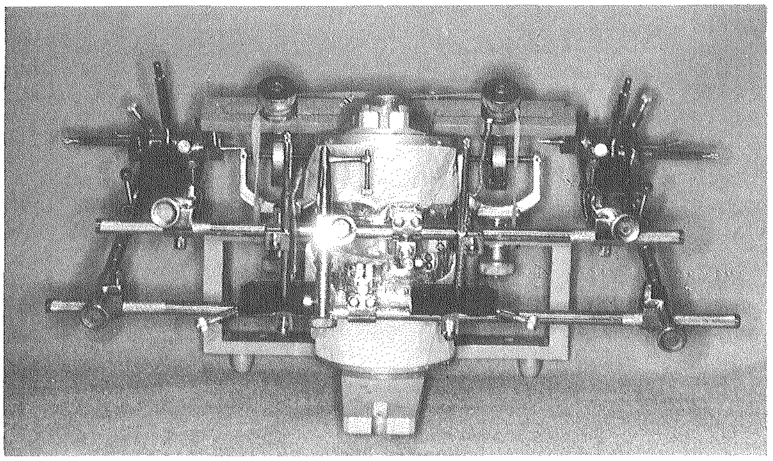
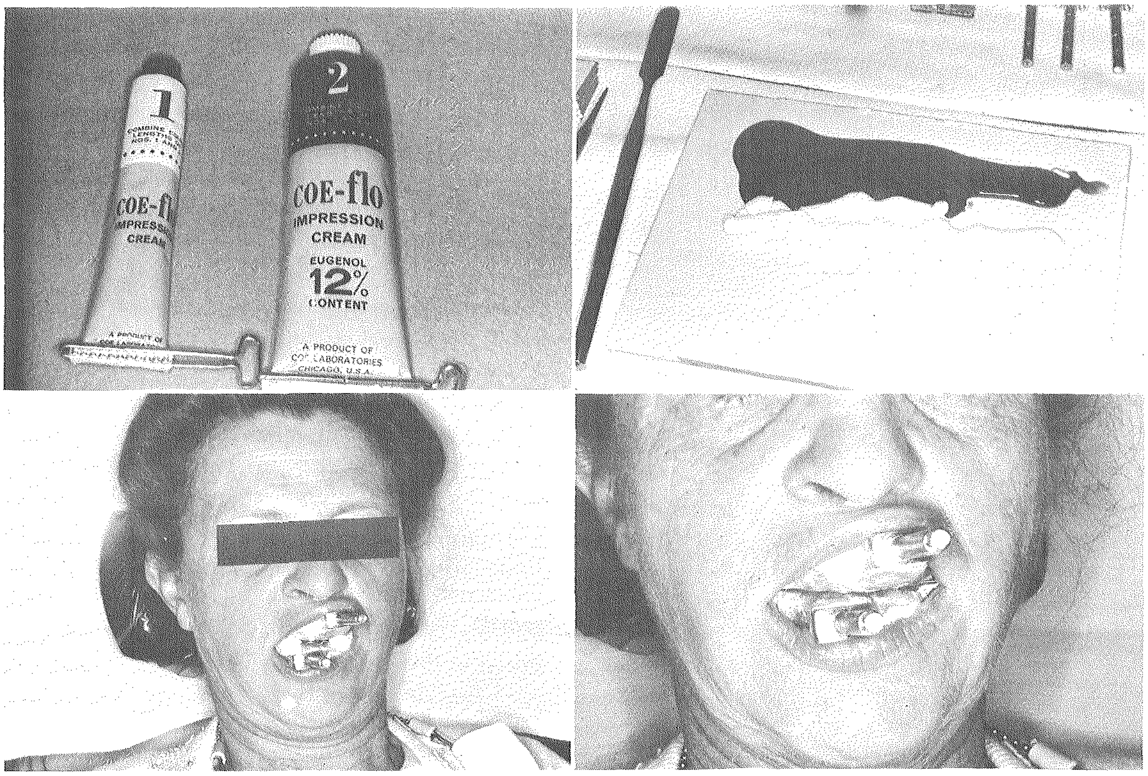


Fig. 13-28. Recording apparatus assembled on articulator preparatory to placing it on patient. Saves chair time and inconvenience.

A B



C D

Fig. 13-29. A and B, Zinc oxide–eugenol paste used in clutch cementation. C, Patient closes on cotton rolls until cement sets. Extra pair of separable studs are attached to stud plates to be able to "eye" parallelism of studs. D, Surplus cement removed and check made to be sure that only center bearing screw contacts upper plate during mandibular excursions.

upper front bar close to the skin in the region of the axis, thereby providing a stationary background against which the axis can be located, and, last, the stylus arms (adjustable sidearms) are placed on the lower front bar with the stylus in the vicinity of the condyle. The next procedure is to locate the hinge axis. (See Fig. 13-30.)

Hinge axis

The hinge axis is that line through the heads of the condyles, constant to the mandible, that determines the arc of closure upon which the teeth meet in every contacting position of the mandible.

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 located precisely in its terminal position with the use of mechanical aids. A fixed point of rotation can be obtained clinically and utilized in restorative procedures.

Lauritzen and Wolford[7] used an experimental instrument to determine how accurately the center of 15-, 10-, and 5-degree arcs of movement could be located consistently. "The results indicate not only that a 10° range of movement is sufficient for hinge-axis location, but that when dentists experienced in axis location are tested on an experimental apparatus, the attainable accuracy in locating the center of the 10° arc is within 0.2 mm."*

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 slope of the glenoid fossa and the temporomandibular ligament, can brace itself superiorly, medially,

*From Lauritzen, Arne G., and Wolford, Lloyd W.: Hinge-axis location on an experimental basis, J. S. Calif. Dent. Ass. **29**:354-359, 1961.

A

B

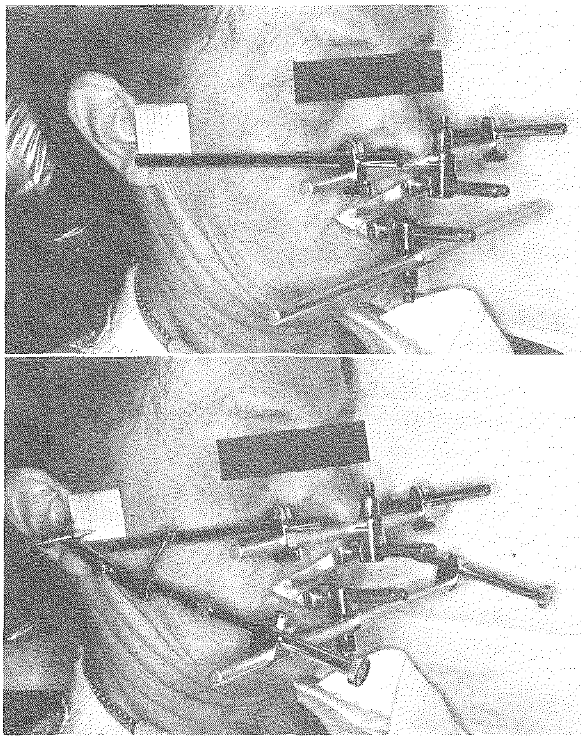


Fig. 13-30. **A,** Attach front bars to clutches; then position flags with graph paper on them close to skin in region of axis (this provides a stationary background against which axis can be located). **B,** Place adjustable sidearms on lower front bar with stylus in vicinity of condyle. (Flag rod was turned around to facilitate photography. Axis can be located accurately either way.)

and at its posterior limit and thereby 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 (see 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. The same relation of the casts to the axis of the instrument as that of the teeth to the axis of the mandible must be reproduced on the articulator. In other words, 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.

Brotman[8] has demonstrated by mathematical means that a precisely measurable error is introduced at the occlusal surfaces when the position of the articulator hinge does not coincide with the anatomic hinge. This error in closure is shown to increase proportionately as the deviation of the articulator hinge from the anatomic hinge increases. This emphasizes the need for accurate hinge axis location to reproduce accurate occlusal relationships on the articulator. A high degree of accuracy of location is obtainable.

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. In other words, we must reproduce on the instrument the paths of motion of the axis.

Granger[9] so aptly points 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 temporo-mandibular joint every time he moves the jaw. Therefore, we cannot ignore the precise location and paths of motion of the center of rotation."*

Why use the hinge axis?†

The use of the hinge axis permits us to accomplish certain things:

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 transferring these to an adjustable articulator, it is possible to reproduce the patient's mandibular movements with *fidelity.* To work on a laboratory instrument that is a mechanical and relational likeness of the mouth, it must open and close on the same axis as the mouth.
3. The hinge axis permits accurate *recording*

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

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

and *checking* of the centric relation of each patient.

a. Then the cusps of the teeth can be arranged so that the closure can be made in centric relation without striking opponents on the way.

b. Then our centric relation can be registered with enough opening between the teeth to avoid any deflective malocclusion that might be present in the dentition, and diagnosed.

4. The hinge axis affords 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 an axis is not located, the laws of geometry, physics, and mechanics are ignored.

9. The location of an axis would not be necessary:

a. If the centric relation could be transferred to articulated mounted casts and the work finished without changing the opening component.

b. If there are no cusps on the teeth around and over which closures are made, no axis determination would be needed unless we want to diagnose the ills of the occlusion.

Because of the previously mentioned reasons, the location on the patient and the transference to an articulator of the hinge axis is well worth the effort involved. *We feel it is imperative—yes, mandatory* (Fig. 13-31).

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 we have a fourth dimension of time sequence—the amount and character of movement in one plane in relation to the other two planes.

The movements of the mandible are a combination of rotation and translation. To duplicate these movements the hinge action must be separated from the translation.

This hinge action must take place in the terminal position because only in this position is it possible repeatedly to produce the same hinge action, thereby enabling us to locate the center of the action.

The real value of the hinge axis lies in being able to relate precisely the lower teeth to the upper teeth as the lower teeth contact the upper teeth. Its importance also manifests itself in allowing us to accurately relate the elements of articulation—the cusps, marginal ridges, triangular ridges (transverse and oblique), developmental and supplemental grooves, and fossae—to minimize the lateral stresses on the teeth.

The hinge axis is not a component of masticatory function. It is not a chewing position; we do not chew with the hinge axis. It is the designation of one portion of mandibular motion and is utilized as a fixed reference point that can be defined clinically and transferred to an instrument.

Another point to remember is that, since three dimensions are involved in the maxillomandibular relationship, our method of approach to treatment requires in some cases, especially those with pathologically involved joints, a series of registrations over a period of time.

Locating the hinge axis

The patient with the hinge-bow rigidly attached and the head back is coached to open and close the mouth with a pure hinge movement, that is, in a rhythmic manner without a protrusive movement that would bring the external pterygoid muscles into action. The thumb and index finger are used to guide this movement, avoiding translation of the mandible. The patient should be instructed to touch the upper plate with the center bearing screw as lightly as possible.

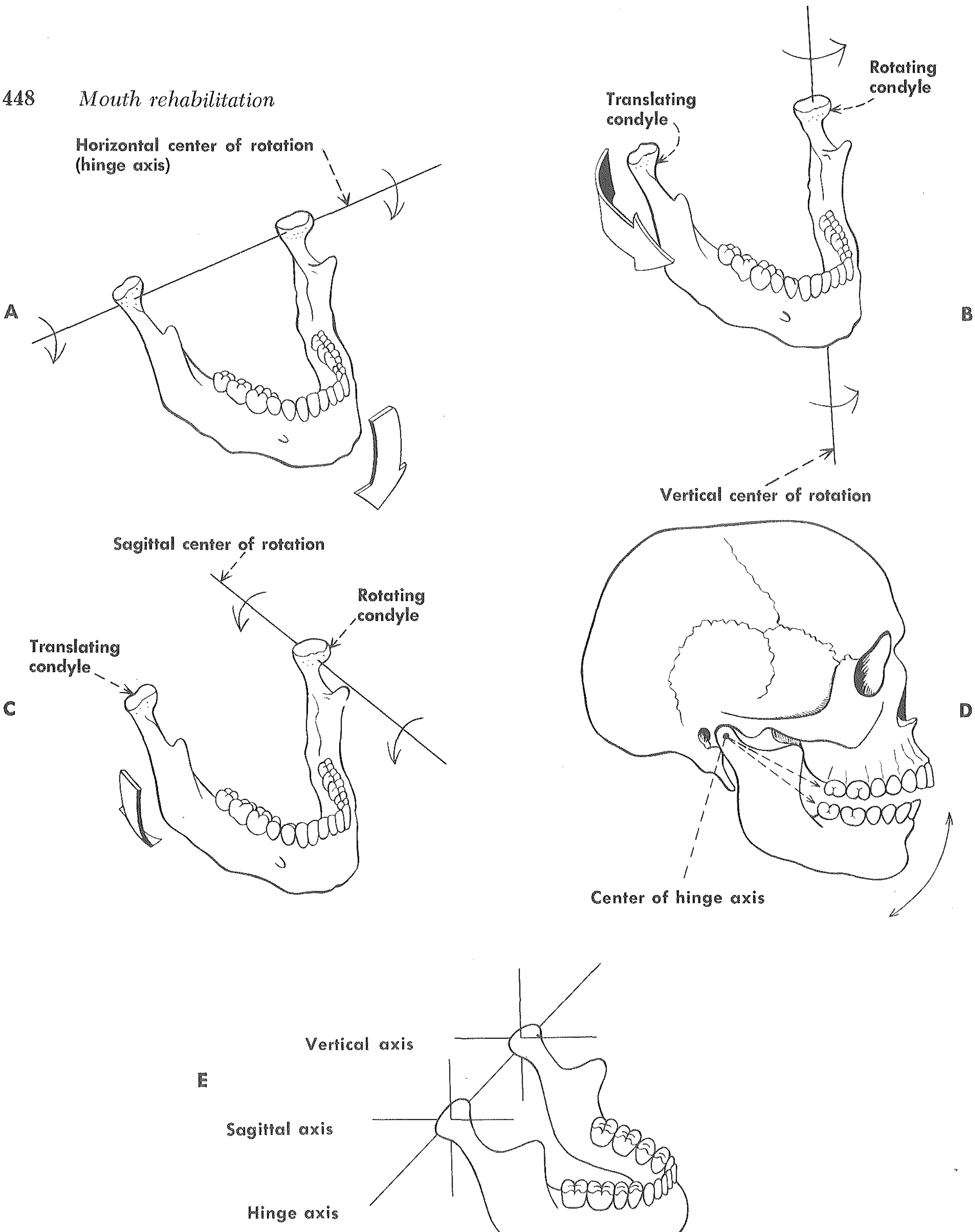


Fig. 13-31. **A,** Horizontal center of rotation (hinge axis). **B,** vertical center of rotation. **C,** Sagittal center of rotation. **D,** If mandible is guided into its most retruded position, we will then have horizontal (hinge) axis in its most retruded position. In this terminal position, with mandible making a pure hinge movement, with no translation, we will find that mandible, condyles, and mandibular teeth are constant to this axis. **E,** Horizontal, vertical, and sagittal axes are in a fixed relationship to mandible. Because mandibular teeth are in a fixed relationship to mandible, they will then be in a fixed relationship to axes. (Courtesy J. M. Ney Co., Hartford, Conn.)

The side arms of the hinge-bow are adjustable horizontally and vertically and carry pointed styli, which are directed at the positions of the condyles. Attention is directed to the action of the *tip of the stylus* while 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. If the stylus moves backward with the opening, it means that the stylus is below the axis; if movement is forward with the opening, it is above the axis; if movement is downward with the opening, it is in front of the axis; and if movement is upward, the stylus is behind the axis.

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 (Fig. 13-32). 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 used now to help see that the stylus tip is definitely rotating. The graph lines will aid the eye in determining if the tip is rotating or if any slight arcing is still present by looking down one line and then down the crossing line. (See Fig. 13-33.)

Location of the center of rotation is carried out on both sides simultaneously, and the located points are transferred to the skin, keeping in mind 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. Loosen the toggles holding the flags and pull them back from the condyle area, or remove the toggles and swab the areas to be tatooed with alcohol. The stylus tip is rubbed with an indelible pencil and gently pushed against the face to transfer the point to the skin, making sure that the lower jaw is in centric position. (See Fig. 13-34.)

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 (1) to use the Cohen or Hickok trainer for five to ten minutes before positioning the hinge bow for location of the axis, (2) what is actually being located is the hinge action in the facial plane (on the side of the face), (3) that this is not the true center of vertical motion, for that is located in the condyle,

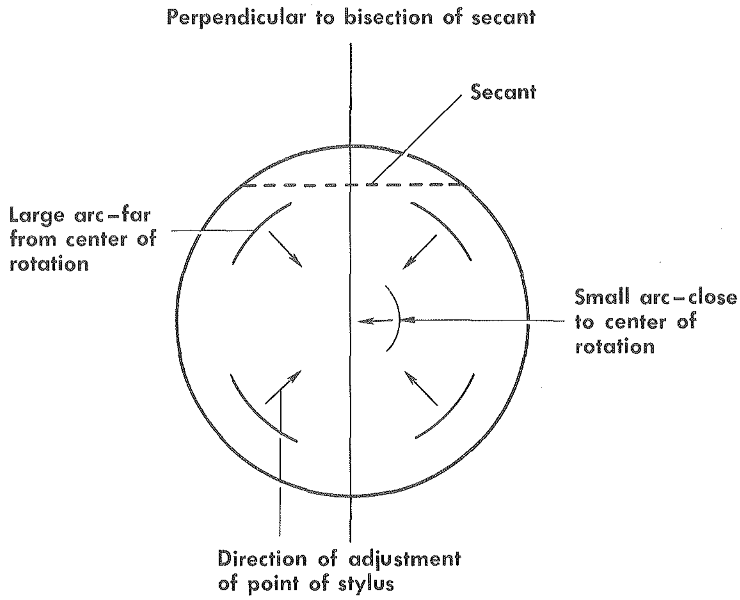


Fig. 13-32. Adjustment of stylus depends upon direction and size of arc scribed when patient opens and closes jaw in terminal hinge position.

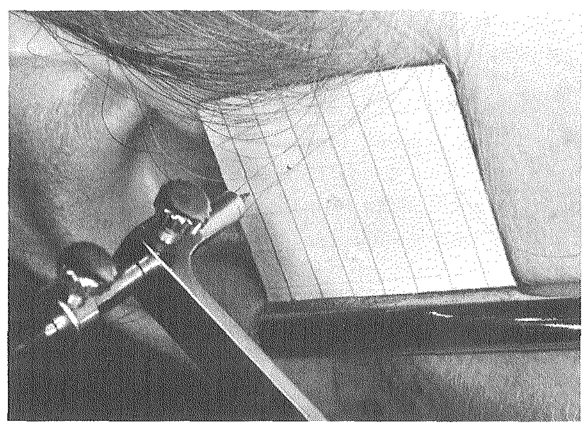


Fig. 13-33. By trial and error and repeated adjustments we arrive at exact center of rotation, which is indicated when tip of stylus will no longer arc but merely rotate.

Fig. 13-34. Loosen toggles holding flags and pull them back from condyle area. Rub stylus tip with indelible pencil, make sure that lower jaw is in centric position, and gently push stylus tip against face, transferring point to skin.

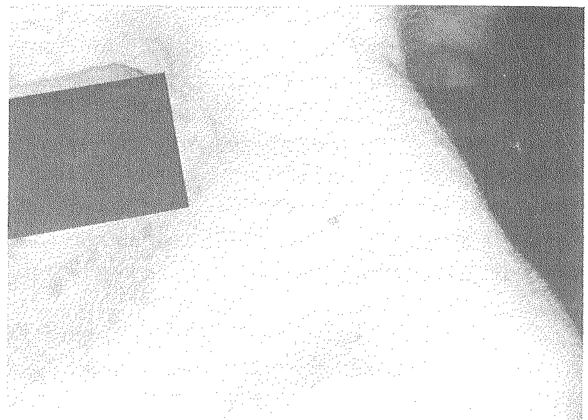


Fig. 13-35. Third point of reference is placed on right side of nose 2⅛ inches from incisal edge of a central incisor tooth. This nose point with axis points are on axis-orbital plane, which is a plane of reference.

(4) what is being located is a point on a line that has been extended from the centers of vertical motion, and (5) centers of hinge action can be located only when the condyle is in a position in which it can scribe these arcs repeatedly—when it is in the most retruded position in the glenoid fossa.[10]

Now the lateral arms of the hinge-bow should be removed from the lower front bar.

The axis points now are related to a third point on the side of the nose. This point usually is placed on the right side of the nose 2⅛ inches from the incisal edge of a central incisor tooth or is placed by locating the inferior border of the orbit on the right side of the nose 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. (See Fig. 13-35.) They are used to make a conventional face-bow transfer so that the cast 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. India ink used in conjunction with a disposable hypodermic needle also is used very successfully. Dip the tattoo needle into the pigment paste, which is made by putting a few drops of alcohol or Listerine mouthwash (evaporates less readily) into the pink marking dye—sulfide of mercury—making a thick paste. Stretch the patient's skin tightly with thumb and two forefingers (which minimizes pain), and press the needle into the skin at the designated points. (See Fig. 13-36.) The tattoo ink is deposited just deeply enough to remain in the pigment layer of the skin. Avoid tattooing into a pore.

My observation has been that these markings can be relied upon for any future transfers and that they do not change their position in the skin. However, in some instances they seem to fade

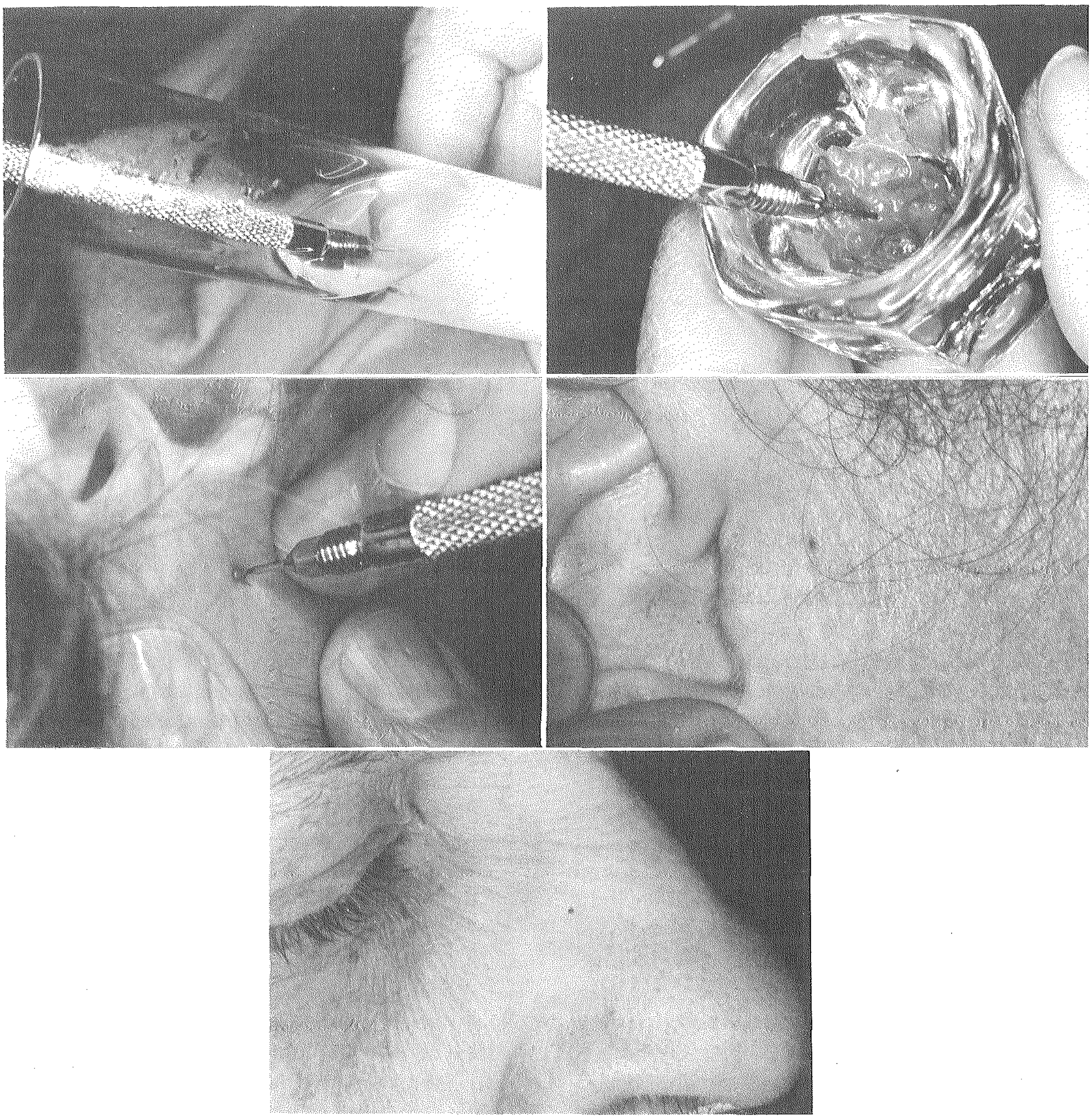


Fig. 13-36. Three points (marks) are made permanent by using a special tattoo needle and a little pink marking dye—sulfide of mercury.

somewhat; so remember to examine tattoo marks at intervals, and re-ink if any of them start to fade out. It can be said that the hinge axis position is a physiologically acceptable maxillomandibular relationship.

Pantograph registrations

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 reproduced faithfully. This is accomplished by the use of twin Gothic arch (needlepoint) tracings. On a suitable articulator, which 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 posisble jaw relationships will have been duplicated. It can be used as a means of creating occlusal

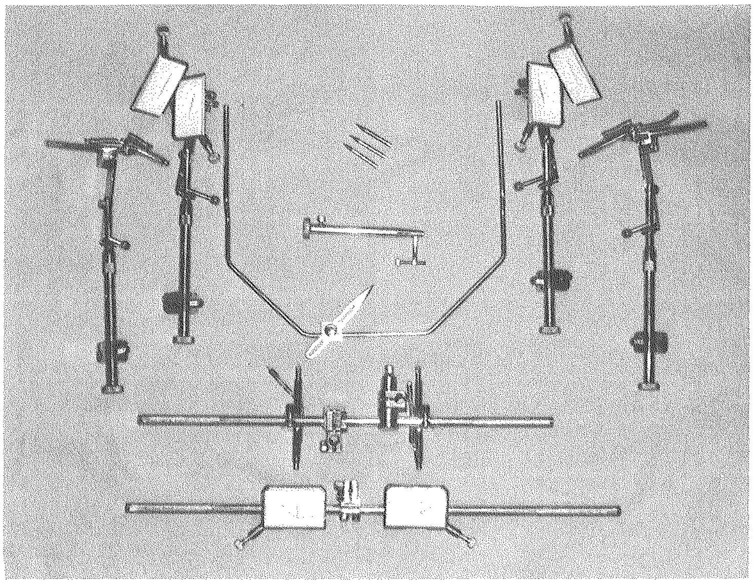


Fig. 13-37. Pantograph, consisting of two face-bows with six recording slides and six styli.

forms, which will be in harmony with the joint, and also the supporting structures of the teeth. In other words, this method of employing the pantograph graphically records the various positions and movements of the mandible. These graphs then are 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.

The most accurate practical method of recording jaw movements is the use of an extraoral tracing device. Actually this is a pantograph, consisting of two face-bows with six recording slides and six styli, that scribes the paths of the centers of rotation of the mandible (Fig. 13-37). The tracings are made in three dimensions simultaneously.

Why use pantograph registrations?

1. Pantograph registrations permit us to accurately record the border movements of our patients and to duplicate these movements on an articulator. This permits us 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. In other words, copying mandibular movements on an articulator is necessary if an organic occlusion that fits the masticatory organ is going to be produced.

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 "tract."

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 maintain the vertical stability of the teeth by distributing the forces of occlusion in the long axes 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 centric relation contacts.

6. *So by logic we feel that 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.*

By now we have become cognizant of the fact that the maxillomandibular relationship is not the simple movement of opening and closing. It is an extremely complex movement that exists in three dimensions. Variations may occur in the vertical, anteroposterior, or mediolateral positions.

This being the case it follows that, after the location of the horizontal axis, the next procedure is to record the paths that this axis traverses. We must locate the centers about which the condyles rotate, both vertically and horizontally, and reproduce the paths that these centers follow as they glide the cusps past each other without colliding and without lateral stresses on the teeth. By geometrical and instrumental means, with the use of face-bows and pantographs we determine on the patient the full character of the condyle paths, their inclinations and shape, the amount and direction of the Bennett movement, the centric position of the mandible, the hinge axis and the maxillomandibular dimensions, and the plane of reference, the axis-orbital plane. What the mandible actually does is duplicated precisely, and the fixed biologic factors of articulation are determined.

This information is transferred to the controls of the articulator, which in turn will produce movements that will dictate an occlusal morphology physiologically acceptable to the periodontium, the temporomandibular joints, and the neuromuscular mechanism.

Compromises in the capturing of the essential elements of the determinants of mandibular movements make necessary excessive and haphazard grinding in the mouth leading to much less than optimum results.

In other words, a three-dimensional recording by means of six simultaneous tracings of the guided border movements of the mandible, a hinge axis in the terminal hinge position as the starting point, and the incorporation of a horizontal reference plane for the mounting of the upper cast is of the utmost importance. This enables us to transfer the occlusal factors of the patient to an articulating instrument for analysis and future use in the restorative procedures.

Pantograph

The pantograph consists of an upper bow, which holds vertical and horizontal recording plates in the condylar areas and carries writing styli on the anterior crossbar. The inner surfaces of the vertical recording plates in the condylar areas carry hinge and axis–indicating pins, which are used to transfer the opening and closing axis of the patient to the articulator. The anterior crossbar also is equipped with a toggle for holding the orbital bow support, which allows transference of the recorder to the articulator on the axis-orbital plane, and a lower bow, which carries the vertical and horizontal styli in the condylar areas and horizontally posed recording plates on the front crossbar. The horizontal condylar area styli are set so that their tips are lying in, or nearly so, the transverse hinge axis of the mandible when it is rearmost in the face, and they write the anteroposterior gliding effect of the opening and closing axis. The vertical condylar styli are set at right angles to the horizontal condylar recording plates and used to record the sidewise, or Bennett, condyle movements.[3]

According to Stallard[3] the anterior vertical styli scribe Gothic arch tracings upon recording plates on the lower front crossbar. These vertical styli are set perpendicular to the recording plates, the plane of which is in line with the opening and closing axis in its rearmost position. The recorder therefore has two styli to write the Gothic arch tracings, two to write the effect of the anterior condylar glidings, and two to write the effects of the lateral condylar glidings.

With the Granger pantograph use is made of finely sharpened pencil lead to trace the paths on a white piece of paper on the plate. This is

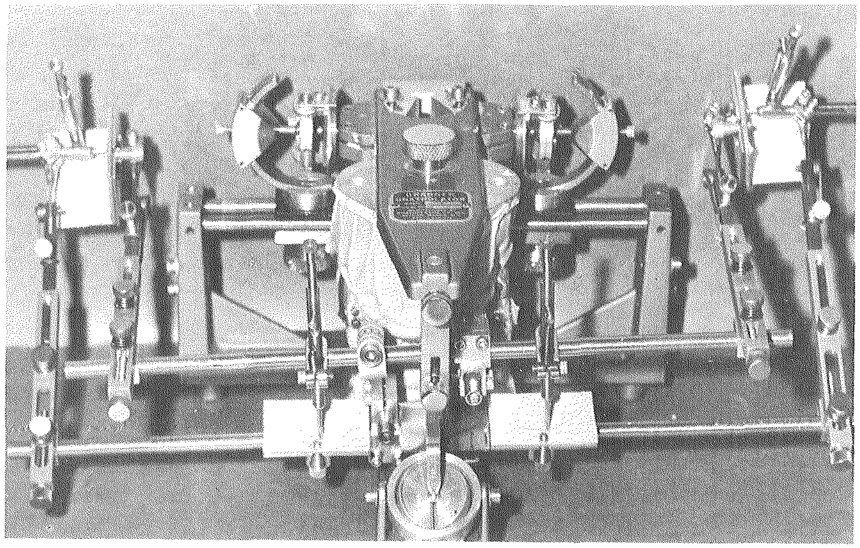


Fig. 13-38. Granger pantograph mounted on Gnatholator.

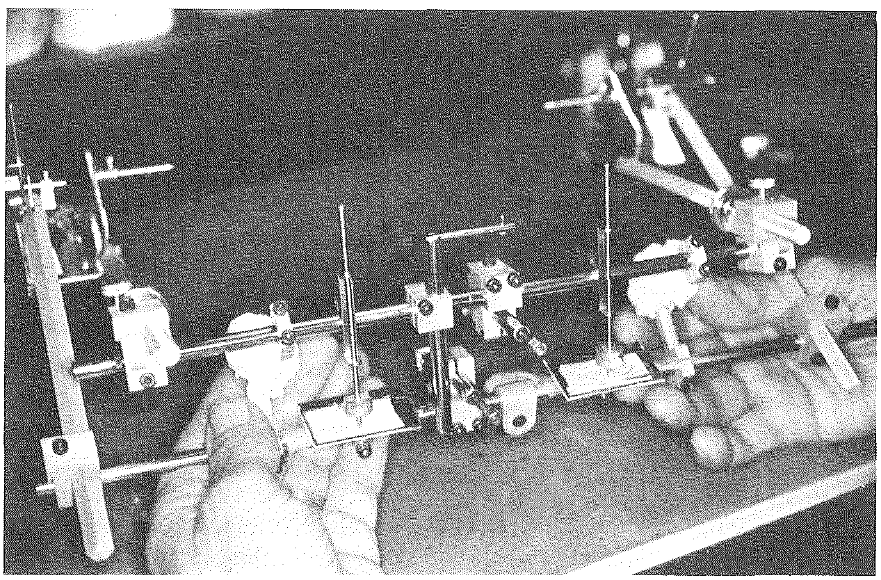


Fig. 13-39. Stuart "jaw-writing" apparatus.

covered with cellophane tape for protection in checking our tracings with the steel styli points and setting of the articulator. (See Fig. 13-38.)

With the Stuart pantograph use is made of a paste of precipitated chalk and alcohol, which is painted on the recording plates. After the paths have been traced, the markings are preserved by covering them with cellophane tape (See Fig. 13-39).

De Pietro has developed and is now perfecting for practical use an electronic method of recording tracings. (Fig. 13-40.) He accomplishes it by passing a low-grade electric potential from a stylus through electrosensitive paper. This eliminates many of the problems inherent in the other methods, such as lack of great accuracy in obtaining definite and very accurate end points for setting intercondylar distance.

Recording of the tracings

The sidearms with the slide holders are placed on each end of the upper crossbar, and

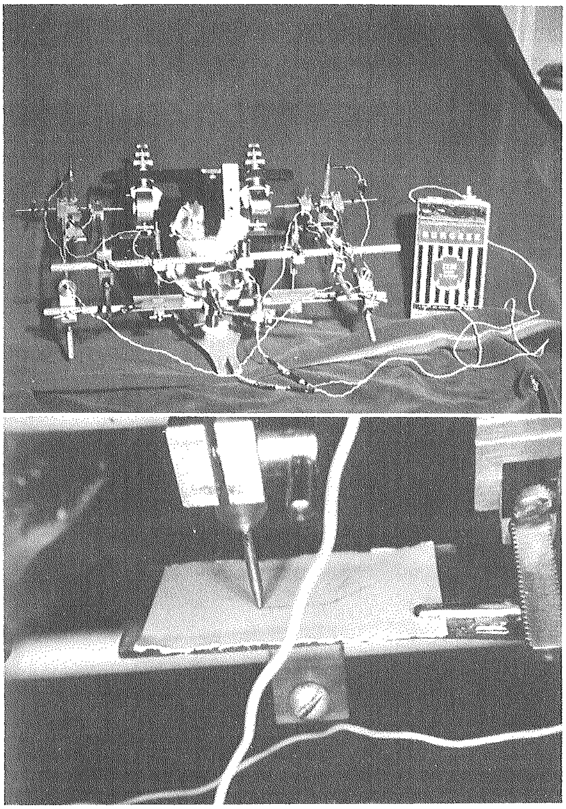


Fig. 13-40. De Pietro electronic recorder. (Courtesy Dr. John Vincelli, Westmount, Que.)

they are positioned so that the axis stylus pins on the inner side of the vertical recording plates are on the axis tattoo marks and barely touching the skin. This is accomplished by having the patient sit upright in the chair with his head out of the headrest, and the sidearms are adjusted until the axis pins (properly selected as to size) are on the tattoo marks with the jaws in centric position. (See Fig. 13-41.) The pins are of several sizes and selection is made on the basis of the width of the face. (Fig. 13-42.) The wider the face, the shorter the pin, etc. The object is to space the sidearms so that they will not interfere with the articulator adjustments when the pantograph is mounted on the articulator for its adjustment. The horizontal slide holders (Bennett movement) are at right angles to the vertical (condyle) slide holders and at convenient angles approximating the condyle path direction (Fig. 13-43).

Next place the lower lateral arms on the lower front crossbar and adjust them so that the horizontal styli is placed on the hinge axis with the patient in the centric relation position (Fig. 13-44).

Place the vertical styli about ¼ inch inside the horizontal recording plate. Be sure that all screws holding these arms are tightened, but do so with care and within reasonable limits so that the threads are not stripped.

The case being described in this chapter was "written" with a type of pantograph that was developed by Dr. E. R. Granger. A special gummed paper is used for the "writings." This paper must cover the tracing surface but not the edges of the slides. A margin of 1/16 inch is left all around. The paper has a surface texture that will enable lead to write with a minimum of pressure.

The lead bushings (cadmium-plated brass) have been accurately drilled and reamed to hold Eberhard Faber grade 2B microtomic lead, and other grades and makes will not fit accurately and scribe efficiently. This particular type of lead was selected because it will mark without heavy pressure and has the proper strength to hold a needle-sharp point during the "writing."[11]

A lead holder is used to hold the lead to sharpen it in the Sharpoint. It is locked securely and then placed in the Sharpoint. The lead holder is grasped firmly with the fingers so that it does not turn in them but does rotate in the sharpener as it is rotated. The sharpener is turned until the lead has a needle point at least ¼ inch longer than the sleeve. (See Fig. 13-45.)

The leads should be prepared and set in the styli beforehand; the slides should be prepared and the springs with the correct amount of tension checked to see that they are all in position.

Tracing the paths. Place pencil styli in their tubes, and position a set of slides in their respective holders. Attach springs to the studs, and inform the patient not to separate the jaws but to hold the center bearing pin in firm contact with the plate on the upper clutch without unnecessary pressure.

Check that everything is in readiness; then have the patient make a practice, or rehearsal, run to check the apparatus for clearance and the patient's behavior pattern in regard to the various mandibular movements. Notice whether or not the patient is using the full Bennett movement because our finished restorations must not have interference in the lateral excursions. This trial run will allow the patient to school himself to make the apparatus record the border positions

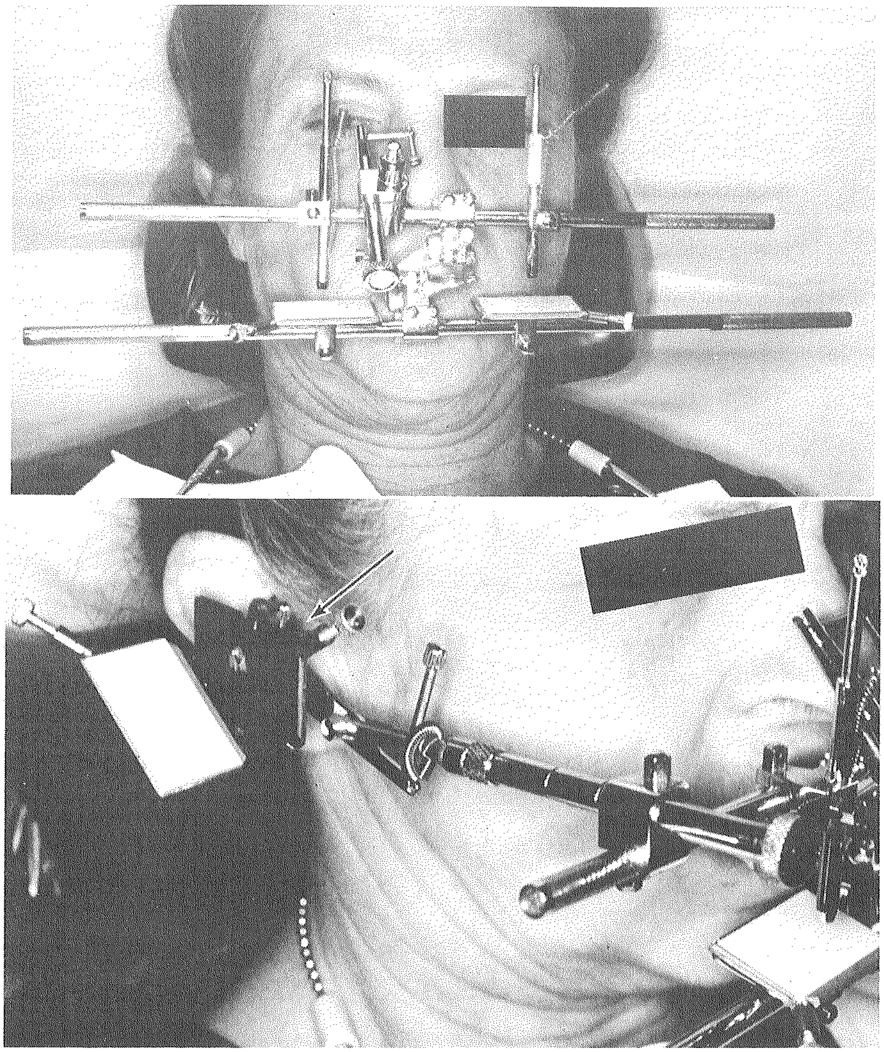


Fig. 13-41. Sidearms with slide holders are placed on each end of upper crossbar and positioned so that axis stylus pins on inner side of vertical recording plates are on axis tatoo marks barely touching skin. With patient's head out of headrest and patient sitting upright in chair, adjust sidearms until axis pins are on tatoo marks with jaws in centric position.

and to comprehend the various excursive movements that we wish him to make. Guide the patient into the lateral excursion being recorded by placing a thumb on the side of the patient's jaw. Also retract the styli after each excursion, and have the patient return to the starting point. With the patient alert and informed we are ready now for the final tracings.

Final tracings. The rehearsal slides are removed and replaced by a fresh set. Each movement will be traced as a separate path, but each path must be traced simultaneously on all six slides. Each tracing must start from centric position, and the styli must be exactly on the starting point each time. Before each tracing instruct the patient to protrude his lower jaw and then retrude it to centric position, checking to see that all styli are on the original starting points.

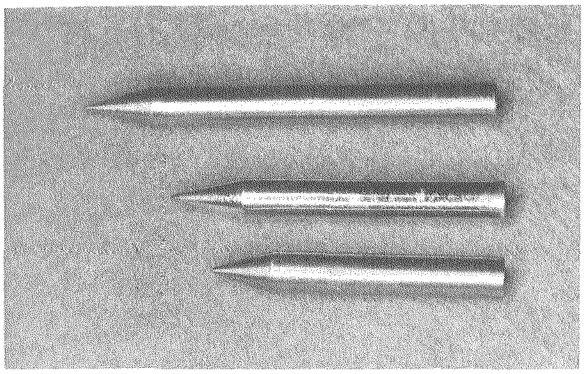


Fig. 13-42. Axis pins (for pantograph) are of several sizes—selection made on basis of width of face.

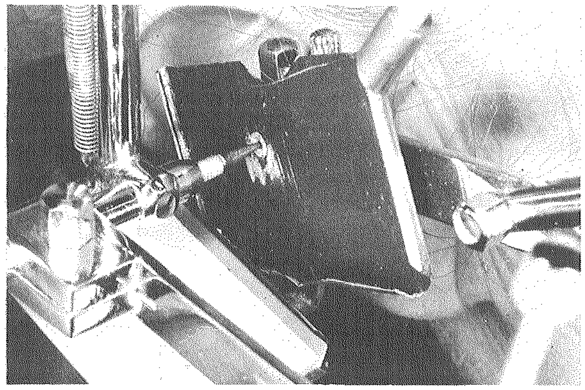


Fig. 13-44. Place lower lateral arms on lower front crossbar and adjust them so that horizontal styli are placed on hinge axis with patient in centric relation position.

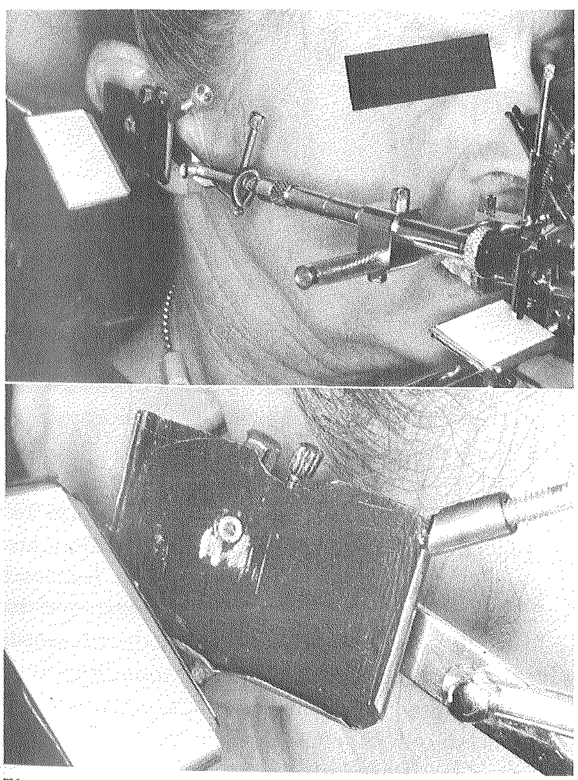


Fig. 13-43. Horizontal slide holders (Bennett movement) are at right angles to vertical (condyle) slide holders and at convenient angles approximating the condyle path direction.

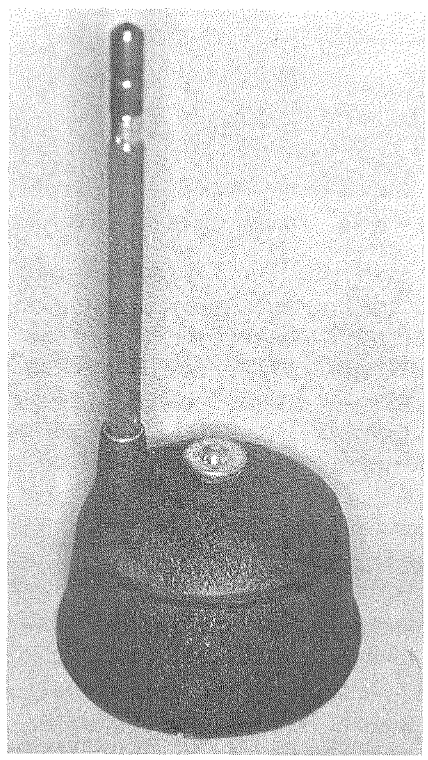


Fig. 13-45. Lead holder used to hold lead to sharpen it in the Sharpoint. Lead must have a needle point, at least ¼ inch longer than sleeve.

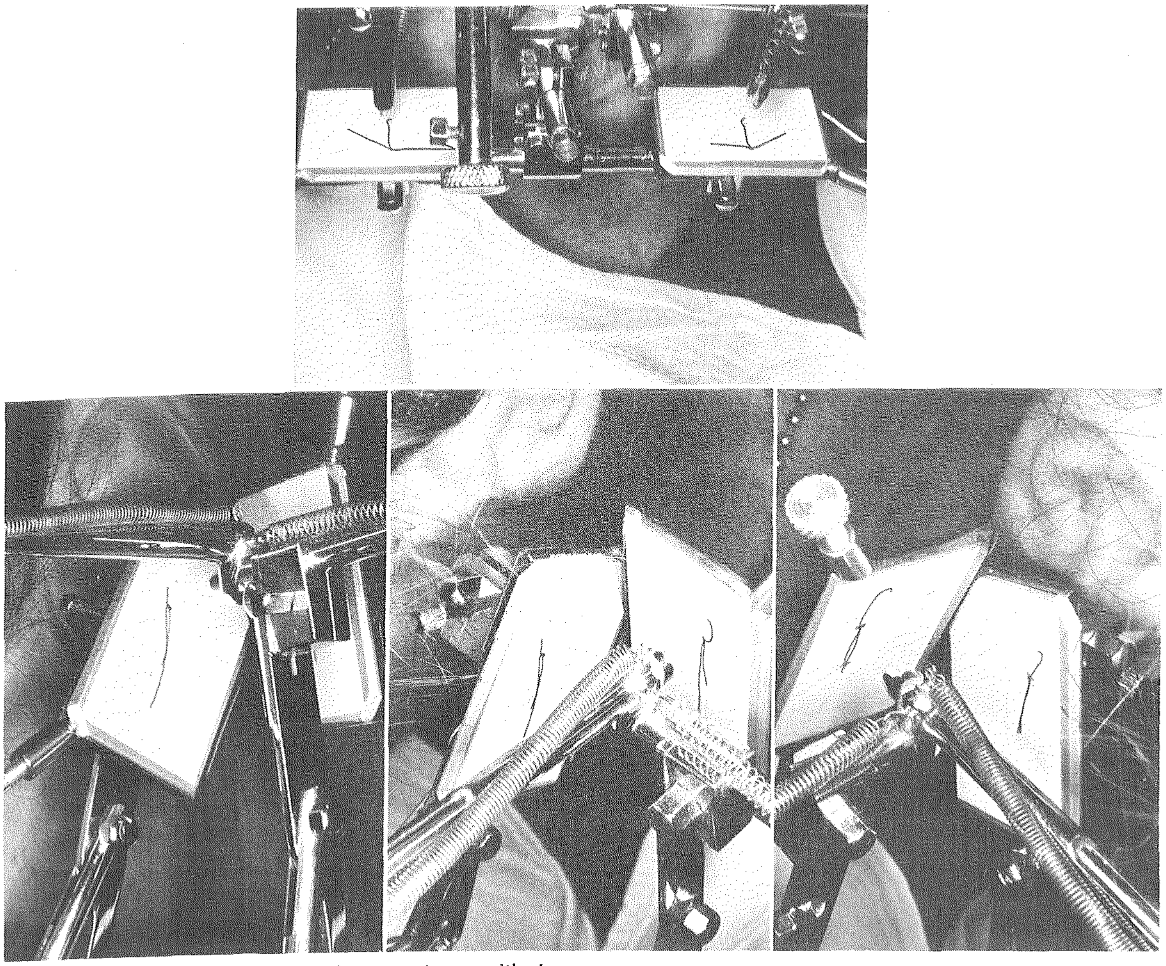


Fig. 13-46. Final tracings of patient's mandibular movement.

Protrusive tracings. Before pencils are placed in contact with the slides the patient is instructed to protrude the lower jaw and to retrude it to centric position several times, the mandible being guided back with light pressure on the chin and held in centric position. The patient should be warned not to separate the jaws. Then styli are released, and the patient is told to slide his mandible forward and to hold it in that position until the styli are retracted and secured out of contact. This is very important, and it is necessary to lift all styli as nearly simultaneously as possible. Ends of the lines are of utmost importance in adjusting the articulator to copy the movements of the patient. The pressure of the styli on the plates must be very even and very light to minimize drag.

The protrusive record is made only once. The patient cannot be taught to repeat a given protrusive movement pattern, and, since this movement is directed solely by muscular control, no attempt is made to repeat it.

Lateral tracings. The patient is returned to, and held back in, centric position. Styli are released and checked carefully to see that they are all on the starting points. The finger is removed from the chin, and the patient is instructed to slide to one side and hold it. Gentle pressure, which is applied to the side of the mandible, will assist this movement. Styli then are withdrawn and locked out of contact. The patient returns to centric position.

The terms right and left are not used during these lateral tracings; they seem to confuse the patient and can spoil the tracing by retracing a path. I "pat" the shoulder of the side of the patient that I wish him to go, and usually it works out well.

Again the patient protrudes and retrudes the mandible, which is being held with light pressure on the chin in centric position, while the styli are released and checked to see that they are all on the same starting point. The patient is instructed (by patting on proper shoulder) to slide to the other side of the jaw and to hold the position. Styli are retracted and locked out of contact. To more accurately record these endpoints, the operator and two assistants simultaneously lift all six styli at the end of each stroke. The patient returns to centric position. (See Fig. 13-46.)

The lateral movements are made only from centric position out to the lateral positions because only the border movements are wanted. On the outward stroke the external pterygoid muscles are in contraction and hold the condyles well up on the slope of the eminentia. On the return stroke, from lateral to centric positions, the external pterygoids are not in active function and are relaxed, thereby not returning along a pure path. A protrusion of the mandible may result. What we want is to have the border movements described while the rotating condyle is seated firmly in the fossa.

The complete envelope of motion is bounded by the following limiting factors: (1) posteriorly, by the temperomandibular ligaments, (2) anteriorly, by the capsular ligaments, (3) inferiorly, by muscle stretch, (4) superiorly, by occlusal contacts, and (5) laterally, by bones and ligaments.[12] If these border limits can be determined and transferred to an articulator, which can reproduce them, and if we can build an articulation without interference at these border positions, we can rest assured that the teeth will function without interference anywhere within them. In other words, when true border movements are recorded and transferred, all other movements are automatically included in the circumscribed areas of movements.[3]

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

If examination of the tracings at this point shows them to be clear and definitive in appearance, all starting from the same centers, they are ready to be covered with cellophane tape for rechecking of the tracings without damaging them. The cellophane tape (Scotch) is applied carefully by attaching one end first and rolling the tape onto the slide to get a very smooth and burnished effect; care should be taken not to trap air beneath it. Overhanging portions of the tape should be removed with sharp scissors.

Checking the tracings

Before checking the tracings, replace the pencil styli by steel ballpoint styli. With and without guidance, check to see that the patient follows all six tracings in every excursion, the only exception being the protrusive line.

Removal of the pantograph

On each crossbar, placed in the space between the sidearms and anterior tracings, a vise grip is locked. The upper vise grip should point back and down at about a 45-degree angle and the lower one up and back. They should cross each other without touching.[11]

With the patient held in centric position a fast-setting bite stone* is mixed and applied around the crossed studs of the vise grips. The patient must be held in centric position until the stone has set, the operator checking to see that all the styli are on the starting points of all the tracings.

The axis-orbital support now is put in place on the upper crossbar; the axis-orbital indicator bow is placed on the support anteriorly and laid across the axis indicator pins posteriorly; the support is adjusted until the indicator point on the bow is on the nose tattoo mark and the support is locked securely. (See Fig. 13-47.) The indicator bow can be removed now. By all means, do not forget this step! If it is forgotten, the "writings" will have been done in vain.

With a wrench driver remove the screws holding the separable studs, and then by applying a small screwdriver in the cut-out notches on the side of the separable studs, while holding the entire "writing" apparatus in one hand (or by having an assistant hold it carefully), gently tease the separable studs apart. Care must be taken not to squeeze the sidearms and throw the styli out of position while removing the pantograph as a unit from the patient and also during the mounting of the pantograph to the articulator and the setting of the instrument. (Fig. 13-48.)

*Whip-Mix Corp., Louisville, Ky.

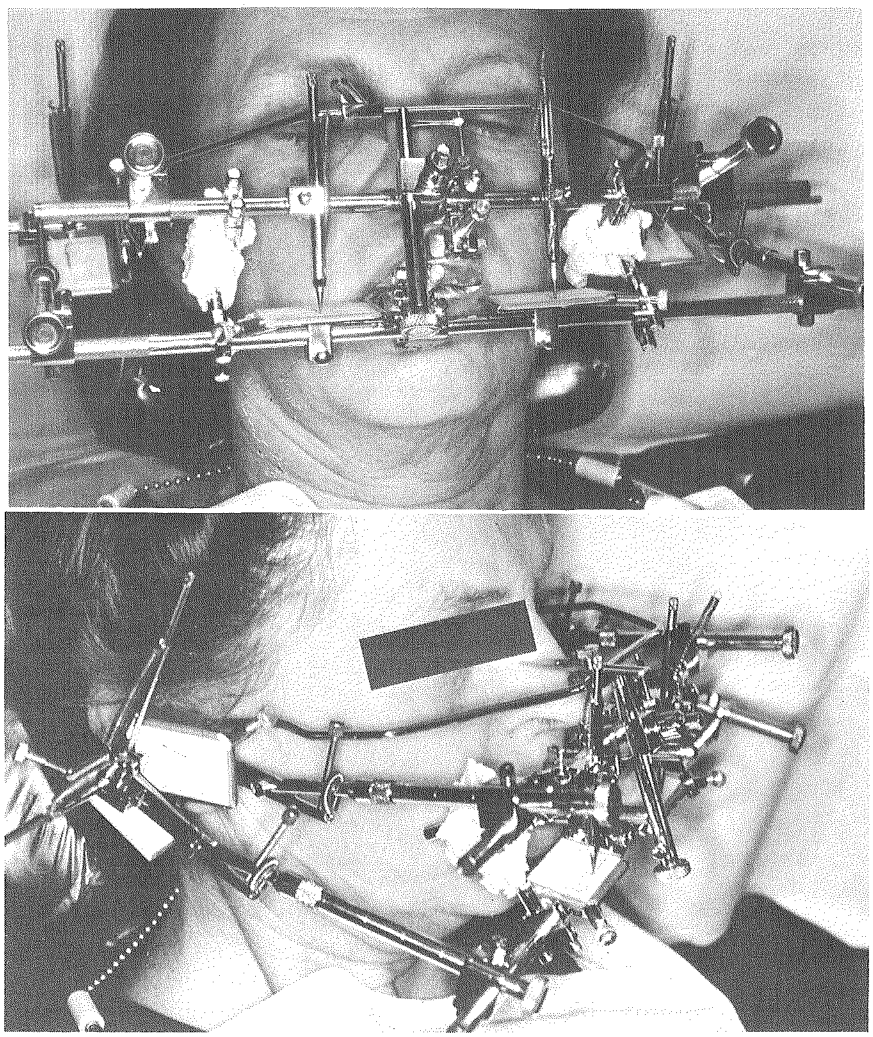


Fig. 13-47. Vise grips are positioned and locked with a fast-setting stone (Whip Mix bite stone), and axis-orbital indicator bow is placed on support, which is on upper crossbar. Bow is placed on support anteriorly and laid across axis indicator pins posteriorly, and support is adjusted until indicator point on bow is on nose tattoo mark. Lock support securely. Don't forget this step!

Be careful—do not jar, jam, or jostle the various parts.

Then the pantograph is placed on the stud of the mounting stand and secured. (Fig. 13-49.)

The next procedural step is the removal of the cemented clutches. Remove screws holding the clutches on the patient's teeth, apply a small screwdriver in the "pry out" notches that were cut previously in the clutches, and gently force the anterior segments of the clutches off the teeth. Then remove the posterior and lingual sections by teasing them out. Avoid using any tools that will bend or distort the clutches. (See Fig. 13-50.)

Then the parts are reassembled, washed, and filled with stone, which serves as a means of attaching the clutches to the articulator (Fig. 13-51). Nodules of stone that are placed on top provide retention of the attachment stone. After the stone has set, place these clutches on the pantograph on the separable studs and tighten screws.

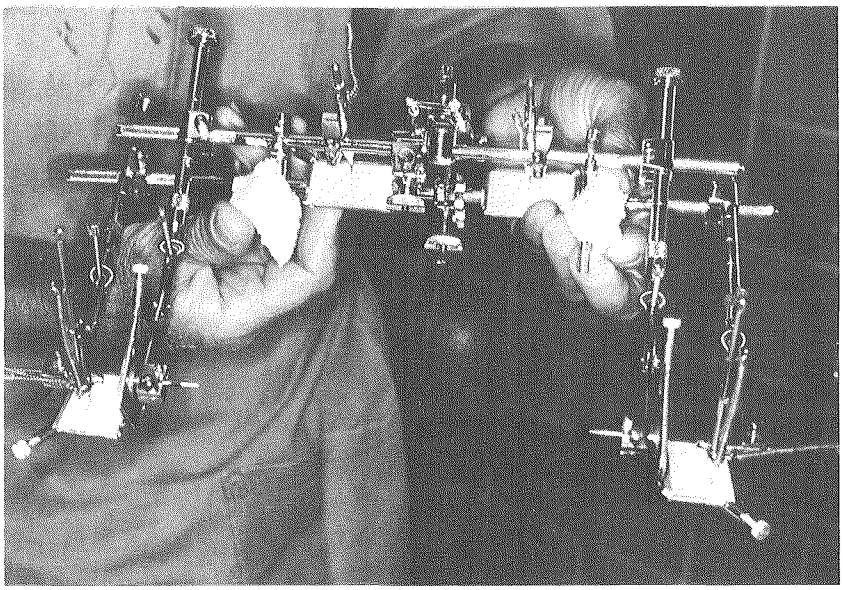


Fig. 13-48. Remove pantograph from patient as a unit.

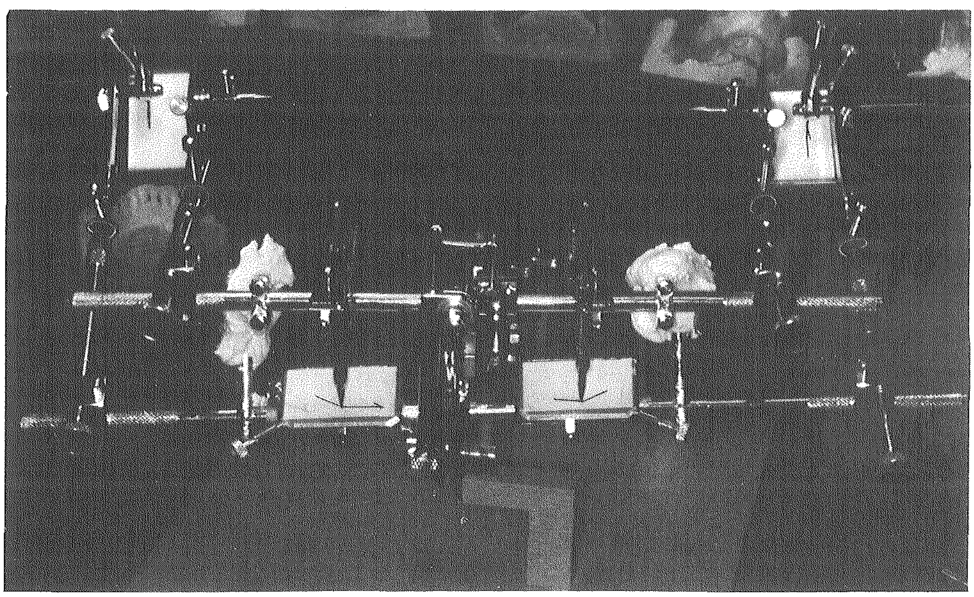


Fig. 13-49. Place pantograph on stud of mounting stand.

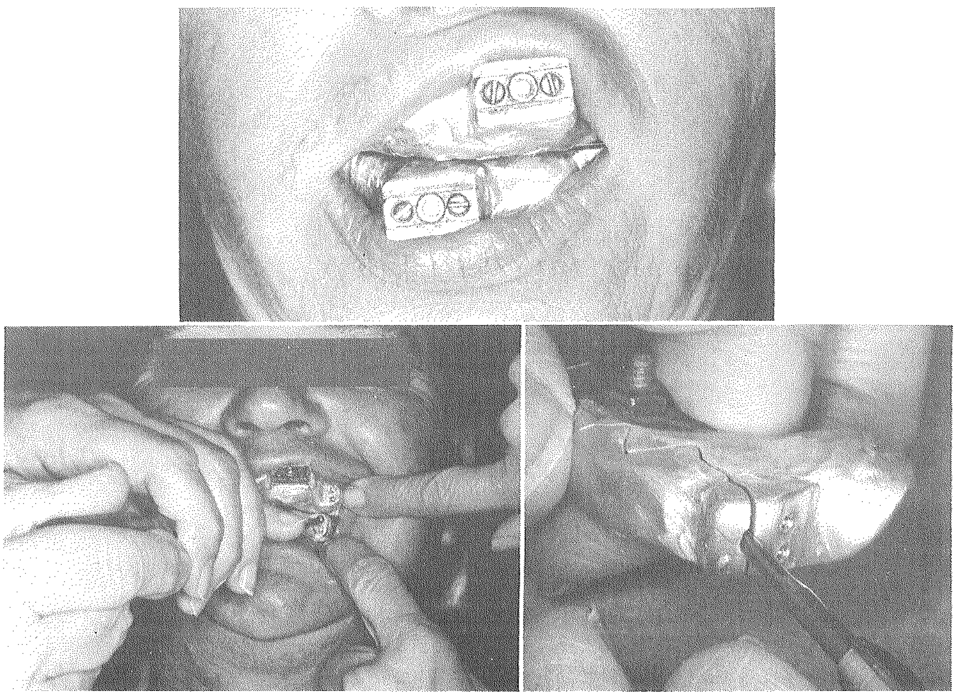


Fig. 13-50. Cemented clutches are removed. Remove screws; then apply small screw-driver in "pry slot" notches, and gently force anterior segments of clutches off teeth followed by removal of remaining sections. Don't bend or distort parts.

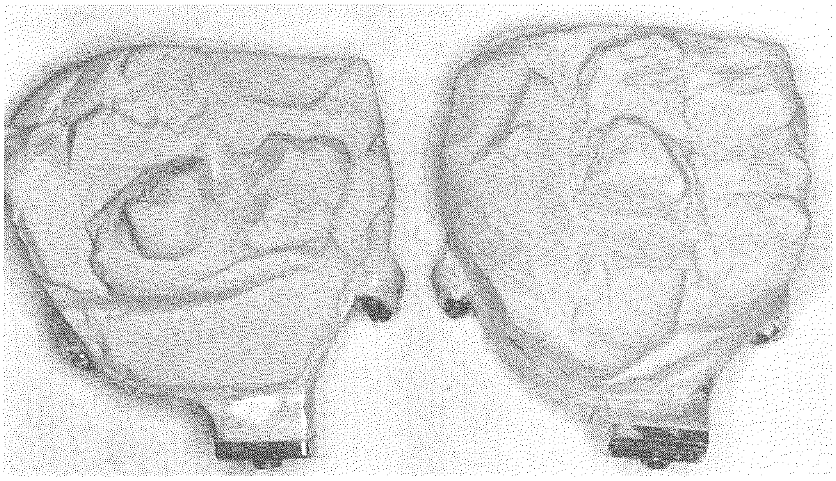


Fig. 13-51. Parts of clutches are reassembled, washed, and filled with stone.

Salient facts on registrations

According to Stuart,[13] "The tracings of the condyle paths are *effects* of the true paths, not the paths themselves. They are outside the face at some distance from the axes of the joints. They are longer than the paths to which they correspond. In other words, they are magnified records; the procedure of using magnified records and then reducing them to original values is used throughout science and industry to improve accuracy. The condyle tracings are each made up of two parts: one is a forwardly drawn tracing, and the other is a backward tracing. The point or dot between the two parts of this line is at the position of the centric relation as indicated by the stylus. Likewise, the lateral tracings are not true Bennett paths, but they represent their *effects* projected at some distances away from the joints. Each tracing is made up of two parts joined at the point of centric relation as indicated by the stylus. The two Gothic arch tracings have in them *effects* of the lateral and anterior movements of the condyles. . . . They are the resultant lines of condylar rotations and slidings.

". . . The accuracy of setting can be increased by using the Bennett tracings to countercheck the Gothic arch tracings."*

At the end of the right lateral and left lateral strokes all six styli are lifted at once so that simultaneous end-points are recorded. These end-points contribute to the determination of intercondylar distance on the articulating instrument. The slightest discrepancy here will result in a highly magnified error in the intercondylar distance setting.[14]

If a double line is made by the patient in a lateral tracing, it is indicative that there has been some protrusion. If so, replace or repaint (Stuart recorder) the recording slides and repeat the procedure from the beginning. Observation will show a number of aberrations, which can be handled with experience. With the Stuart recorder a paste of alcohol and precipitated chalk is used to paint the recording plates upon which the styli make the tracings. With a good camel's-hair brush paint the areas only in which the styli will traverse on all six recording plates. Paint this paste in a direction that is opposite to the one that the stylus is moving. Paint with striations perpendicular to the recording. Coating should be reasonably thick and evenly applied without streaks, and then all surfaces should be dried with a light stream of air.

The locking of the vise grips with fast-setting stone in the centric position after completion of the tracings provides a centric bite for the upper and lower pantograph parts and is used to place the lower part of the recorder on the articulator in centric position.

Observations are that the action of the mandible is movement in three planes—horizontal, vertical, and sagittal—and that these movements cause rotation about three different centers—horizontal, vertical, and sagittal.

During function, movement in these planes and rotation about these centers occur simultaneously. If the rotational centers can be located and registered, these registrations then could be transferred to a mechanical counterpart (articulator) whose mandibular member was so constructed that it also could move in the same three planes with rotation about the same three centers.

The location of the hinge axis orients the axis in one plane, and the location of the center of rotation orients the axis in another plane. If the two axes can be located the third axis is located automatically. The three axes coincide at a point center.[2]

For restorations to be related properly to dental function, it will be necessary to locate and register these centers of rotation.

"We must differentiate between two terms which are often used. A changing axis is not the same as a moving axis. The opening axis and the closing axis are changing axes. They are different every time they operate. The hinge axis is a moving axis, always moving with the mandible, yet unchanging in its relation to tooth closures."*

Relating pantograph to articulator (Stuart)

Articulator fossae and condyles are set at 40 mm. on each side, and axis slide brackets are placed in the outer portion of the slot in the rear of the upper articulator frame. Jackscrews in

*From Stuart, Charles E.: Accuracy in measuring functional dimensions and relations in oral prosthesis, J. Prosth. Dent. 9:220-236, 1959.

*From Granger, E. R.: Principles of obtaining occlusion in occlusal rehabilitation, J. Prosth. Dent. 13:714-718, 1963.

side-shift guides are withdrawn, and orbital level replaces the anterior guide pin in front of the upper frame.

Remove the locking device on the rear of the mounting stand, and carefully slide the articulator onto the stand from the rear so that the hinge axis styli of the pantograph are between the frames of the articulator in the region of the axis. The orbital level will rest on the orbital indicator in front at approximately its midpoint. Replace hold-down, or locking, bracket on the rear of the mounting frame.

Adjustment of the pantograph assemblage to the articulating instrument is next. The hinge axis styli must be aligned with the hinge axis bracket pins of the Stuart articulator. The axis bracket pins of the instrument (on the upper articulator frame)—never the pins of the facebow—are pulled in or out, and the bracket pins of the articulator must be set so that the same number of calibrations are present on each side.

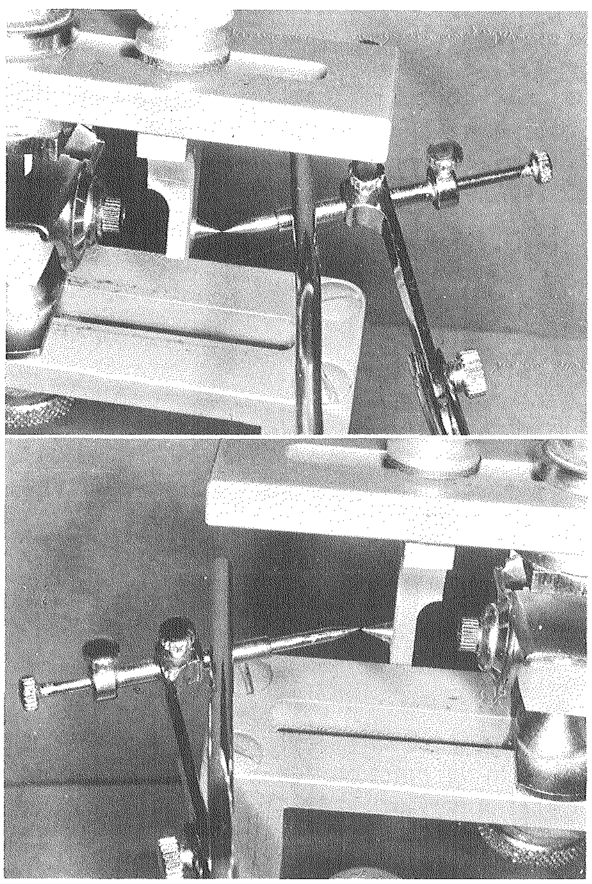


Fig. 13-52. Hinge axis styli are aligned with hinge axis bracket pins of Stuart articulator.

The lower member of the articulator has elevating thumbscrews, which permit adjustment of the articulator to the pantograph. When the tips of the bracket pins of the instrument are aligned correctly with the axis pins of the pantograph, making the axis continuous, the lock screw at the rear of the mounting stand is tightened so that the articulator is held securely (Fig. 13-52).

Now wedge blocks are placed between the lower clutch model and the lower articulator frame, using a passive contact. The purpose of these wedges is to avoid any downward springing of the pantograph, with the weight of the upper articulator frame and the stone being used to connect it with the clutch. (See Fig. 13-53.)

The ⅛-inch right-angle bars at the outer ends of the upper articulator frame are adjusted into position along the inside of the rear part of the vertical recording plates—they should be very close to the plates but should not touch them. The right-angled bars are attached to the plates with sticky wax. The purpose of this step is to hold the upper bow of the pantograph in precise position with the upper articulator frame. (See Fig. 13-54.)

Attach the upper clutch to the mounting plate with stone. When the stone has set, remove orbital indicator, support stud, and the axis-indicating styli. Remove hold-down bracket at rear of the mounting stand, replace orbital level with the anterior guide pin, loosen toggle that is holding pantograph to the mounting stand, and carefully slide out pantograph–articulator assemblage from the stand. Remove wedge blocks and axis slide brackets.

Now set the fossae and condyles on the articulator at 55 mm. from center, screw a mounting plate into position on the lower articulator frame, and check clearance between the lower clutch model and the lower mounting plate (excessive stone is ground away on model trimmer).

Make a stiff mix of a fast-setting stone, and place one or two small cones of this mix on the lower mounting plate with the tips of these cones touching around the center of the lower clutch model. When cones of stone have set, the anterior guide pin is set at zero. The purpose of this step is that the cones will help support the weight of the models and pantograph and will allow the opening to be maintained.

Now place stone around and between these cones between the lower clutch model and the

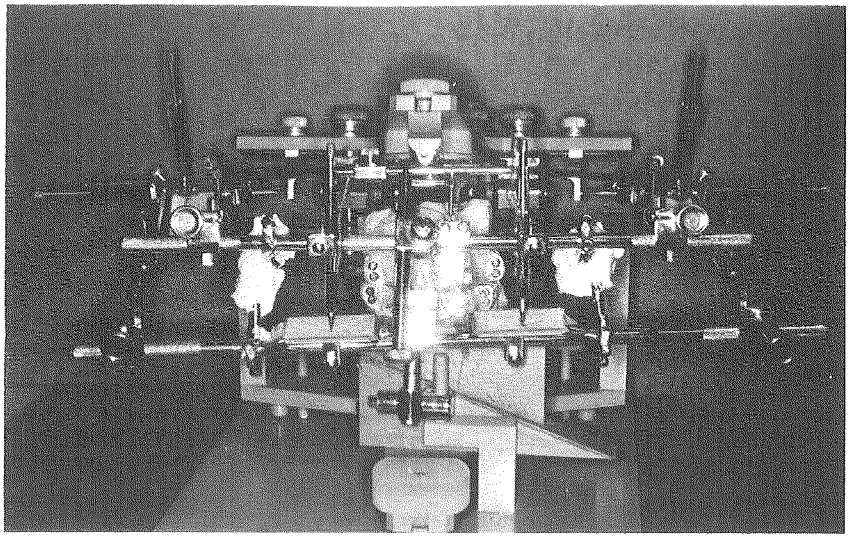


Fig. 13-53. Wedge blocks are placed between lower clutch model and lower articulator frame, using passive contact, to avoid downward springing of pantograph from weight of upper articulator frame and attaching stone.

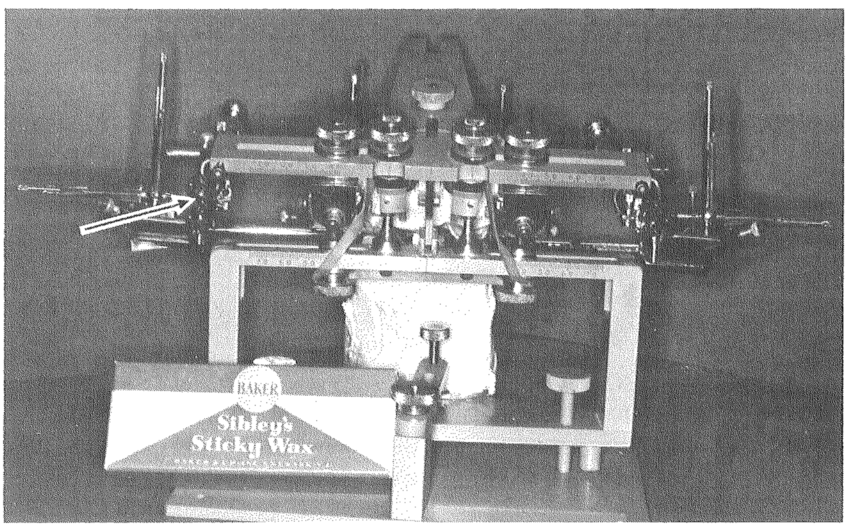


Fig. 13-54. Right-angled bars at outer ends of upper articulator frame are placed along inside of rear part of vertical recording plates and attached with sticky wax. Holds upper bow of pantograph in precise position with upper articulator frame.

lower mounting plate, thereby attaching the pantograph to the lower frame of the articulator. When stone has set, remove screws holding vise grips together with the attaching stone, and take off the vise grips[6] (Figs. 13-55 and 13-56).

If these procedures have been executed carefully, the styli pins should be at their centric positions.

We now are ready to begin the setting of the articulator and to retrace the lines scribed on the pantograph slides.

Setting the Stuart articulator

Articulator

The articulator will receive and register the axes of mandibular rotations and the paths in

Fig. 13-55

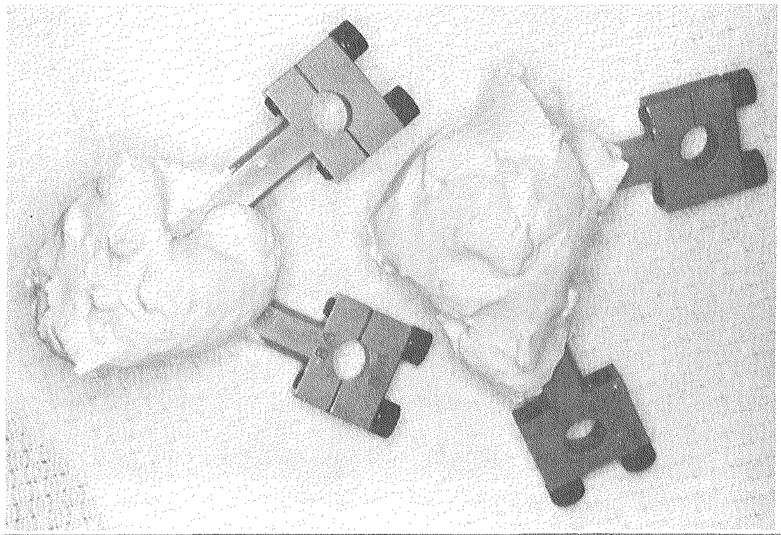
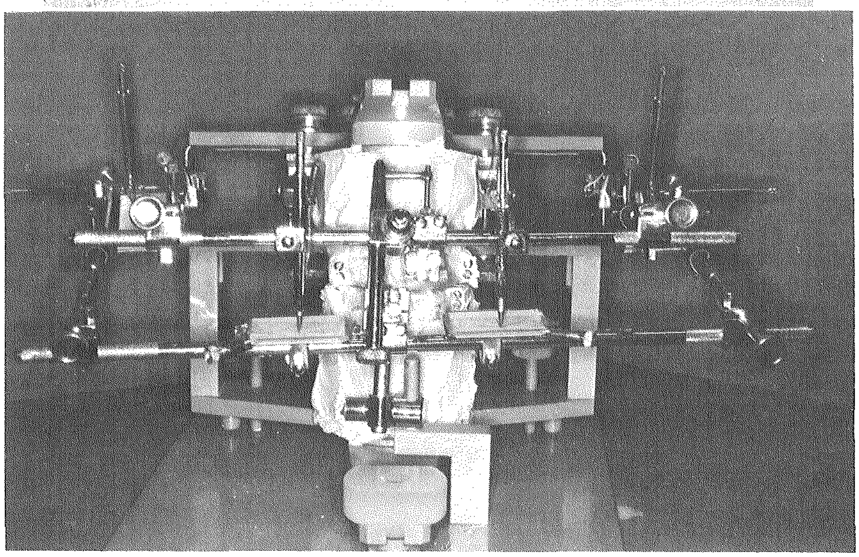


Fig. 13-56



Figs. 13-55 and 13-56. After completion of attachment of pantograph to lower frame of articulator, vise grips and attaching stone are removed.

which these axes travel in the various movements of the mandible.

"The articulator consists of two main frames, an upper and a lower. The upper frame is centered on the lower and maintained in centric relation by a spring-loaded arm engaging a groove. The upper frame carries all of the cams that direct the gliding of the condyle mechanisms, namely, the right and left guides for the side shifts (the Bennett movements) and the right and left fossa cups which carry the eminentiae under which the condyles glide. [See Fig. 13-57.]

"The lower frame of the articulator carries the mechanical condyles and simulates the mandible. The mechanical condyles are truncated spheres through the centers of which passes the opening-and-closing rotation axis. The vertical axis of each rotating mechanical condyle (outer) passes through the spheres at right angles to the transverse axis. . . .

"To simplify the construction of the articulator without changing or violating any principles, the split mechanical condyles are placed on the lower frame. The outer half of the mechanical condyles traverse the under surfaces

A

B

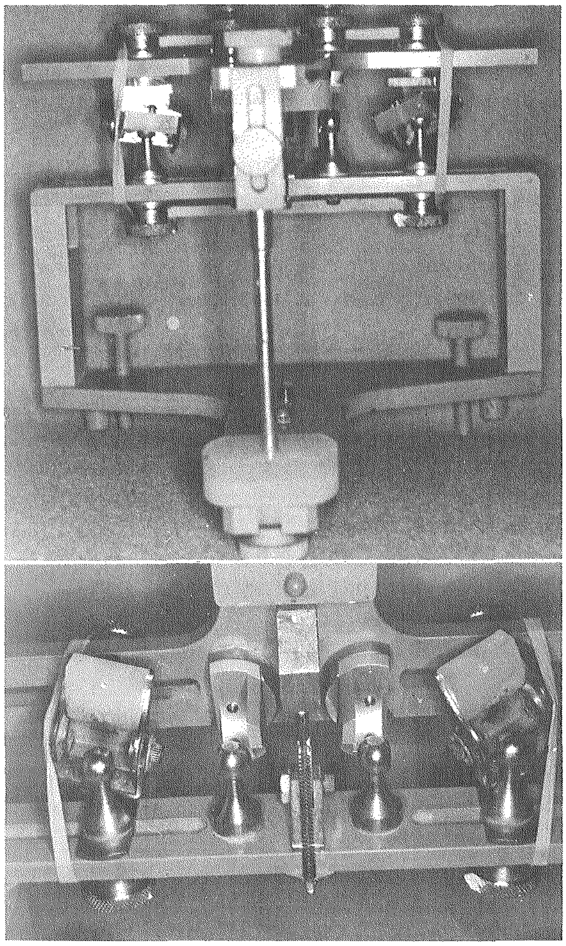


Fig. 13-57. A, Stuart articulator. **B,** Upper frame of this articulator carries all cams that direct gliding of condyle mechanisms—right and left guides for side shifts and right and left fossa cups, which carry eminentiae under which condyles glide. Lower frame carries mechanical condyles and simulates mandible (split mechanical condyles are placed on lower frame).

of the mechanical eminences, and travel in the fossa cups laterally when rotating for lateral mandibular movement. The inner half of the mechanical condyles engage the adjustable cams that guide the sideshift movement of the lower frame.

"...Eminence blanks are made of plastic in nine geometric radii from ⅜ inch up to 1 inch, in ⅛ inch steps. Also, one has a radius of 2 inches, another has one of 4 inches, and another one is straight. They are interchangeable. They may be ground, or "quick-cure" plastic material may be added to obtain the proper anatomic contour or curvature."*

All parts of the articulator are held together by radial tightening because set screws have a tendency to malalign parts.

In a semiadjustable articulator the condyle paths, being on the lower member of the articulator, do not remain constant with the maxillary teeth. With no adjustment for intercondylar distance, etc. being available, cusp height, angulation, and depth of fossa will be incorrect because a semiadjustable articulator cannot be adjusted to accept the lateral records of a patient with definitive accuracy. All this leads to much unnecessary grinding of the finished restorations; as a rule, an inadequate occlusal relationship is the end result.

Adjustment of the articulator†

In setting the instrument do not attempt to adjust any one thing perfectly, except the grinding of the Bennett guides, because in changing one setting the others are going to be altered. For example, in grinding the side-shift guides the intercondylar distance can be changed to some degree, etc. All the adjustments should be made progressively.

When setting an adjustable articulator of the type used in this case presentation, remember the following: (1) examine all screws to be sure that they are tightened, (2) keep incisal pin free, (3) do not open the articulator while the pantograph is attached because the styli may become jammed, (4) during articulator adjustment do not bump the pantograph or put any pressure on the lateral sidearms because even a slight movement may disturb the synchronizing of the styli on the recordings, and (5) always maintain lateral contact with the side-shift ball.

Setting the angle of the eminentia. The jackscrew on the side to be adjusted (lateral position) is turned inward until the recorder stylus (horizontal) approximates the end of the re-

*From Stuart, Charles E.: Accuracy in measuring functional dimensions and relations in oral prosthesis, J. Prosth. Dent. 9:220-236, 1959.

†I highly recommend careful reading of Chapter 10 in Lucia's book, *Modern Gnathological Concepts,* published by The C. V. Mosby Co. It is definitive and well illustrated.

corded line on the vertical (condyle) plate. Use a right-angle Allen wrench, loosen the screw holding the fossa, and, if the stylus point is above the end of the line, increase the angle by tipping the eminentia downward. If the stylus point is below the end of the line, decrease the angle by tipping the eminentia upward. We are only interested at this time in obtaining a coincidence of the horizontal stylus at the end of the line of the lateral condyle path on the vertical plate. Tighten the fossa cup–holding screw.

Setting angle of Bennett guide or side shift. With jackscrew turned inward for the previous adjustment (in fact, leave the jackscrew turned inward on the side being set until the operation for that side is completed) and lock nut holding side–shift wing loosened, set the vertical stylus to the end of the line on the horizontal plate, making use of the jackscrew as a handle for turning side-shift cam or wing. The side-shift control ball must be against the side-shift guide wing.

If the stylus point is medial or inside the end of recorded line, decrease the angle of the side-shift wing. If the stylus point is lateral or outside the end of the recorded line, increase the angle of the side-shift wing. Tighten the holding screw.

Now recheck the tracing used for the setting of the angle of the eminentia on the same side to determine whether there has been any interaction as a result of the setting of the side shift.

Setting center of lateral rotation. Keep jackscrew turned inward as before, and maintain the same lateral position with styli on the ends of the lines of the condyle and side-shift tracings.

Now we are ready to set the rotation center on the opposite, or rotating, condyle side. Examine the relation of the vertical stylus on the front horizontal plate on the rotating condyle side. Slightly loosen the holding nut of the main fossa bracket on the upper frame, as well as the holding nut of the condyle ball on the lower frame of the articulator.

If the stylus is behind the line (means rotation center is too far out), move the main fossa bracket and the condyle ball medially 2 or 3 mm. at a time, until coincidence is obtained with the vertical stylus on the end of the line. Always move main fossa bracket and condyle ball an equal number of millimeters because it is important always to have the same calibration number on the upper bow as on the lower bow; otherwise, the articulator members will not be centered.

If the stylus point is in front of the end of the line, it is indicative that the rotation center is too far inward and should be adjusted outwardly or laterally, 2 or 3 mm. at a time, keeping the calibrations of upper and lower bows of the articulator equal. Tighten the holding nuts after each adjustment.

Adjusting tilt and rotation of axis. Holding the articulator in lateral position with the jackscrew and being sure that the styli points in the three adjustments that were just made are on the ends of their respective tracings, observe the position of the horizontal stylus in relation to the end of the "back line" on the vertical condylar recording plate on the rotating condyle side. This back line, or reciprocal tracing, is a short line, and it is there because our recordings are taken outside the rotation center or vertical axis, which is in the condyles; that is the recordings, or tracings are projected from the actual centers of rotation. The back line is a guide in determining the direction and extent of the axis shift.

If the stylus point is above the end of the line, slightly loosen the screw holding the fossa trunnion bracket and raise the medial end a few degrees; adjust it until there is coincidence at the end of the line. Tighten screw, and check to see that coincidence at the end of the line is absolute.

If the stylus is below the end of the line, slightly loosen the screw holding the fossa trunnion bracket and depress, a few degrees at a time, the medial side of the trunnion holding the fossa and produce coincidence at the end of the line.

If the stylus point is behind the end of the "back line" when the opposite tracings of the side shift and condyle paths on the sliding condyle side are at the ends of their respective lines, then slightly loosen the nut holding the main fossa bracket and turn the bracket a few degrees, rotating the outer end of the bracket anteriorly. When the main fossa bracket is being rotated, care must be taken not to move the position of the fossa in relation to the condyle ball of the lower frame.

If the horizontal stylus on the rotating condyle side is in front of the end of the "back line" when the opposite, or sliding, condyle side styli are at the ends of their respective lines, rotate the main fossa bracket's outer end posteriorly. Again make certain that the fossa cup setting agrees in millimeters from the center with the condyle ball of the lower frame.

It is sometimes necessary to tip the trunnion bracket, as well as to turn the main fossa bracket to have the stylus coincide at the end of the "back line."

Checking adjustments. After the aforementioned adjustments have been made, recheck the styli points for coincidence at the ends of the lines on the condyle path, side shift, rotation center, and "back line" tracings. It probably will be necessary to make slight readjustments in some of the settings because there is an interaction between the different controls.

Now back out the jackscrew that has been holding the articulator in the lateral position and return the articulator to centric position. Turn inward the opposite jackscrew to place the articulator in the opposite lateral position near the end of the condyle path tracing, and adjust the controls for this side in the same sequence and the same way as just described.

Both lateral positions at the ends of the lines now have been set.

Recheck settings in first lateral positions because of interactions of the controls, and then also recheck settings in the opposite lateral position. In other words, recheck both lateral positions at the ends of the tracings.

Grinding of the Bennett guides

Up to this point we have dealt with stylus coincidence at the ends of the lines; now we must duplicate the paths between centric and the lateral positions.

Turn out both jackscrews, and return the articulator to centric position. Move the articulator from centric to lateral position on one side, making sure to ride the side-shift ball against the side-shift guide in the direction in which the articulator is being moved.

The upper bow is moved in the same direction as when setting the wings of the guides. To set the articulator for the line going to the left on the Gothic arch tracing, hold the right side-shift guide, as you look at the instrument from the front, against the side-shift ball, and move the upper bow to the left. For the other side it is just the reverse, as it will be for all other subsequent adjustments; that is, the left side-shift guide of the bow is held against the side-shift ball, and then the bow is moved to follow the line going to the right on the Gothic arch tracing.

Observe the vertical stylus on the sliding condyle side as it passes from centric position to the end of the line on the horizontal plate, which records the side-shift path. If the stylus cuts across and does not follow the side-shift path, it will be necessary to grind the side-shift control wing to reproduce the curve of the side-shift path.

Place carbon paper between the ball and the side-shift wing on the sliding condyle side, and move the articulator from the centric to the lateral position, being sure that the side-shift ball is against the wing. The articulator is moved from where the stylus begins to leave the line to where it resumes on the line, moving it back and forth between these two points, thereby marking the area on the side-shift wing that has to be ground.

Remove the side-shift wing by loosening the small holding screw at the top of the side-shift adjustment nut. Do not disturb the large holding nut that maintains the angle of the side-shift wing. Observing this important fact allows the side-shift wing to be returned to the same angle after each grinding.

Using a stone that has a ⅝-inch diameter, carefully grind out the marked path until the vertical stylus point follows the entire side-shift path on the horizontal recording slide. When grinding the side-shift guide wing, make a wide path to allow for subsequent changes in the condyle adjustments. Be careful not to grind the start of the path on the side-shift wing because the important positive centric guide will be lost. In other words, the grinding must be done completely and with extreme accuracy. If this is not done, the articulator cannot be set correctly.

Examine the opposite side-shift guide wing in the same way, and grind if necessary, repeating the same steps as just outlined.

Selection of condyle path

It may be found that the anatomic curve produced by the patient does not agree wholly with the geometric curve supplied in the eminentia.

"When non-agreement exists make sure that an eminentia with a positive error is used; that is, one which causes the stylus to pass below the recorded line on its path, but agrees at the end of the line. With this situation the plastic eminentia may be ground to bring agreement with the anatomical curve produced by the patient."*

Move the articulator to a lateral excursion (riding the side-shift ball with the side-shift guide wing on the condyle sliding side), and examine the relation of the horizontal stylus point to the lateral condyle path on the vertical recording slide.

If the stylus point arcs below the patient's tracings and then agrees at the end of the line, it is indicative that an eminentia of greater radius of curvature is needed; that is, a flatter path is needed.

If the stylus point on the condyle path tracing cuts across above the arc of the path and then agrees at the end of the line, it is indicative that an eminentia of smaller radius of curvature or with more curvature is necessary. A steeper path is needed.

Several eminentiae should be tried until one that produces the closest coincidence along most of the path is found. When changing to an eminentia of different curvature, reset the angle of the eminentia holder for coincidence at the end of the line.

Grinding eminentia for lateral path

If the horizontal stylus cuts below the tracing in some area, grind the plastic eminence on the medial side until the stylus tip follows the entire lateral condylar path.

If the horizontal stylus cuts above the line, add "cold-cure" plastic to the eminence on the medial side. (The inner wall is lateral.)

Grinding eminentia for protrusive path

The protrusive path is usually above the lateral path on the vertical recording slide and is a short line.

In many instances the stylus point will follow the protrusive path after the other adjustments have been made. If this is not the case, the eminentia can be reset to a steeper inclination, marked with carbon paper, and ground for coincidence along the protrusive path.

Be careful not to grind the lateral path when grinding the protrusive path. To avoid this, first mark the lateral path on the eminentia with carbon paper.

After protrusive grinding has been done and the stylus faithfully follows the protrusive path, it is necessary to remark and sometimes regrind the eminentia of the lateral path.

In other words, to summarize:

1. If the stylus point cuts below the tracing, grind the plastic eminence.
2. If the stylus point cuts above the tracing, add "cold-cure" plastic to the eminence. (The outer wall is protrusive.)

The next procedure is to repeat the above steps for the opposite side (Fig. 13-58).

When the articulator has been completely adjusted, the settings are recorded on a special chart (Fig. 13-59). The patient's name is engraved on the unused side of the side-shift wings if they were ground and on the eminentiae if these were ground or added to. This enables us to reset and reassemble the articulator accurately when work is started.

Pantograph and clutch models now can be detached from the articulator.[6,10,11,15]

Mounting the study casts to correct axis

A wafer of red modeling compound or hard wax is softened in a water bath at 135° F. The compound is placed on the rim of a face-bow fork and shaped to the approximate contour of the upper dentulous arch. The compound-covered fork is placed against the maxillary teeth without permitting the teeth to penetrate the compound. The lower jaw should be positioned as near as possible to centric position.

The indentations of the maxillary teeth must be accurate because the cast of the maxillary teeth will be set in these indentations in making the transfer, and if the bite block is in any way inaccurate, the cast will rock and the transfer be inaccurate. Remove excess of compound so that only indentations of the tips of the cusps are left, and then the cusps of the cast will fit easily into the shallow indentations.

The stud of the face-bow fork should be in the region of the upper left central incisor. The patient is directed to close the mandibular teeth lightly into the inferior surface of the modeling compound to hold the fork firmly in position while the face-bow is attached to the stud of the face-bow fork. With the patient's head away

*From Stuart, Charles E.: Instruction for use of gnathological instruments, Ventura, Calif.

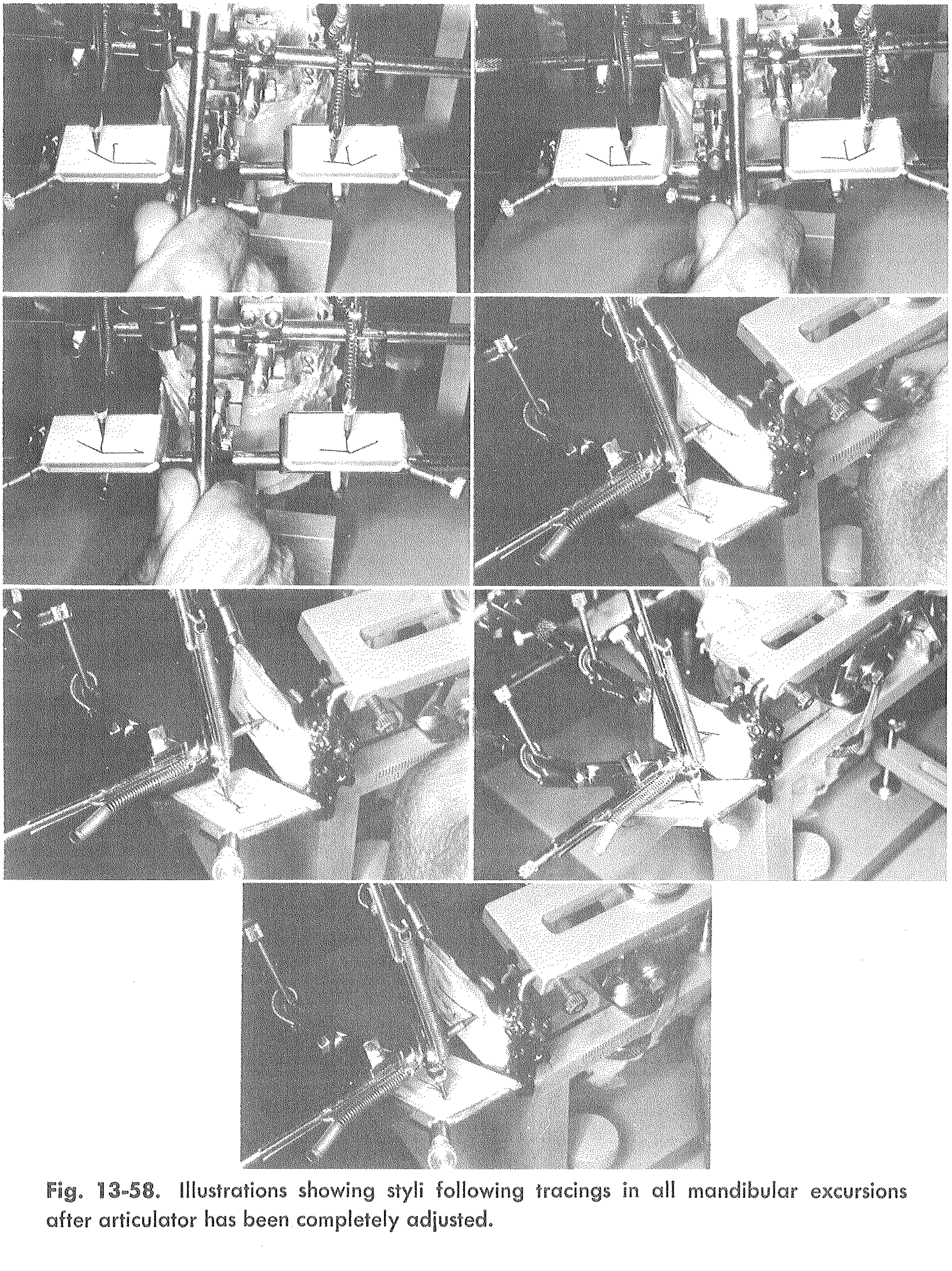


Fig. 13-58. Illustrations showing styli following tracings in all mandibular excursions after articulator has been completely adjusted.

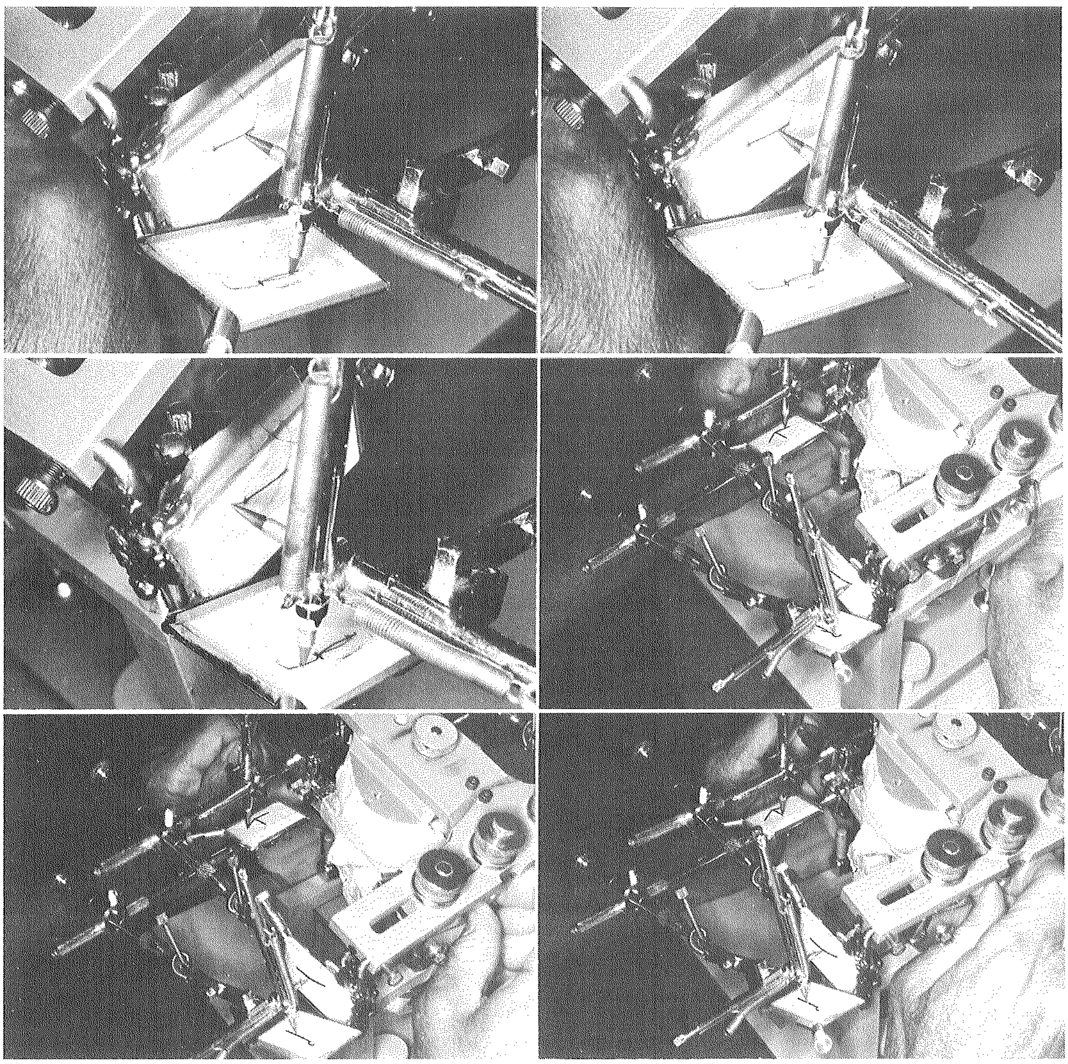


Fig. 13-58, cont'd. Articulator has been adjusted perfectly to recordings of a three-dimensional pantographic tracing of controlling mandibular axes.

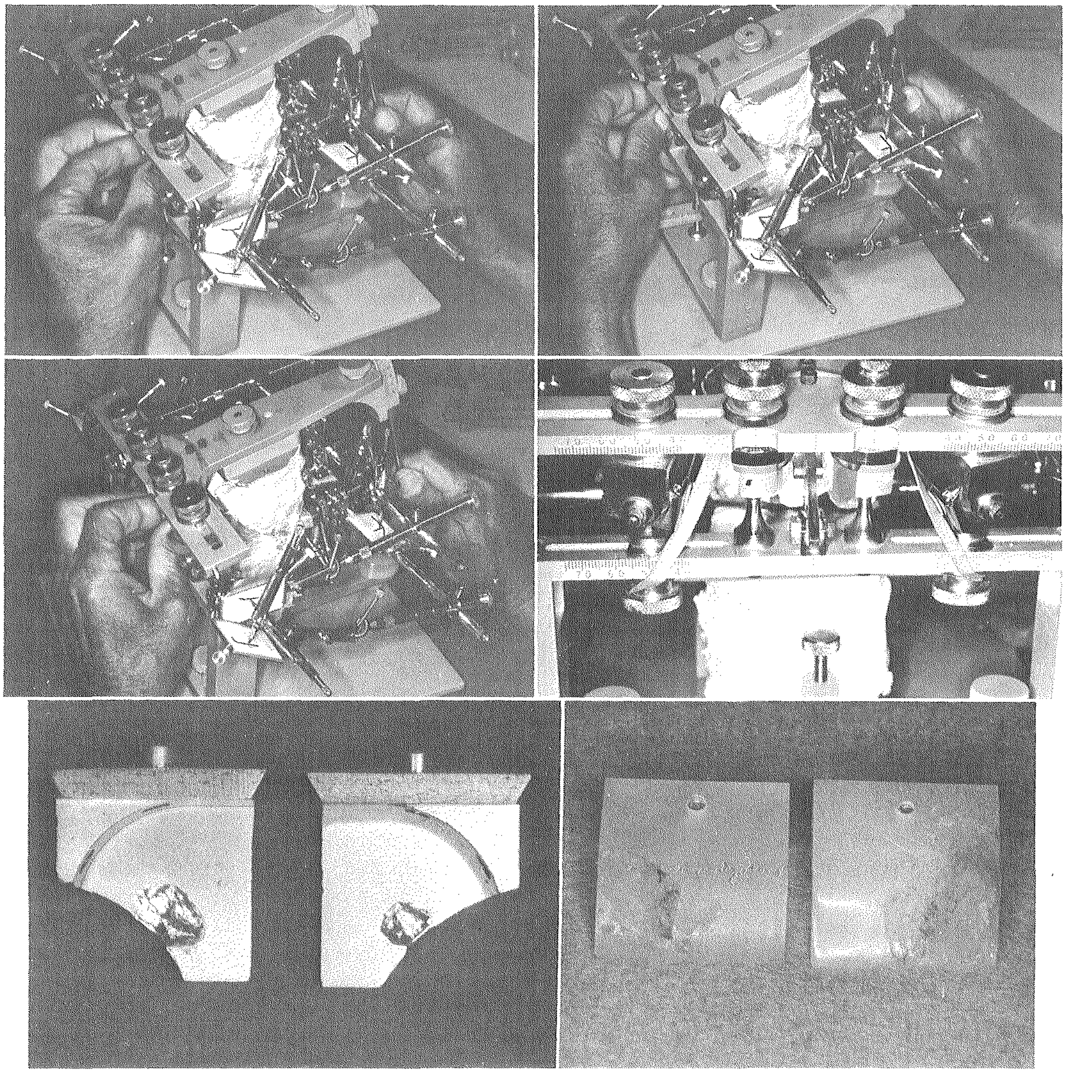
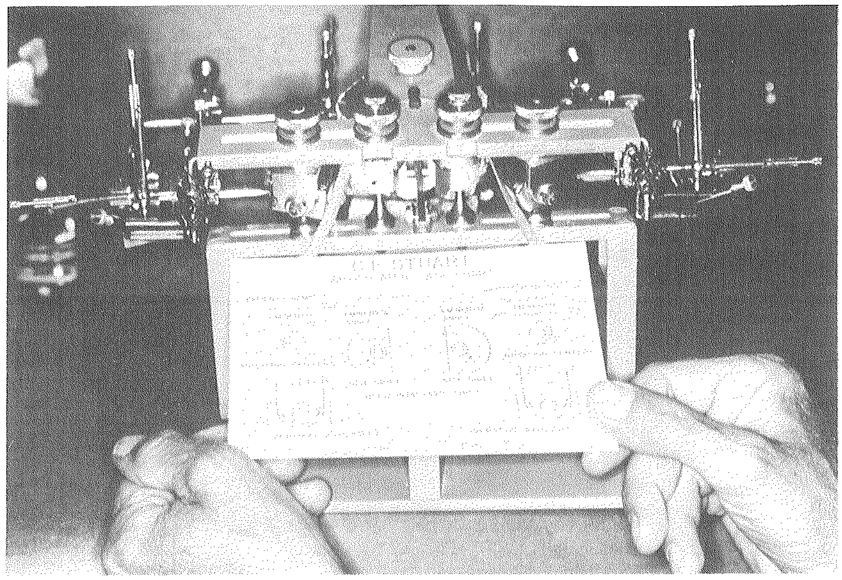


Fig. 13-58, cont'd. For legend see pp. 471 and 472. Note ground side shifts and ground and added eminentiae.



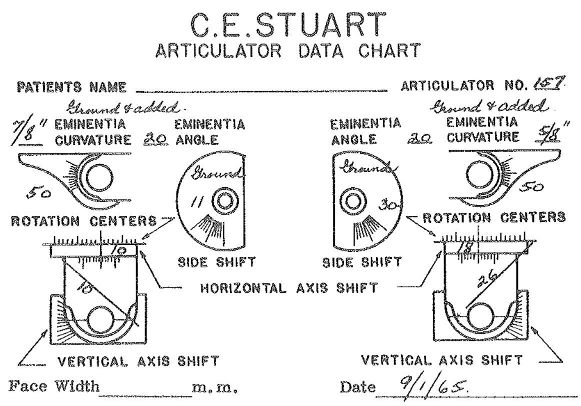


Fig. 13-59. When articulator has been completely adjusted, settings are recorded on a special chart.

from the headrest, the points of the styli are adjusted to touch the tattoo marks opposite the condyles. Anteriorly, the infraorbital indicator is positioned to coincide with the tattoo mark on the nose. The face-bow is removed carefully. (See Fig. 13-60.)

The face-bow is attached to the base of the mounting stand and the Stuart articulator with the anterior guide pin replaced with the orbital level is placed on the stand. The two adjustable pins on the upper bow of the articulator, which are lined up with the axis of the articulator, are set on an equal number of calibrations on each side of the upper bow so that the entire articulator is centered between the stylus pins of the face-bow. The tips of the pins are aligned with the tips of the styli of the face-bow, thereby making the axis continuous (Fig. 13-61). The lower member of the articulator has elevating thumbscrews, which permit adjustment of the articulator to the face-bow. A locking device holds the articulator in this position on the mounting stand until the mounting to the upper bow is completed.

The maxillary cast is seated firmly in the modeling compound on the face-bow fork. It is best to position slide blocks under the bite fork to support weight of the model, mounting stone, and upper articulator frame. The maxillary cast is attached to the upper member of the articu-

A

B

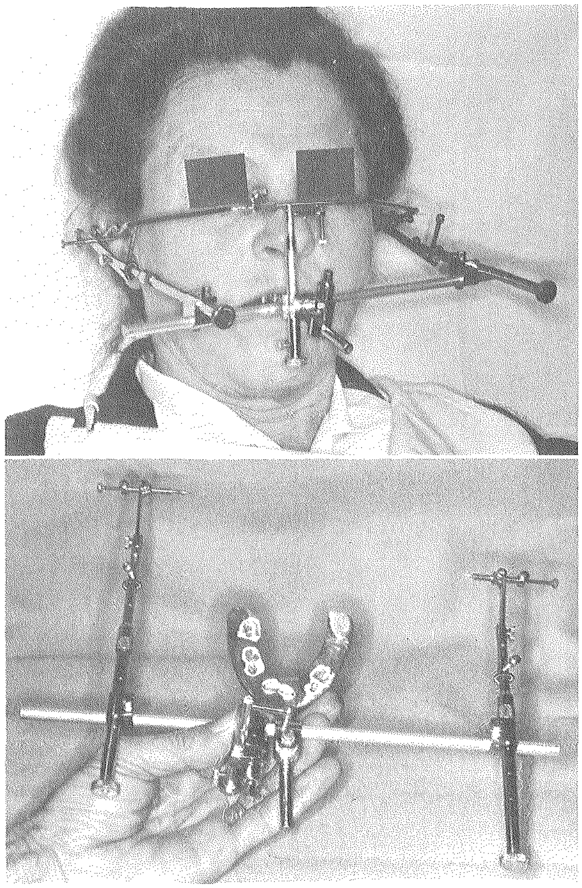


Fig. 13-60. A, Hinge-bow transfer for mounting study casts on correct axis. B, Face-bow assembly removed. Cusp indentations in bite-fork block rebased with zinc oxide–eugenol paste (Kydac).

lator with fast-setting stone. This relates the upper model to the axis-orbital plane of the articulator. (See Fig. 13-62.)

The lower cast is attached to the lower member of the articulator by means of a centric interocclusal record and by inversion of the instrument (Fig. 13-63).

Now accurately oriented to the correct axis, the study casts can be used to study the positions and conditions of the teeth and their relations with the mandibular movements. We also can correlate our findings from a study of these articulated study casts with the roentgenograms.

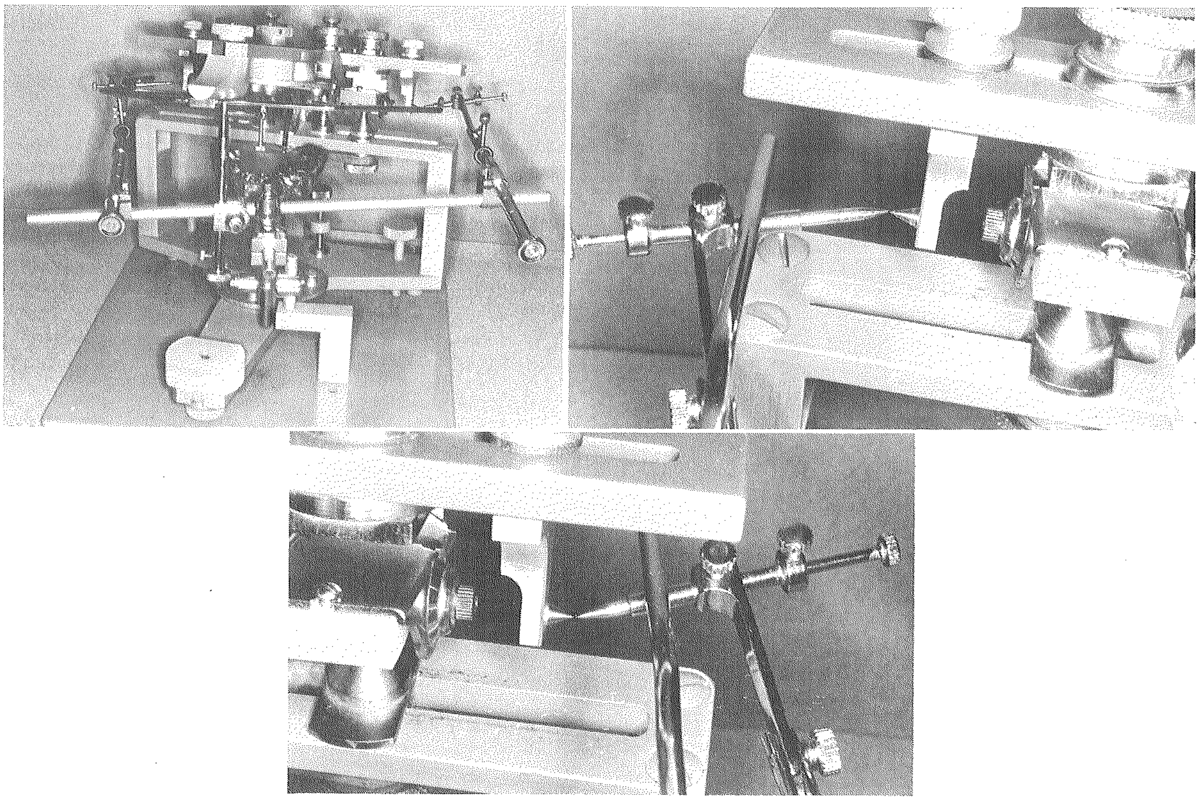


Fig. 13-61. Tips of articulator axis pins are aligned with tips of styli of face-bow, thereby making axis continuous.

A

B

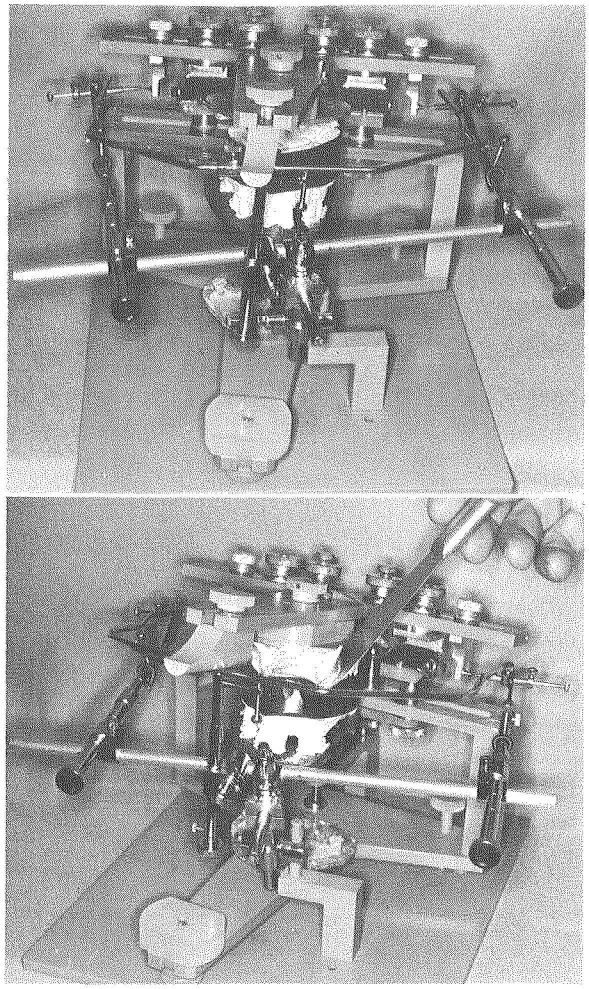


Fig. 13-62. **A,** Maxillary cast seated firmly into rebased cusp tip indentations in modeling compound on face-bow fork. **B,** Maxillary cast is attached to upper member of articulator. Do not have too much stone between upper mounting plate and cast because, with too much stone, axis pins can move.

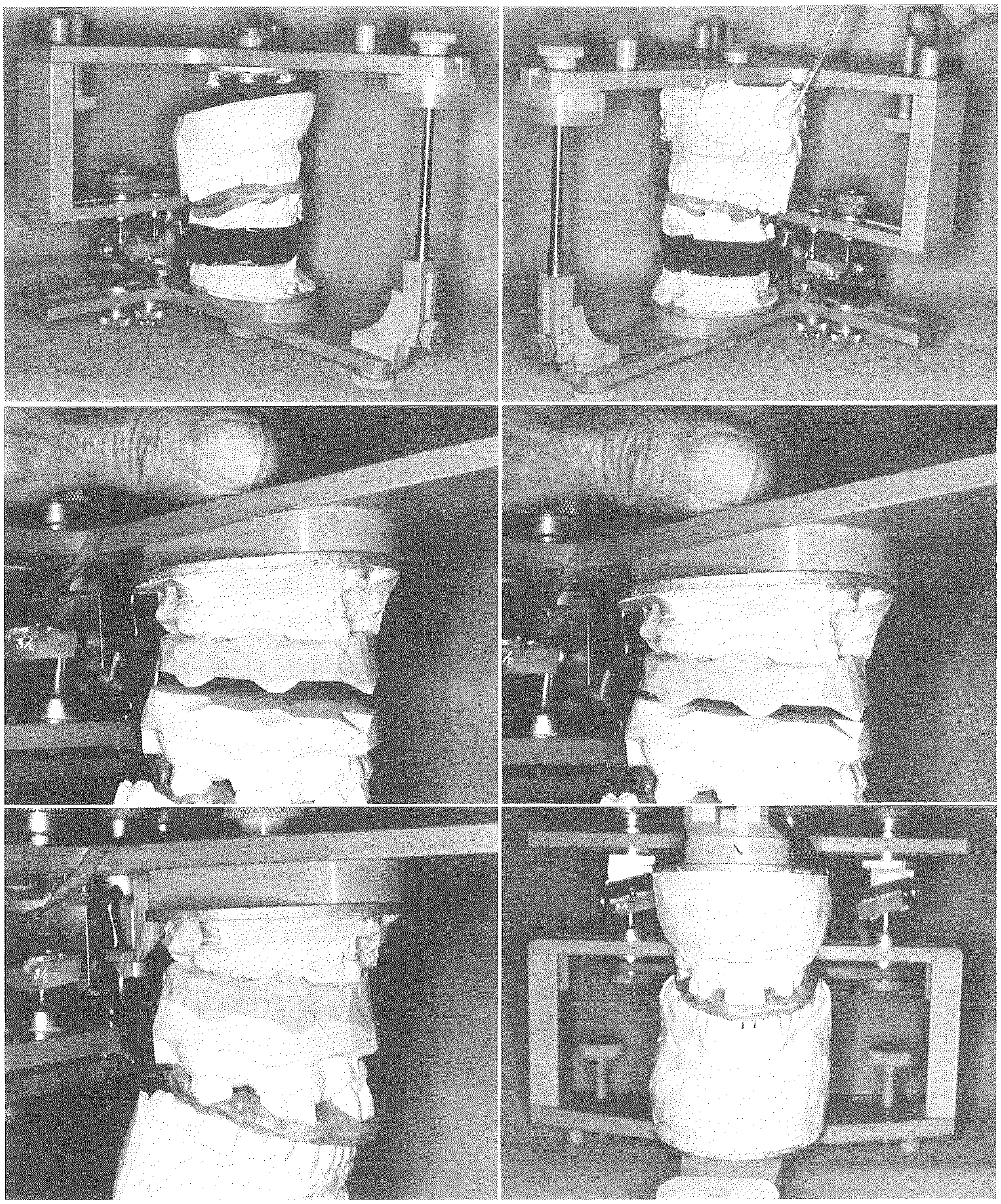


Fig. 13-63. Lower cast attached to lower member of articulator (invert instrument) by means of a centric relation record. Verify accuracy of centric relation records by utilizing split-cast method as advocated by Lauritzen.

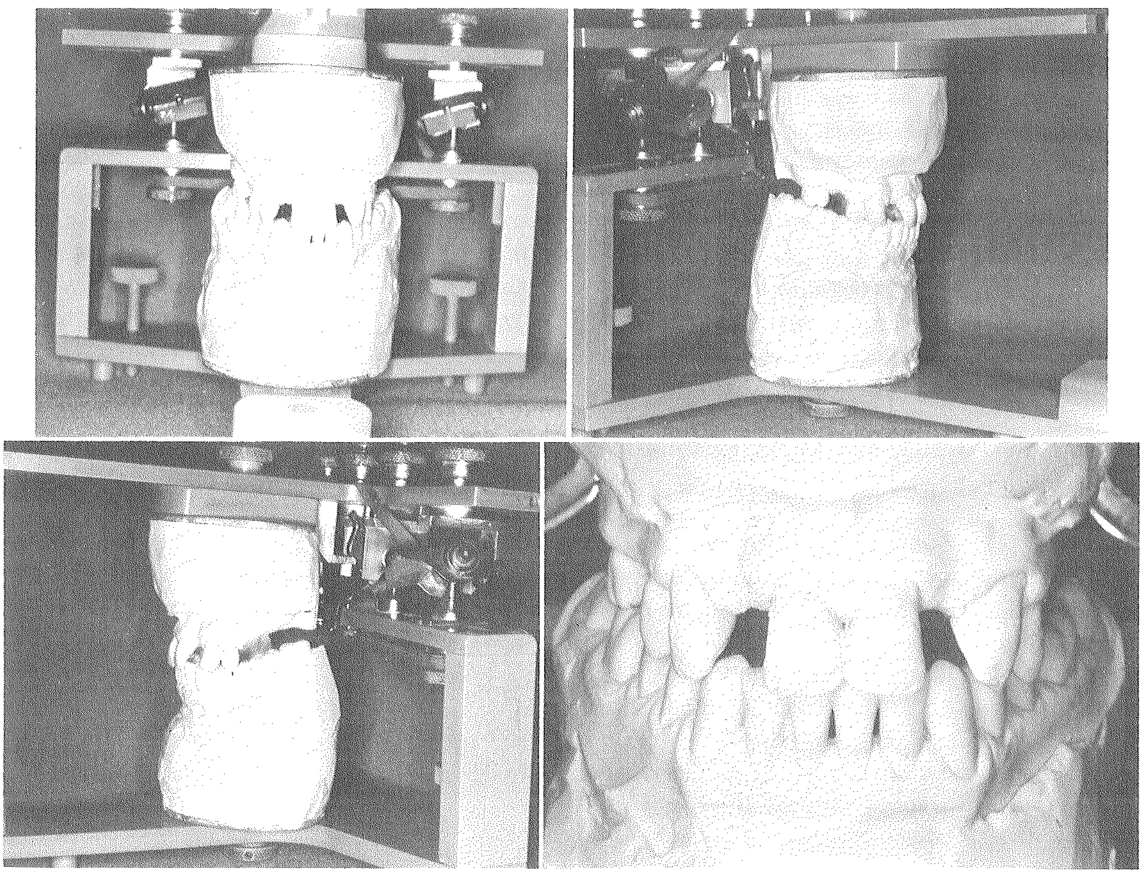


Fig. 13-63, cont'd. Note relation of upper and lower teeth—anterior relation, relation of teeth on right side, and relation of teeth on left side. These casts have been accurately oriented to correct axis.

Diagnosis

Clinical findings correlated to roentgenograms and cast orientation

A study of the collected data was undertaken to arrive at a diagnosis and to determine the plan of treatment.

As previously stated, the medical history showed a patient in good general health with no unusual medical history, no nutritional or diet problems, and no obvious psychogenic factors to account for the afunctional contacts of the teeth.

The patient complained of a radiating facial pain extending to her head and neck on the right side and a proprioceptive sense of discomfort. Observation revealed no clicking of the joints, no limitation of motion, no trismus or tinnitus, no subluxation, and probably a slight deviation of the mandible on opening and closing. There was no tenderness of the joints on palpation, and no history of muscle spasms was elicited.

The tongue, palate, lips, cheeks, floor of the mouth, and throat were normal in appearance. Special medical laboratory tests seemed unwarranted, especially since a physician's report gave her a clean bill of health.

The gingival tissues were injected in a number of areas; there was some pocket depth, and some teeth had a limited degree of mobility, whereas a few exhibited a great deal of mobility.

Pulp testing, electric and ice, was within the range of "norm."

Roentgenographic manifestations revealed a widening of the periodontal ligament space, some loss of lamina dura definition, and marginal bone resorption, which indicated the presence of occlusal trauma.

The clinical findings in conjunction with a close study of the articulated casts enabled us to correlate our findings with the roentgenograms. The amount of functional disturbance seemed to correspond with the roentgenographic data. Centric closure on the instrument demonstrated the distinct prematurities seen clinically. Not only was the absence of correct centric closure detected, but also tooth contact seemed to be "heavy" on the anterior teeth while almost totally lacking on a number of the posterior teeth.

The constant removal of the upper removable partial denture (which was ill-fitting and unwanted) created a trauma, especially evident in the roentgenogram of the left upper first bicuspid.

Eccentric relations were studied carefully, and proper relations were found wanting. A unilateral crossbite (on the left side) was present.

Wear facets were observed, and tooth contours as related to the investing structures showed much to be desired.

Tooth-to-tooth positions and interarch and intra-arch relations were observed, as were overbite and overjet relations. Anterior guidance and vertical dimension were evaluated.

A study was made of the plane of occlusion and the curves of Spee and Wilson, and the amount of possible alteration of these variable factors was taken into consideration, remembering the influence these changes will have on the planned restorations.

The semaphore, or survey plate, supplied with the Stuart articulator was used at this point (Fig. 13-64) and is a helpful adjunct. The relation of the plane of occlusion to the condyle path will be apparent. The survey plate provides a guide in obtaining in the finished case a smooth-flowing anteroposterior and lateral curve in the occlusal surfaces of the teeth. It indicates which teeth may be shortened or lengthened and the amount of such changes.

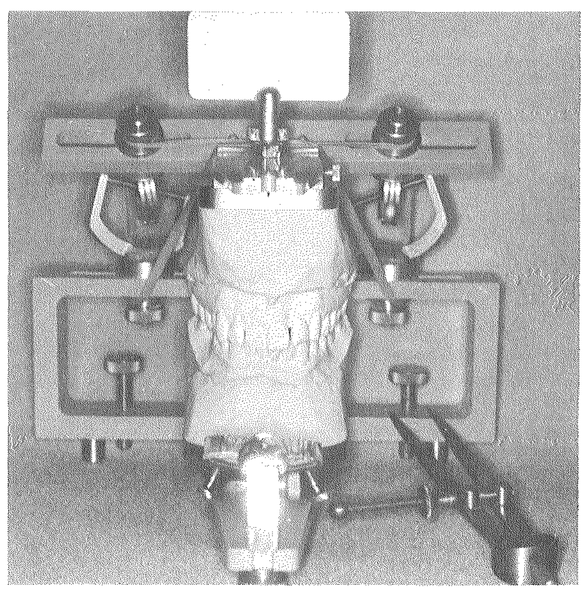


Fig. 13-64. Semaphore, or survey plate, is a helpful adjunct. (These are study casts of a case discussed in Chapter 14.)

The questions of orthodontic assistance and elective endodontics were given consideration.

Cuspid relations were analyzed, as was the extent to which the occlusal misfittings could be overcome by proper placement of the cuspal elements.

A preliminary wax-up to determine the type of preparations that would be required in this case and the amount of tooth structure to be removed, as well as the end result, whether it would be acceptable functionally and esthetically, was deemed necessary.

The cuspid relationship and incisal guidance had to be worked out in the preoperative wax-up. The paths of movement of the mandible are governed by the condylar guidance and the anterior or incisal guidance. We know that in any individual the condylar guidance is fixed and immutable. The anterior guidance may be altered within certain limits. It can be done only when we can change the degree of vertical or horizontal overlap of the anterior teeth. However, once the vertical and horizontal overlap of the anterior teeth, the plane of occlusion, and the curves of Spee and Wilson, in conjunction with the fixed factors, have been established for a given patient, there is one tooth form, and only one, that will function best for that individual.

Setting anterior guide

In some cases setting of the mechanical anterior guide of the articulator can be done with adjustable guides, but with the Stuart articulator (to date) the anterior guide is made of plastic and has a $\frac{3}{32}$-inch deep depression in its center (Fig. 13-65). The depression is rounded outwardly from the center, providing lateral and protrusive lift to the upper articulator frame by means of the anterior guide pin. The lift of the anterior guide may be decreased by reducing the plastic or increased by either deepening the pin rest depression or by adding plastic to the guide.

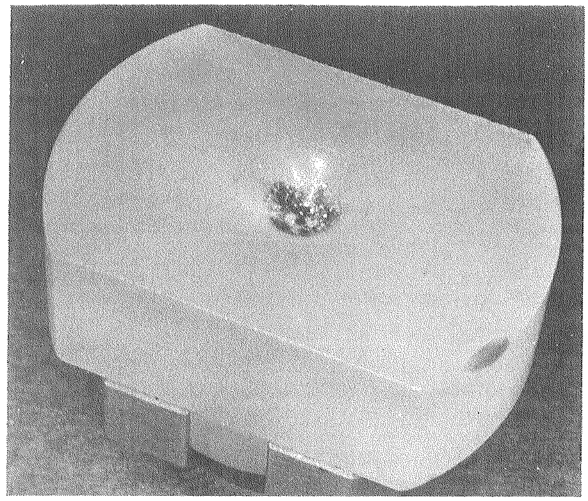


Fig. 13-65. Anterior guide is made of plastic and has a 3/32-inch deep depression in its center. Depression is rounded outwardly from the center, providing lateral and protrusive lift to upper articulator frame by means of anterior guide pin. Anterior guide can be individualized by addition or subtraction of plastic.

Lucia[10] uses the following procedure in cases requiring adjustment of the table. "After setting the incisal pin to contact the incisal table in centric position, move the upper bow of the articulator to the protrusive position. This is determined by the edge-to-edge relationship of the anterior teeth. When the articulator is in this position, fill the space between the tip of the incisal pin and the incisal table with quick-curing acrylic resin. A rounded slope is created from this cusp height to the bottom of the centric location of the incisal table. Carry out the same procedure in the lateral excursions, using the cuspid for guidance. The cuspid contact may be waxed up to assist in setting the anterior guide. When the table has been properly made and adjusted, it should be possible to move the upper bow of the articulator in every excursion, with the anterior teeth just contacting. When the articulator is in centric position, the 'centric hole' should allow the correct vertical dimension."*

Cuspid guidance

The main function of the cuspids (with their long roots and proportional amounts of root surface embedded in alveolar bone) during mastication is to guide the mandible into centric relation in a medial-vertical direction so that contact of the remaining opposing teeth is prevented until they meet in centric occlusion.[16]

Cuspid guidance is the creation of freedom in the lateral and lateral protrusive movements of the posterior teeth which are compatible with the Bennett side-shift movement. This necessi-

*From Lucia, Victor O.: Modern gnathological concepts, St. Louis, 1961, The C. V. Mosby Co., p. 280.

tates the incorporation of the Bennett side-shift into the cuspids.

Coomer[17] has this to say:

"Properly placed or properly restored cuspids also act as defenders of the cusps of posterior teeth. By their guiding influence they prevent excessive cusp contact and guard against extra cyclic movements of the mandible. Habitual grinding of the posterior teeth is prevented if the cuspids are placed or restored in such a way that wide lateral occlusal contact is impossible.

"The restoration of the lingual surface of an upper cuspid may also introduce contacts that can destroy even this very strong tooth. For example, if the anterior half of the lingual surface is not sufficiently concave from the tip of the cusp to the cingulum, this surface will interfere with the normal chewing cycle of the mandible, thus introducing a destructive lateral force."*

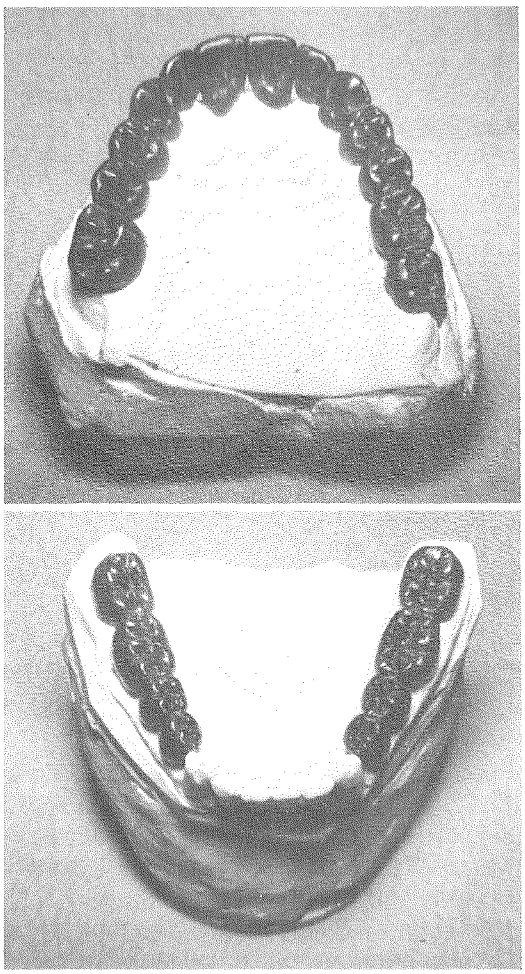


Fig. 13-66. Teeth on mounted study casts were prepared conservatively, and case was waxed for preoperative study and observation.

The teeth on the articulated casts were prepared as conservatively as possible, and the case was waxed, employing the method advocated by P. K. Thomas (Fig. 13-66).

The preliminary wax-up provides the opportunity to develop the occlusal forms within the recorded limits of the patient's mandibular movement pattern. It also allows for incisal guidance modifications, and proper form and contour of the facial and lingual surfaces can be worked out. Impressions can be taken of the wax-up for the construction of acrylic "shells" (Chapter 7) to be used for "immediate" temporary restorations after tooth preparation by rebasing with cold-curing acrylic resin. It not only tells what areas of the tooth need more or less cutting for proper development of the cuspal elements but also allows for the handling of any aberrations. Esthetic possibilities and whether or not tooth position and axial inclination indicate that the esthetic pattern can be controlled within reasonable limits can be evaluated carefully.

In summing up the situation thus far it was believed that the problem was one of occlusal traumatism with afunctional tooth contacts the amount and frequency of which was not known, dental restorations that had been poorly conceived and executed, a disturbed periodontium, a poor esthetic pattern, abhorrence of a removable appliance of any kind on the part of the patient, and establishment of the proper rapport for this type of an operation.

Treatment plan

Periodontic treatment, including subgingival curettage and some surgery, was deemed necessary. Along with these procedures, some fixed splinting was needed to offset the potentials of excessive individual tooth leverage. This would necessitate temporary and permanent splintage. It was believed that the patient had the ability to resist and repair damage.

Any increase in the vertical dimension was unnecessary, but, if during the therapy a change of plan was indicated, it was to be kept to a minimal amount. The possibility of keeping the

*From Coomer, O. B.: Occlusion in operative dentistry, J.A.D.A. 58:34-40, 1959.

crown-to-root ratio within the range of norm seemed feasible. In fact, alteration in incisal guidance and reduction of anterior crown length, keeping in mind conformation to patient's esthetic and phonetic needs, was part of the plan to help the weaker teeth.

A correct centric relation–centric occlusion relationship as well as the development of precise, harmonious, excursive paths was necessary. This was doubly important since the frequency and amount of the afunctional contacts were not known and the neuromuscular protective mechanism exerts no appreciable influence during bruxism, which was thought to be a component of the case under consideration.

The correct positioning of the occlusal tables to increase the possibility of transmitting occlusal forces axially within the alveolar housing was to be done as well as possible, since orthodontic movement was ruled out.

Elective endodontics for parallelism, crown-to-root ratio, etc. was not necessary. The same held true for extractions.

It was decided to maintain the lower anterior teeth unrestored even in the presence of a moderate amount of mobility. This was considered to be feasible because the lower anterior teeth were, within reasonable limits, positioned correctly and inclined axially over their root attachments. However, these teeth were to be shortened slightly to reduce the crown-to-root ratio. The proximal contact areas were tight enough, and, since "mutual-protective occlusion" was the method of choice, the cuspids and posterior teeth will give support and stability to the maximum occlusal position, thereby permitting the amount and direction of the load on the lower incisors to be limited.

An upper precision-type removable partial denture was to be used, with careful consideration being given to the placement of attachments. In this case a split-lingual attachment was to be used in the upper right pontic region and a precision attachment in a cantilevered pontic (supplying the upper left second bicuspid). The edentulous area was outlined carefully.

The selection of each retainer was based on the need of the case, keeping in mind the position and condition of each tooth as well as the function and esthetics. Because of the particular position of previous restorations, erosion areas, recessions, etc., full coverage was necessary for most of the retainers. Some modified pin–M.O.D. onlays were indicated also.

Two temporarily cemented restorations (lower right second molar and lower left first molar), which were constructed only one week before the patient reconsidered her decision for complete mouth rehabilitation, were to be used because this was the patient's desire, and it was believed that it would not effect the end result adversely. However, during the wax-up stage I decided to remake these restorations (full crown and pin-onlay). This necessitated new lower impressions, hinge-bow transfer, and centric relation records for orientation of "working casts" on adjusted articulator.

A night guard was to be constructed at completion of the case to minimize any possible afunctional contacts during sleeping hours.

The patient was informed of all the inherent advantages and disadvantages of this type of work, and the promising of the impossible was absolutely "out."

Efficient scheduling of appointments to minimize the patient's and operator's time and energies was completed. The fee and method of payment were discussed thoroughly and agreed upon. A letter stating what was to be done, what the patient can expect within the realm of reality, and the patient's responsibilities as to fee and home care, etc. was mailed to the patient.

The prognosis in this case appeared to be favorable. It is always possible that some tooth or teeth may not respond to treatment. A plan of treatment, should such an emergency arise, is held in abeyance.

It should be remembered that a compromise of ideal objectives is necessary at times.

RESTORATIVE PROCEDURES

Preparations

Subgingival curettage was carried out carefully and thoroughly, after which indicated periodontal surgery was performed. After healing and keratinization of surgerized tissues, preparations were started.

Preoperative photographs were taken before preparations were started (Fig. 13-67).

All preparations were completed in three sessions. The preparations of the upper teeth and temporary coverage were completed in one session. In the lower arch the preparations and

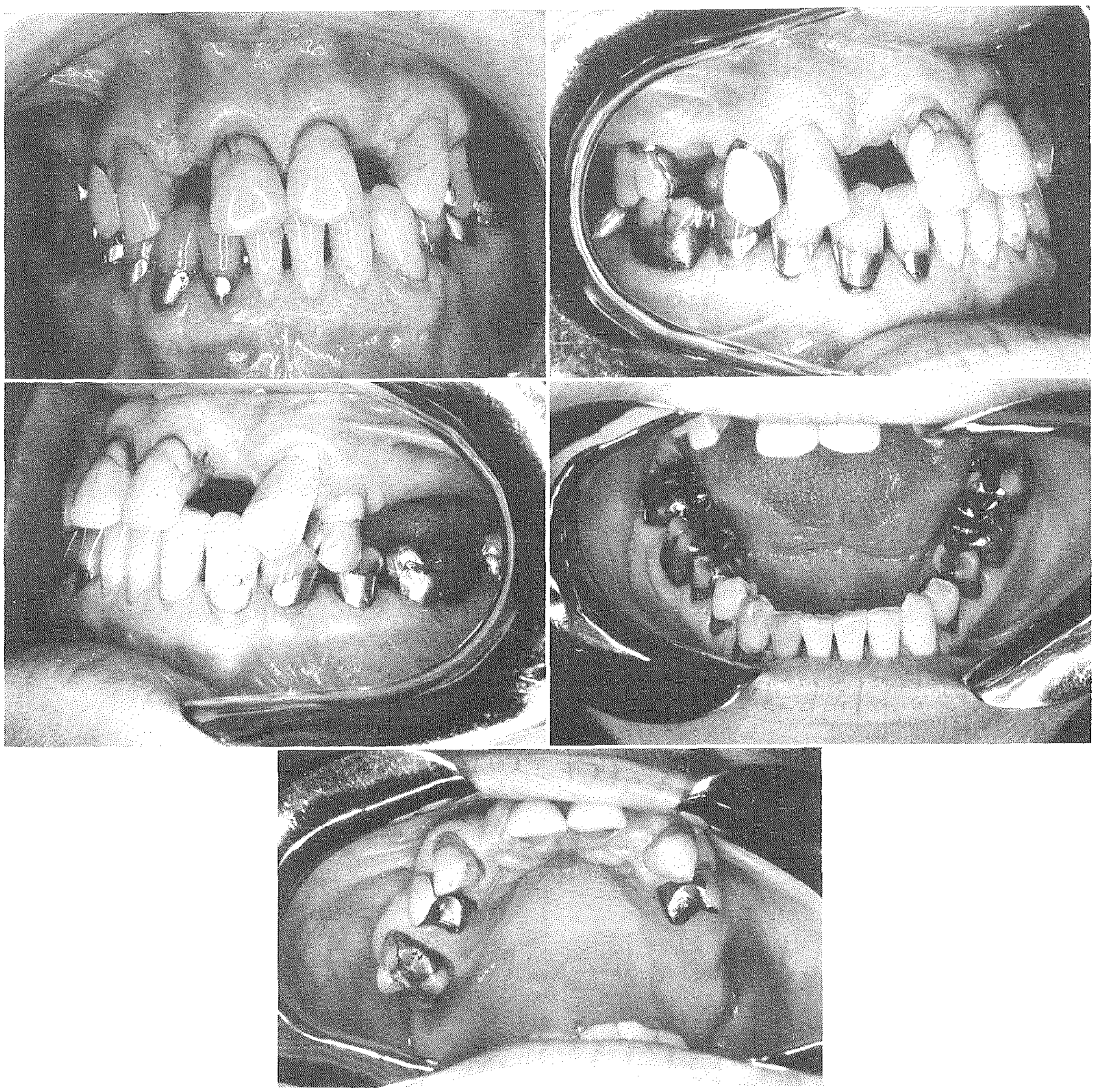


Fig. 13-67. Preoperative photographs taken before preparations were started.

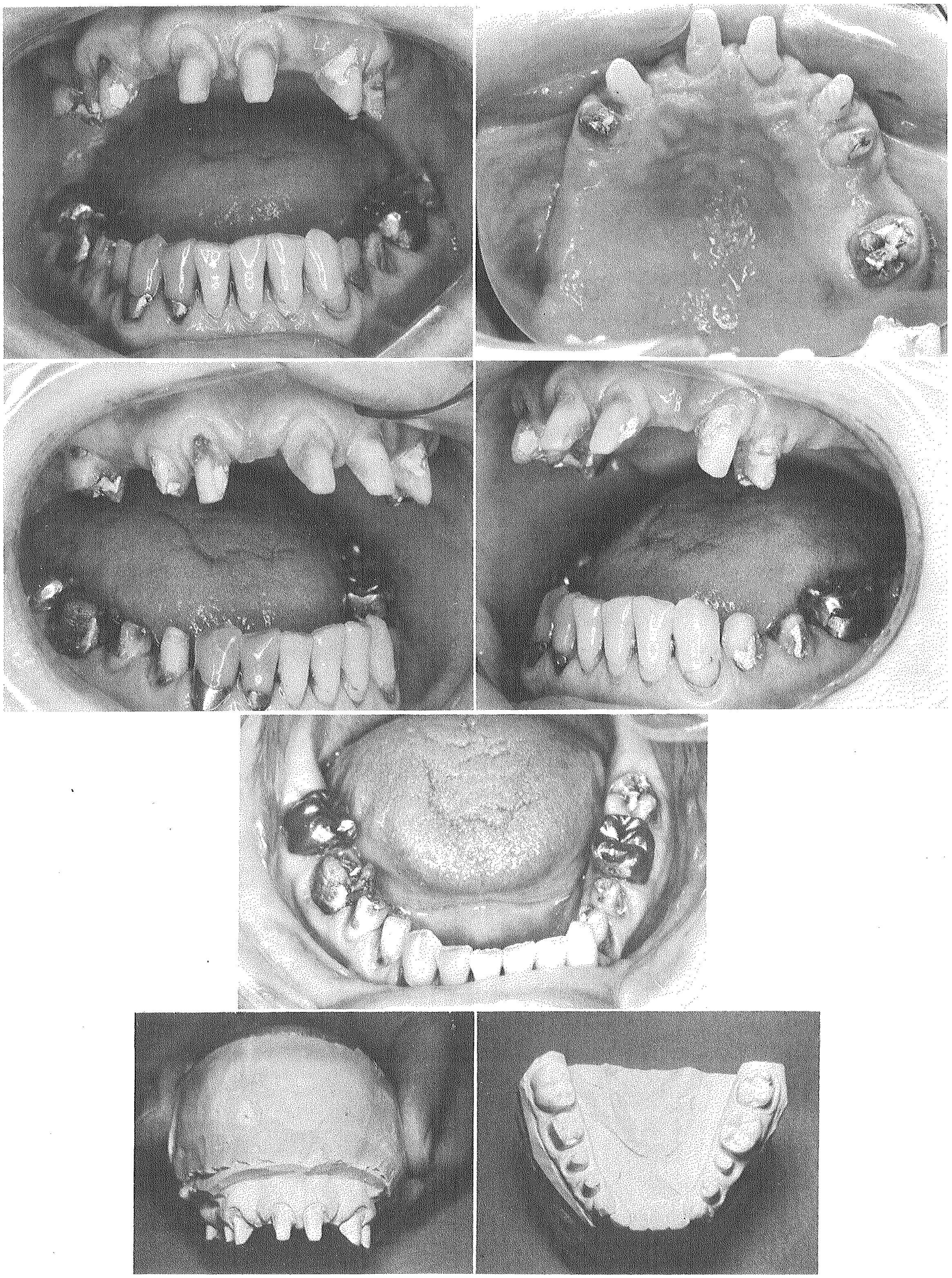


Fig. 13-68. Illustrations of preparations of case under consideration are shown.

temporary coverage were completed one quadrant at a time.

This section will not give a detailed description of the type of preparations (full coverage and modified pin onlays) used for this patient because a detailed description of every phase of the preparations is covered in Chapter 6.

Illustrations of preparations of this case are shown in Fig. 13-68.

Impressions, dies, and temporary coverage

A detailed description of impression taking, die and cast construction, and temporary coverage used for the patient will not be given in this discussion because the displacement of the gingival tissue, preparation of the impression material, loading of trays, injection of the material into and onto the preparations, positioning of trays, chilling, and proper removal of the impres-

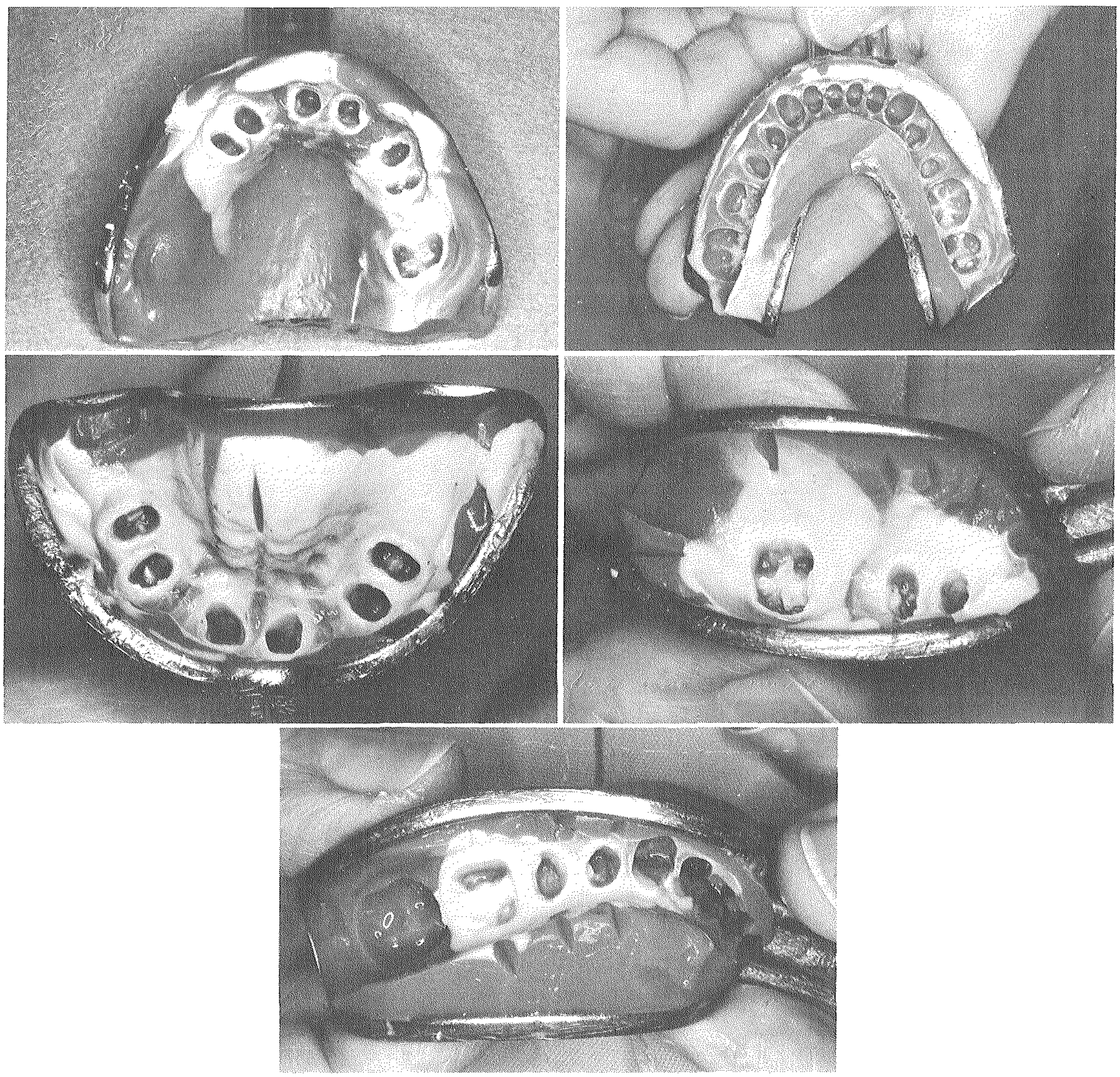


Fig. 13-69. Illustrations of impressions (full and sectional), development of individual dies, and temporary coverage.

sion, as well as the treatment of the impressions, making of the working casts, finish dies, etc. are covered thoroughly in Chapter 7. Many illustrations of these steps, taken from the case under consideration, are shown in Fig. 13-69.

Use of the hydrocolloid technique gives us the mirror image of multiple preparations of teeth prepared for partial and full coverage, and it eliminates the need of transfers.

After all impressions have been taken and poured, a hinge-bow transfer and centric relation bites are taken for the proper orientation of the working casts on the adjusted articulator for the carving of an articulation (Fig. 13-70).

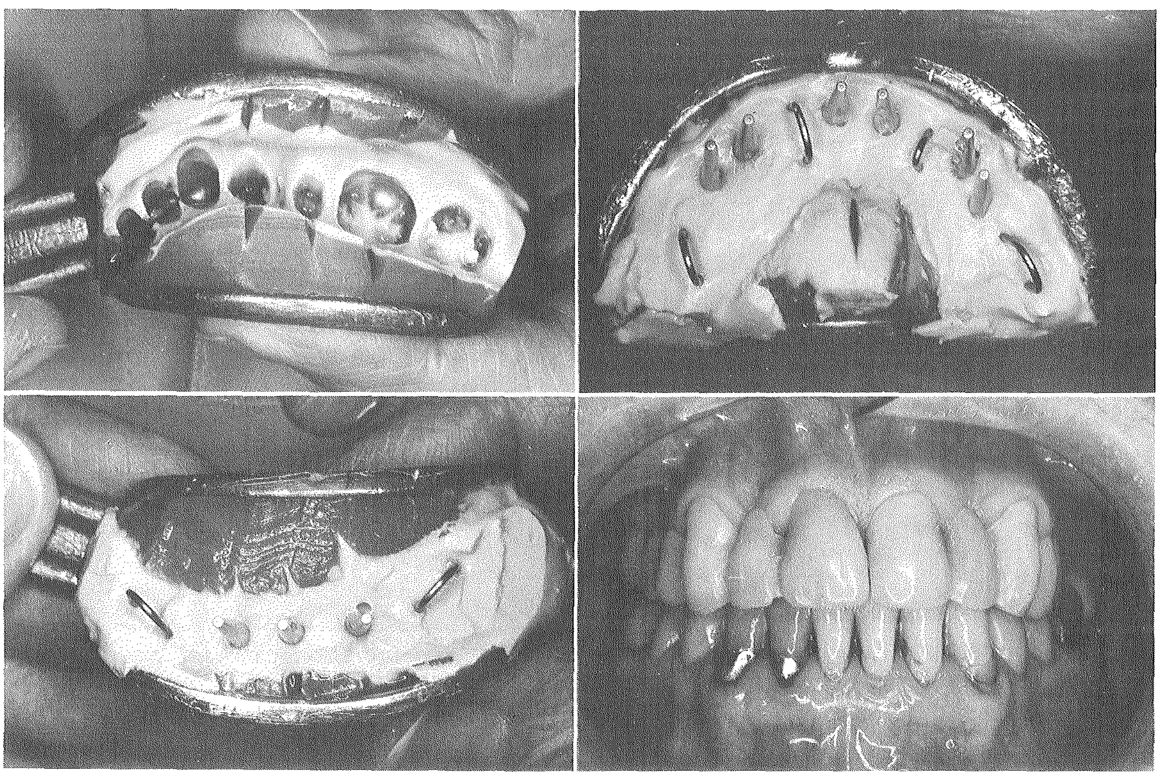


Fig. 13-69, cont'd. For legend see opposite page.

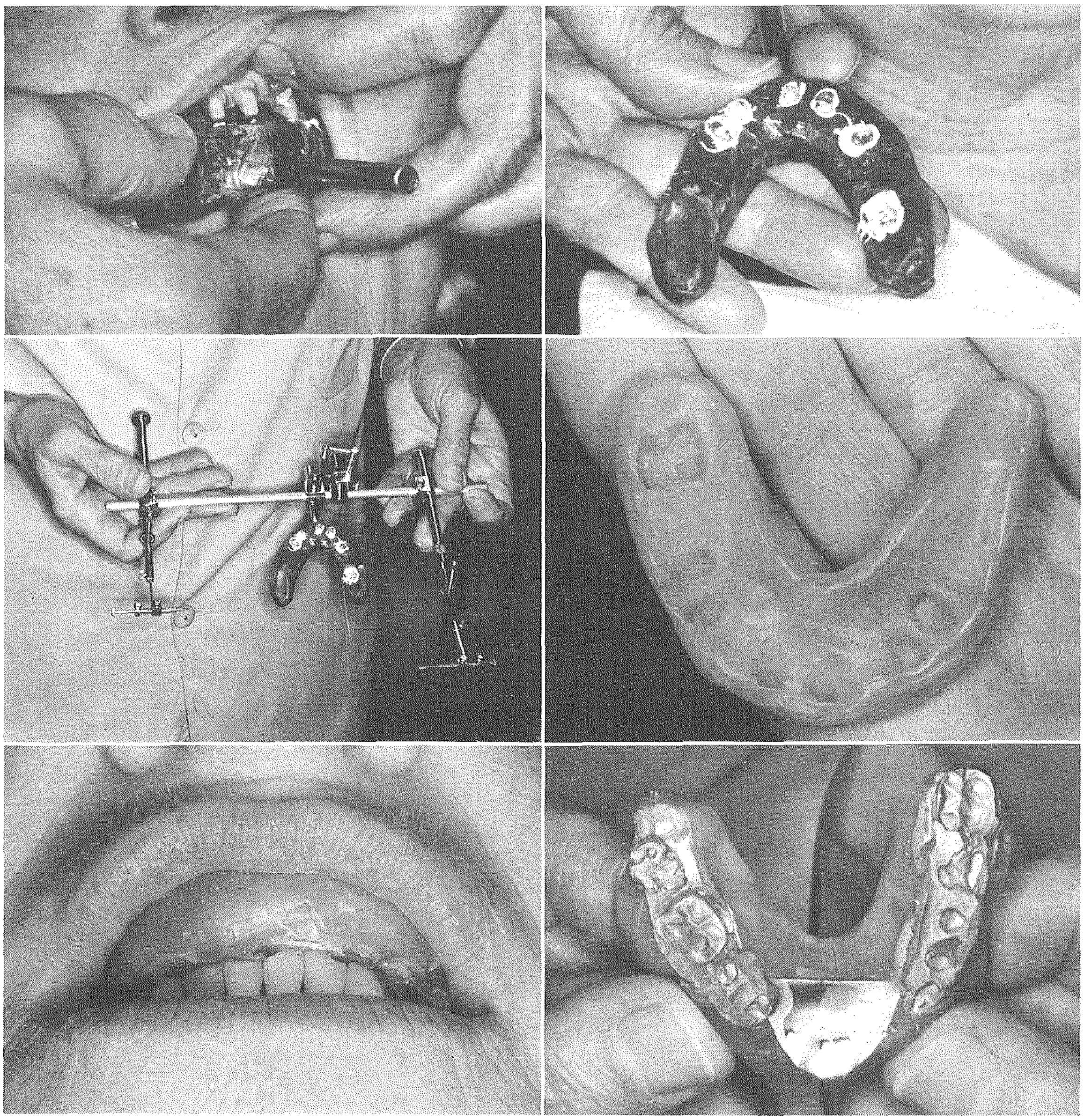


Fig. 13-70. Hinge-bow transfer and centric relation records are taken for proper orientation of working casts on adjusted articulator in preparation for carving of articulation.

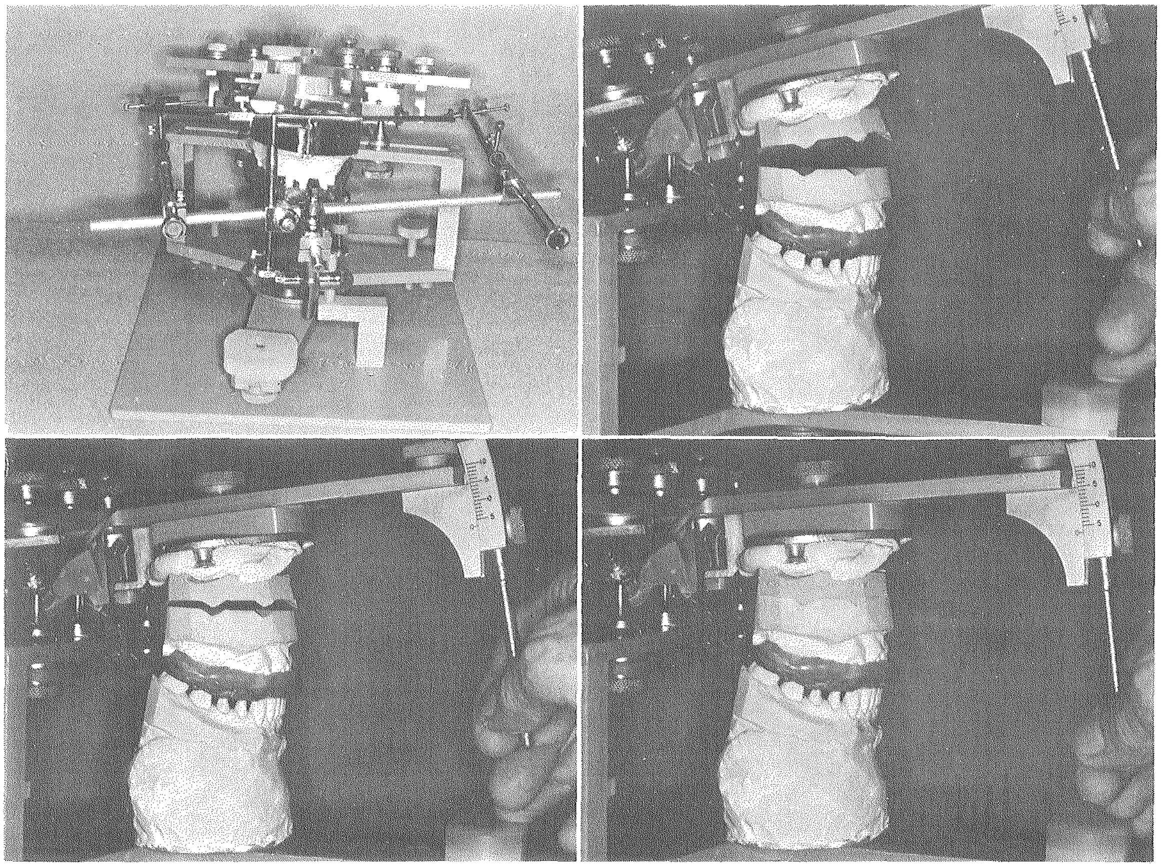


Fig. 13-70, cont'd. I decided to use a well-developed wax form, "air-chamber" metal to provide anterior resistance and act as a fulcrum, Aluwax as recording medium at this stage of reconstruction, and Lucia method for remount procedure. Accuracy of centric relation records verified by Lauritzen split-cast method.

Wax-up*

Form and function of the teeth

Correct anatomic tooth form and position occupy a very important place in restorative procedures. The restoration of the correct form of a tooth will help regain its function. It can be said therefore that any restoration that does not provide the tooth with the anatomic factors necessary for function constitutes a deformity and a menace. (See Fig. 13-71.)

In the waxing of a full-mouth rehabilitation occlusal and incisal surfaces of the teeth must be properly related to each other so that they will function in harmony as the jaw makes its various movements. The relationship of the teeth must be satisfactory not only in the centric position, but also in protrusion, lateral protrusion, lateral, or any of the intermediate positions. The condyle-eminentia relations, rotation centers, and

*The waxing technique outlined in this section and a thorough understanding of the determinants of occlusion and their importance in organizing an organic occlusion were taught me by Drs. C. E. Stuart, P. K. Thomas, and Harvey Stallard.

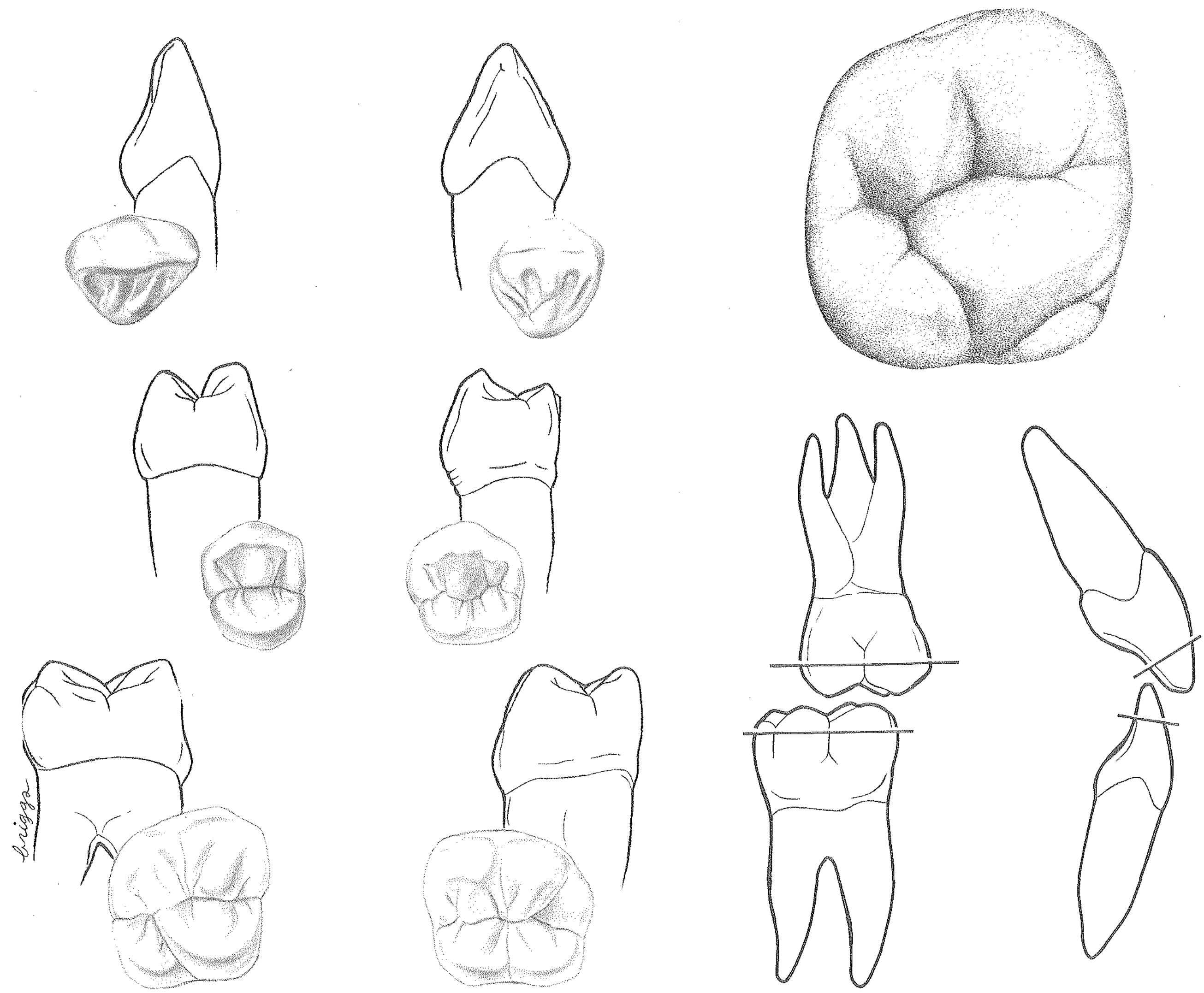


Fig. 13-71. Restoration of correct form of a tooth helps regain its function. A knowledge of dental anatomy and physiology is a "must." Note relatively small portions of tooth used exclusively for reduction of food.

side-shift angulation and its timing must be copied precisely in the articulator.

The dimension of space between the preparations of the teeth varies as the mandible moves in these various excursions. In the protrusive movement this dimension will be different than that found in either the right or left lateral excursion. In other words, the space factor is continually changing in dimension as the mandible moves in function, making it necessary to carve the articulation to function in harmony under whatever conditions the patient's mandibular movements dictate. All this again emphasizes the importance of consideration of condylar guidance and incisal guidance, which in turn means that the patient's mandibular movements should be recorded and transferred to an adjustable articulator.

"The instrumentation we use collects and installs determinants of ridge and groove direction, cusp height and fossa depth, and the concavity of the lingual surface of the upper anterior teeth"*

A measuring instrument has to be used because these determinants must be obtained from the facial position of the teeth in relation to the rotating center, side shift of the mandible, rotating condyle movement (laterotrusion), angle of the eminentia, intercondylar distance, plane of occlusion, curve of Spee, overlap of the upper anterior teeth, etc. For example, in determining lingual concavity of upper anterior teeth, laterotrusion (coronal plane) upward, designated laterosurtrusion, means that more lingual concavity is necessary on upper anterior teeth, whereas laterotrusion downward (laterodetrusion) calls for less lingual concavity on the upper anterior teeth. In laterotrusion (axis-orbital horizontal plane) forward, designated lateroprotrusion, means more lingual concavity is necessary on the upper anterior teeth, whereas laterotrusion backward (lateroretrusion) calls for less lingual concavity on the upper anterior teeth.[19]

The cuspal elements are (1) cusp tips, (2) marginal ridges, (3) triangular ridges (transverse and oblique), (4) developmental grooves, (5) supplemental grooves, and (6) fossae. From these elements proper form, position, size, and runways are given to each cusp.

Stuart, Stallard, and Thomas[20] refer to cusps that work in fossae or grooves as *stamp cusps.* All lower buccal cusps are stamp cusps in a "tooth-to-tooth" occlusion, and only the distal and buccal cusps of the lower molars are stamp cusps in "tooth-to-two-tooth" occlusion. The upper lingual cusps are stamp cusps.

The upper buccal and lower lingual cusps are called *shearing* cusps.

Each stamp cusp should have close groove relations when working but should make no contact on its way to its fossa. The lower buccal stamp cusps work in transverse buccal grooves of the upper teeth; they idle in the upper oblique lingual grooves (Fig. 13-72). The upper lingual

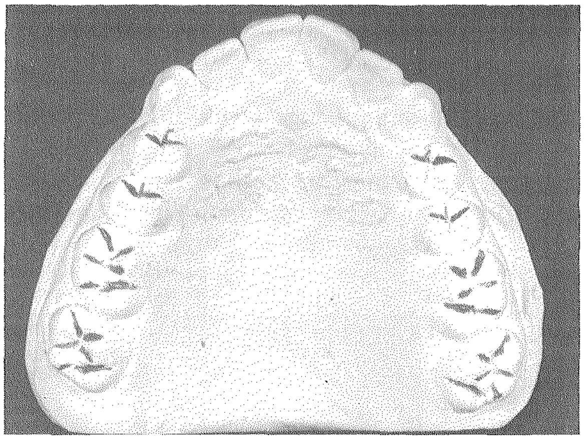


Fig. 13-72. Lower buccal stamp cusps work in transverse buccal grooves of upper teeth and idle in upper oblique lingual grooves.

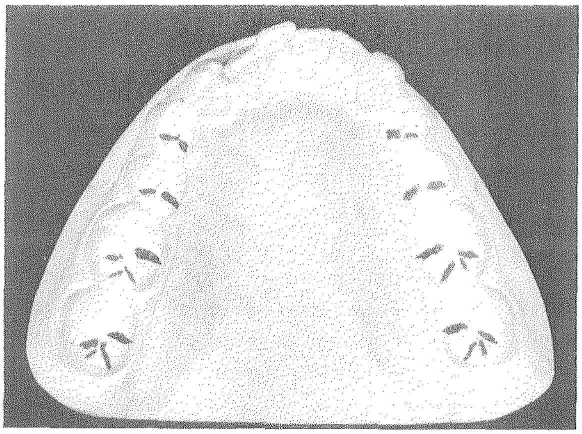


Fig. 13-73. Upper lingual stamp cusps work in transverse lingual grooves of lower teeth and idle in lower buccal oblique grooves.

*From Stallard, Harvey: Personal communication.

stamp cusps work in transverse lingual grooves of the lower teeth; they idle in lower buccal oblique grooves (Fig. 13-73).

The central grooves of the occlusal surfaces provide runways for the cusps in the protrusive mandibular movements.

Stamp cusps should glide by (scissor) near the blades of the shearing cusps and should momentarily approximate their edges without making contact with them.

When the teeth are in centric position, the occlusal contacts are numerous and pinpoint in size. Also a buccolingual and mesiodistal interlocking, which provides stability in these directions is present. The parabolic architecture of the surfaces permit point contacts and thus serve to reduce occlusal stress (Fig. 13-74).

The type of carvings to be described and the castings made from them minimize occlusal stresses and lessen the strains because less power is required to dice and mince the food, create a passive harmony of the excursive pathways, and allow for a negative occlusal perception.

Procedural steps of the wax-up

The instruments that I use in this technique are (1) a No. 23 sickle explorer or a specially prepared pair of cotton pliers as a wax spatula for carrying small droplets of wax to the desired areas and (2) P. K. Thomas carving instruments* (Fig. 13-75). The Wilkinson wax pen and spatula is a fine adjunct.†

Casts are treated with Slikdie‡ lubricant, and wax is applied in a thin layer over the prepared upper teeth and joined interproximally so that the patterns will not become displaced in the ensuing procedures. At this point no wax is present in the prepared lower teeth. It may be necessary to add wax to the lingual surface of the upper cuspid while carving bicuspids and molars for cuspid guidance.

1. Place buccal cusp cones of the upper

*E. A. Beck & Co., Anaheim, Calif.
†The Wilkinson Co., Santa Monica, Calif.
‡Slaycris Laboratory, Portland, Ore.

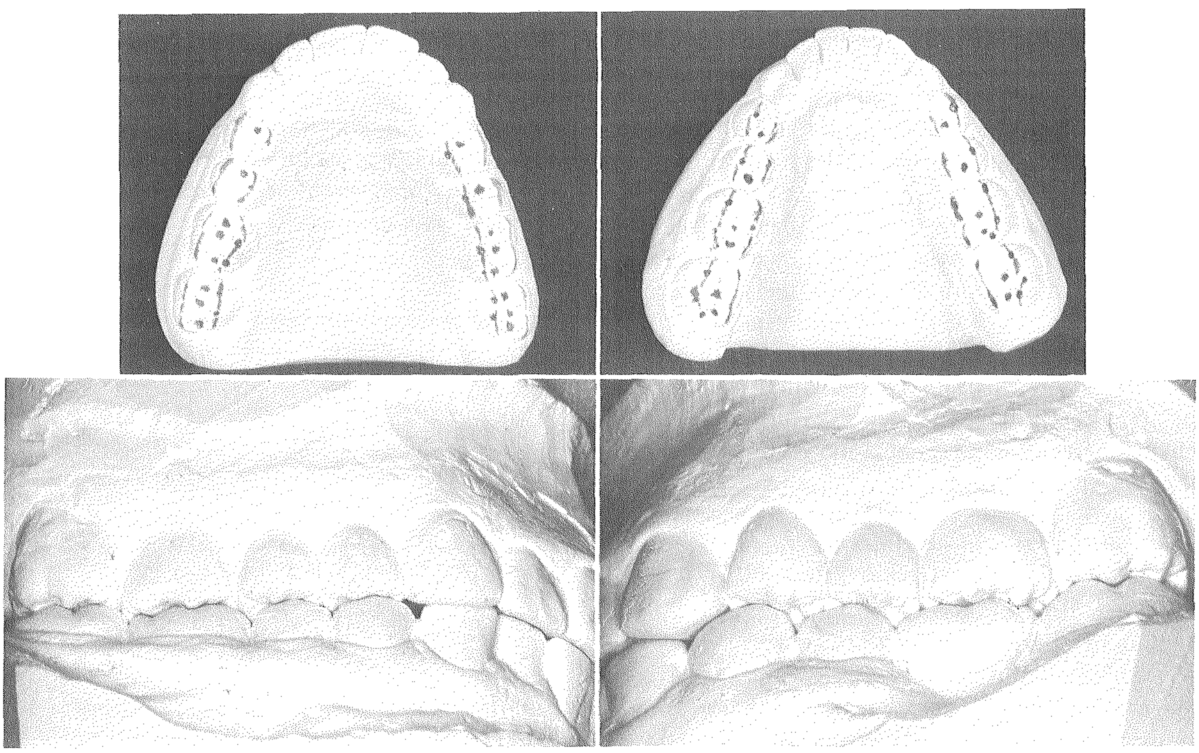


Fig. 13-74. When teeth are in centric position, parabolic architecture of surfaces permit point contacts and reduce occlusal stress. Buccolingual and mesiodistal interlocking provides stability in these directions.

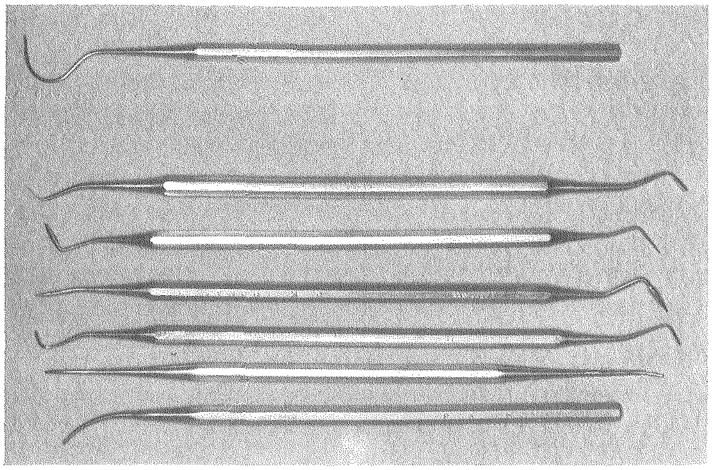


Fig. 13-75. Instruments used in wax-up of the case. A No. 23 sickle explorer and P. K. Thomas carving instruments.

teeth, proceeding from the first bicuspid and working toward the last molar tooth.

Each wax cone is placed carefully so that it has the correct length, mesiodistal position, and buccolingual position. We are establishing the proper overbite and overjet relations as well as the desired plane of occlusion and curve of Spee.

Test the position of the cones by moving the articulator in the working relations for the side being waxed, that is, straight protrusive, lateral protrusive, straight lateral, and centric occlusion. These cusp cones must pass correctly through, over, and between the projected lower buccal cusps with ample clearance.

2. Place upper lingual cusp cones carefully as to length and position. If they have been placed correctly in the mesiodistal and buccolingual positions, they will seat in the proper projected fossae of the opposing teeth. Distolingual cusp points will be a little shorter than the mesiolingual cusp point of the same molar. The lingual cusp point of the upper first bicuspid will be a little shorter than the buccal cusp point, whereas the lingual cusp point of the second bicuspid will be about the same length as the buccal cusp point.

Again carefully observe both buccolingual and mesiodistal positions of the cusp cones for desired plane of occlusion, curve of Spee, curve of Wilson, and distance between these cones and the prepared teeth below (to allow for the adequate thickness of metal on all projected castings and to allow for casting without voids and for removal of some metal during the remount and adjustment procedures).

3. Apply a thin layer of wax to the lower preparations covering all the prepared areas, and join all together interproximally.

Lower buccal cusp cones are carefully placed and checked for length and position. Their relation to the previously established upper cones is extremely important. The same general principles that were outlined for the upper wax cones are followed. The protrusive, lateral protrusive, working, and balancing relations are tested to be sure that there is no conflict or touching with opposing cusp points of the upper cones. When all lower buccal cusp points are placed, the curve of Spee should be even-flowing and, if it is not, corrections of length are made to adjust it.

4. Place and check lower lingual cusps for length, position, and relation to the previously placed cones. Make articulator test glides for conflicts or touching points.

The lower lingual cusps will be slightly shorter than the lower buccal cusps of the molars, and the lateral curve of Wilson should be in evidence.

With all the cusps cones now positioned properly, reexamine them in all their relations to each other and make sure they fulfill all requirements for length, position, clearance, even-flowing curves of Spee and Wilson. If the cusp cones do not, make necessary corrections—shorten, lengthen, or even bend them to fulfill the necesary requirements.

5. Next place the marginal ridges that outline the perimeter of the occlusal surfaces. The upper marginal ridges are placed from cusp cone to cusp cone and in definite relation to the lower cusp cones.

6. Place the lower marginal ridges from cusp cone to cusp cone and in definite relation to the upper cusp cones and marginal ridges.

Again be sure to move the articulator in all test glides to be sure that correct clearance, without conflict, is obtained.

7. Fill in the buccal and lingual contours from the marginal ridge to the margins of the preparations.

8. Place the triangular ridges (transverse and oblique) from the cusp cones to their respective fossae. Close the articulator to check for contact with opposing ridges, and then move

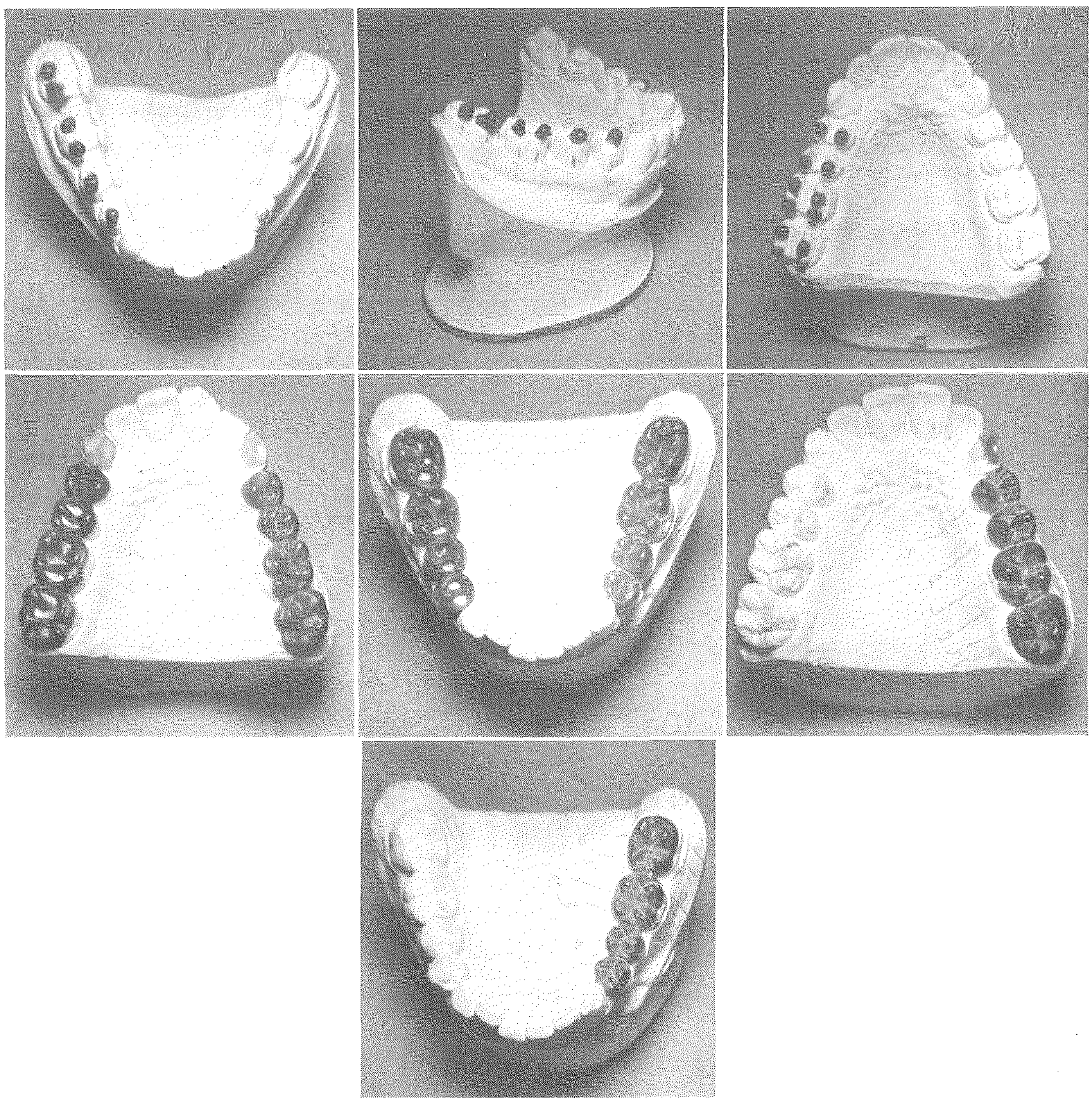


Fig. 13-76. Various stages of waxing technique from positioning of wax cones to development of marginal ridges, filling in of buccal and lingual contours, placing of triangular ridges (transverse and oblique), filling in of fossae, and carving of developmental grooves and supplemental grooves. (I learned this waxing technique from Dr. P. K. Thomas.)

it to test for clearance in the eccentric relations, thereby establishing cuspid guidance.

9. Fill in the fossae, and close the articulator with each addition. Remove excess wax, and carve the developmental grooves between the cusp lobes. In the finished wax-up all cusps will be over developmental grooves, but the tip of the cusp will not touch the bottom of fossa.

10. The supplemental grooves are those running along each side of the ridges, and the sharpness of the ridges are enhanced by these grooves.

11. Examine contacts in centric relation. Dust talcum powder on the wax carvings, and gently close the articulator several times. The points of contact will appear through the talcum dust. Check very carefully to make sure that the points of contact in centric relation are correct. (See Figs. 13-76 and 13-77.)

Now feeling assured that the wax-up is correct and that the patterns follow the dictates of the adjusted articulator in centric position and of all eccentric movements, the wax patterns (oc-

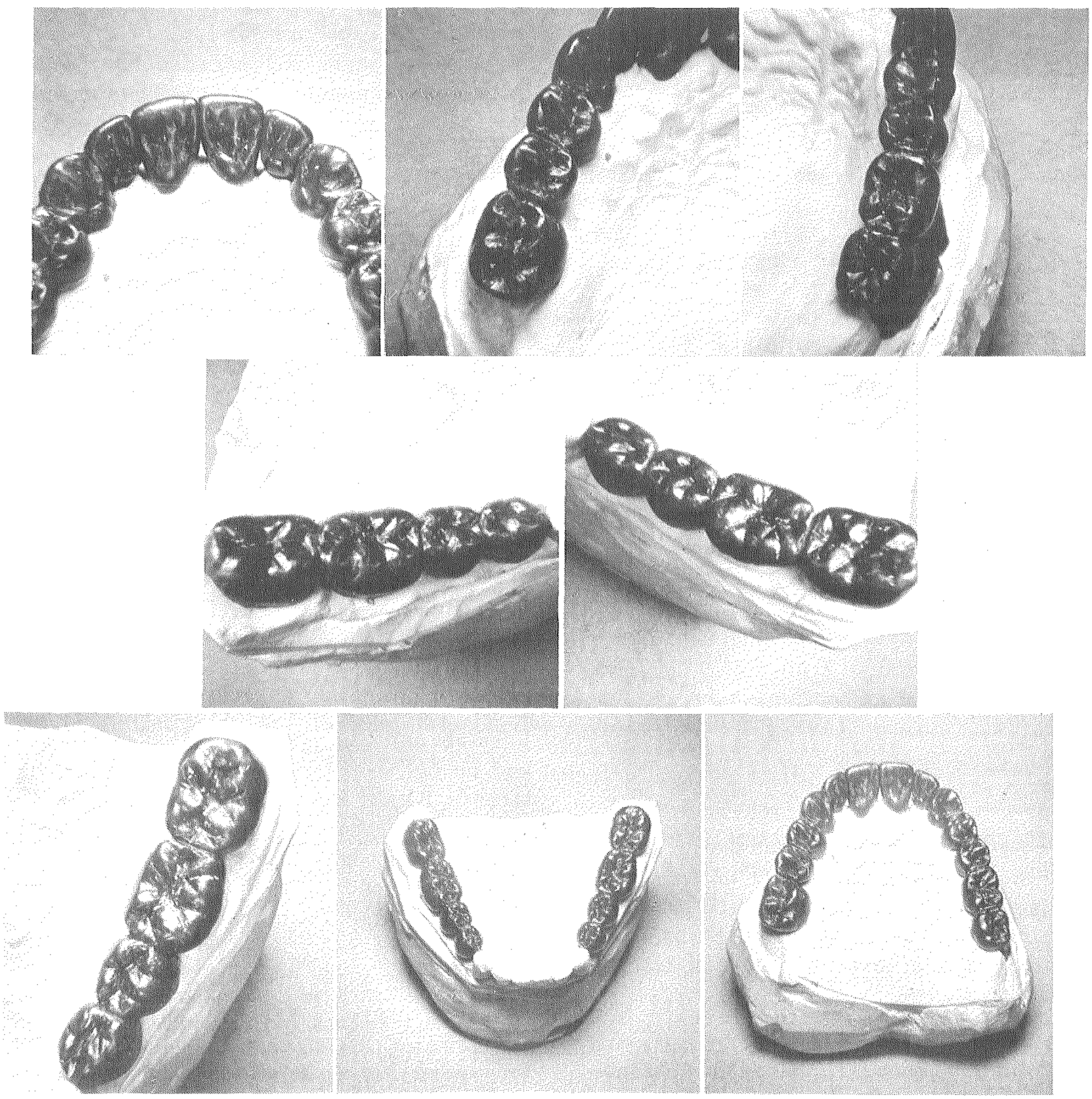


Fig. 13-77. Illustrations of wax-up indicated in case under consideration.

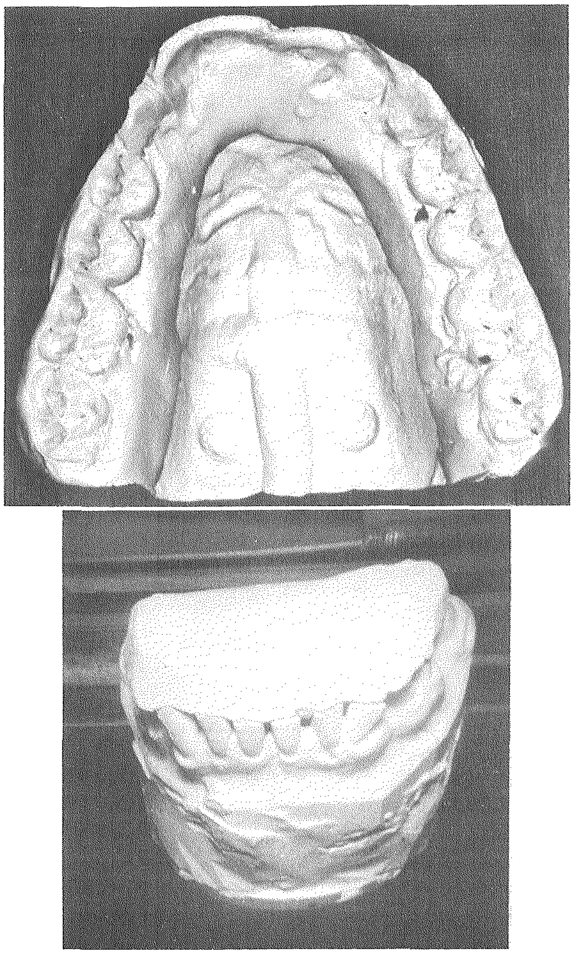


Fig. 13-78. Wax patterns (occlusal third) are treated with a thin lubricant and stone indices made of carvings. It is a safety measure in case one or more wax patterns do not cast or do not cast to dimension.

clusal third) are treated with a thin lubricant and stone indices made of these carvings. This step is a safety measure in case one or more wax patterns do not cast to dimension (Fig. 13-78).*

Casting

The wax patterns are separated with a very thin razor blade and transferred to the "finish dies" for marginal adaptation and correct positioning of contact areas, spruing, investing, burnout, casting, fitting, and adjustment of castings to finish dies, etc.

*I highly recommend Peter K. Thomas's *Manual on Full Mouth Waxing Technique* (University of California–University Extension Dental Program). It is definitive and precise in every phase of the procedure.

Each wax pattern is placed on its respective finish die, and about 1 mm. of wax is cut away at the area of the margins. This area is filled in with a "dead soft" wax and carefully adapted to the margins and finished with an overwaxing of approximately 0.5 mm.

The spruing and casting procedures are covered in detail in Chapter 8. Keep the sprues away from the occlusal carvings, as much as possible.

In the case under consideration, a number of the wax patterns were invested with Clean-Cast investment* and placed in the water bath because of their long length, which required a great deal of expansion for a somewhat passive fit on these surgerized periodontally involved teeth with a mobility pattern. The remaining wax patterns were invested, making use of the Hollenback method.

After the completion of the casting operation, the sprues were cut off and the remaining sprue projections very carefully removed with stones and burs. Magnifying loupes were used for the detection of any small nodules, which were removed. After the castings were "sanded", they were replaced and fitted on their respective dies. "Stripping" for better dimensional fit was resorted to, and the individually fitted castings on their respective dies were positioned in the sectional casts for contact area adjustments.

The stripping creates internal surface relief for the proper adaptation of the casting to the die, to the prepared tooth, and to its correct dimension. The casting is stripped for five seconds and then fitted onto the die or tooth. If it cannot be seated completely, additional stripping is indicated, but excessive stripping is contraindicated. Carry out this procedure in five-second intervals until the casting is completely seated, and do not strip for more than a total of fifty seconds. Bassett and Stauts[21] refer to this method as electrochemical milling. The margins of the castings do not have to be protected if not more than fifty seconds in total are used, "since the electrical charge is concentrated on the large bulky areas of the casting and not on the sharp angular areas of the margins."†

*Miner Dental Products, Inc., Emeryville, Calif.
†From Bassett, Russell W., and Stauts, Braden M.: Evaluation of electro-chemical milling (stripping) versus etching with aqua regia, J. S. Calif. Dent. Ass. 34:478-483, 1966.

The castings involved in the areas requiring splintage were seated on the prepared teeth in the mouth and checked for alignment and marginal fit. Then sectional plaster core index impressions were taken for making the necessary solder joints (see Chapter 9).

Remounting

In this particular case it seemed feasible to cast the pontics that were carved and developed on the upper working cast. The pontic carving in the region of the upper first molar was prepared for a splint-lingual attachment, and the pontic in the region of the upper left second bicuspid was prepared for a lingual strap in conjunction with a mesial box and a precision attachment on the distal surface. These pontics were cast and then assembled on the working cast and soldered to adjoining retainers, that is, the cantilevered upper left second bicuspid to the first bicuspid and the upper right pontic to the second molar retainer distally but not to the bicuspid mesially. During assemblage for splintage, when the castings were seated on the prepared teeth, a plaster core index impression on the upper right side allowed for the soldering of the pontic to the bicuspid retainer. (See Fig. 13-79.)

An upper aluminum tray was made so that a mucostatic impression of the ridge area could be taken for the construction of a removable precision partial denture (Fig. 13-80).

Before the castings are removed from the sectional models, cut a piece of coat hanger wire of a length extending from the mesial surface of the first bicuspid to the distal surface of the last molar in the area of the central grooves. This is to reinforce the modeling compound cores to be used for taking the remount impressions.

Now the castings, including the attached pontics, are seated on their respective preparations and ridge areas and examined for marginal fit, contact areas, contour, alignment, and relationship of pontics to the ridge (Fig. 13-81). If a sensitive tooth is encountered, place a small amount of Xylocaine ointment in the restoration.

The next procedural steps will be (1) hingebow transfer, (2) centric relation records, and (3) remount impression taking.

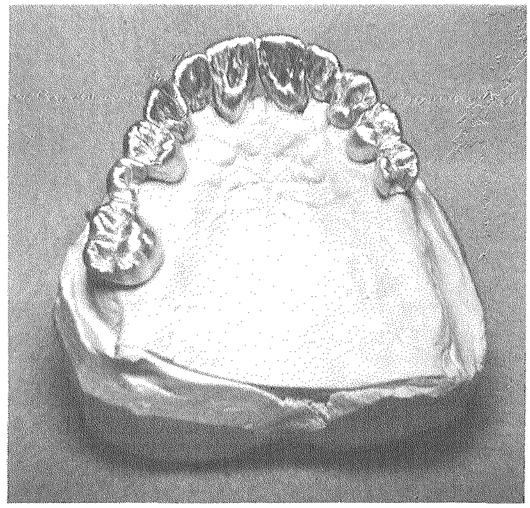


Fig. 13-79. All castings were made, including pontics that were prepared to receive precision attachments, and assembled on working cast. Castings were ready to be seated on prepared teeth, after which plaster core index impressions would be made for soldering joints.

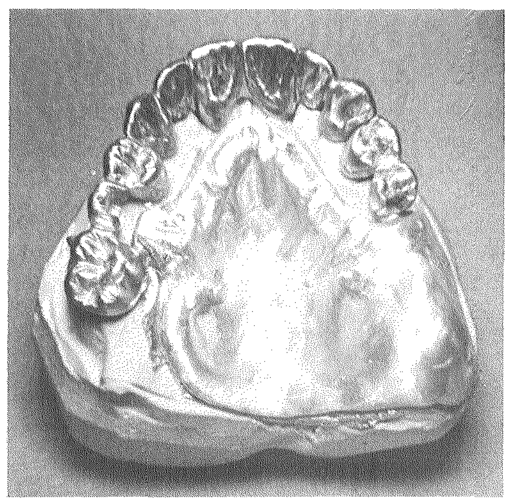


Fig. 13-80. Upper aluminum tray was made for taking of a mucostatic impression of ridge and palatal areas.

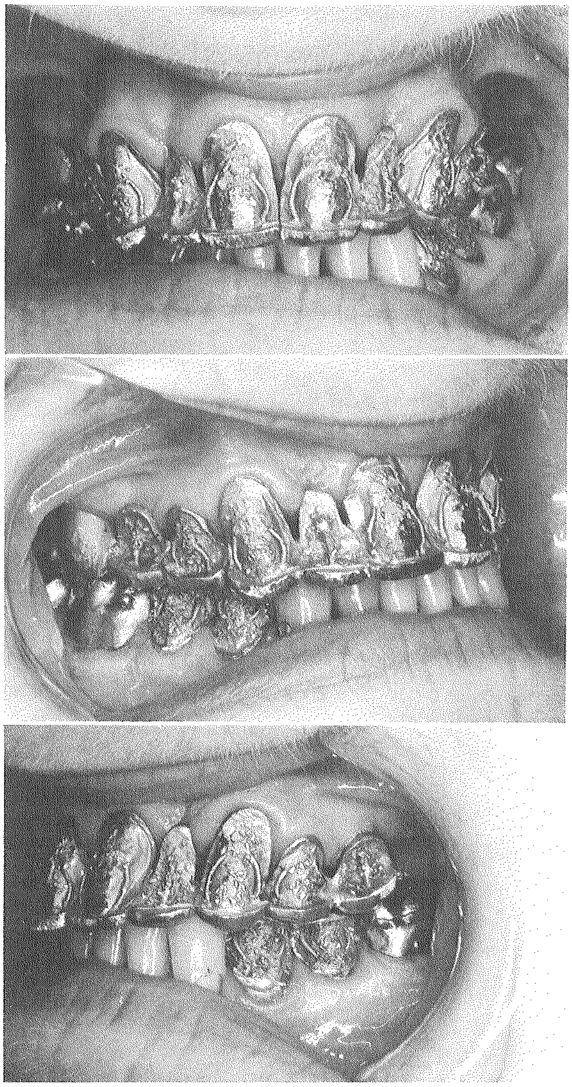


Fig. 13-81. Castings are seated on their respective preparations and ridge areas and examined for marginal fit, contact areas, contour, alignment, and relationship of pontics to ridge.

Hinge-bow transfer

The cusp tip indentations in the maxillary portion of the prepared bite-fork modeling compound block are lined with a thin mix of a zinc oxide-eugenol paste (Kydac*) and placed into position on the teeth, and the patient is told to close the mouth until the paste sets. Be sure to lubricate the occlusal third of castings with Masque† before contacting paste to castings. When paste has set, remove the bite-fork, trim away surplus edges of Kydac, and reseat the bite-fork on the teeth to correct any small distortion.

Complete the face-bow transfer (as previously described), and place it on the mounting frame (Fig. 13-82).

Centric relation records

Value of centric relation

This phase of the procedure has been covered in an excellent manner by Lucia in Chapter 3, but for continuity the technical steps merit repetition.

Dykins,[22] a serious and knowledgeable student of the problems of occlusion, recently had the following to say:

"We may say that we have teeth to bite and chew and, in order to do this, we must exercise force. Immediately we see that we are involved in bio-mathematics and, since mathematics is an exact science, the necessity of obtaining and working with constants is absolute. It is in the recognition and proof of attainment of the constant that all techniques must be evaluated.

"Everyone agrees that the chewing stroke is composed of rotary movement in the horizontal and vertical planes and in combination with the translatory component. It is in the horizontal rotational aspects that we are able to establish our first constant, otherwise known as the axial center of rotation. The objective of bio-dento-engineering is, in part, one of relating the axial center constants located in the moving member or mandible to the fixed component of the chewing apparatus known as the maxillae. It is this condyle-fossae relationship which establishes our second constant and together with the opposing occlusal surfaces is universally known as centric relation. Controversy regarding the value of this second constant has always been present simply because very few have subjected their centric jaw relationships to visual proof by means of the split-cast idea and at least three registration wafer records.

"Clinically, it can be demonstrated that the difficulty of registering the second constant revolves around what we may call for lack of a better term, the 'sagged' or non-bracing relationship of the condyle in the fossa. Anatomically, the menisci and temporomandibular liga-

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

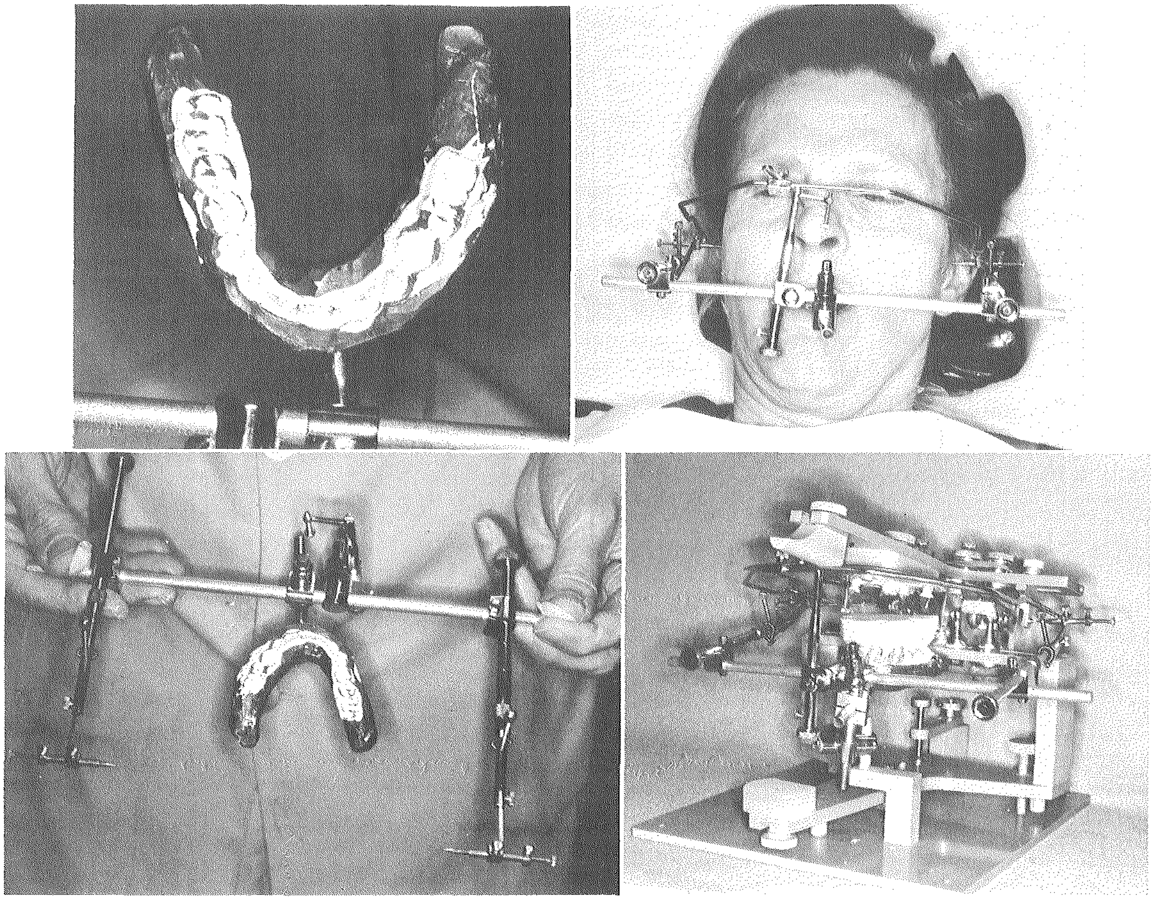


Fig. 13-82. Face-bow transfer made and assembly removed and placed on mounting frame (to be mounted to upper bow of articulator after remount impression and cast are completed).

ments appear to be the culprits in our perplexity. It is admitted that centric relation is not an anatomical entity, but only a reference and bracing factor.

"The determination of the constant is one of the demands of bio-mathematics; and since it has been clinically demonstrated that the mandible is not capable of reproducing identical *positional* arcs of movement by free closure, it should be obvious that all centric relation records must be registered under load.

"The use of the anterior fixed stop provides the fulcrum by which the patient's energized musculature can seat the condyle in its maximum bracing relationship in the fossa. When this is accomplished, it serves a two fold purpose:

(1) It provides the constant which is essential in all of the mathematics of function, and in turn is part of the equation in creating a nonpathologic cuspation;

(2) By its bracing effect, it enables all of the skull to assume some of the burden in the dissipation of the masticatory forces. In so doing, there is established the broadest possible base for force distribution and the ensuing reduction of the traumatic impact on the tooth and its adjacent osseous support."*

The technique used for obtaining centric relation records for the remount procedure is the one suggested by Lucia (Chapter 3). An anterior stop (plastic jig) is used, and in the adjustment of this jig in the patient's mouth, we also are training him for correct closure, that is, in an easy hinge closure. Never allow the patient

*From Dykins, William R.: Personal communication.

to bring teeth together once the jig adjustment stage is started; insert a saliva ejector. This is very important because this jig adjustment and training period blocks the proprioceptive reflexes developed by the patient to prevent injury to their tissues. Closure of the teeth therefore will cause the loss of the effect of training.

Technique

Fundamentally, the problem of joint fossae relationship involves directed joint positioning, application of patient bilateral muscular effort, and means of joint stabilization.

Operator guidance serves as the means of orienting the posterior relation of the condyles to the fossae, whereas the musculature is interpreted as the factor in placing the condyles in their correct superior relationship. To utilize bilateral muscular balance, an anterior stop must be provided as close to the desired vertical dimension as possible. The stop must not be capable of any movement, since constancy in its relation to the supporting teeth is an absolute requirement; neither should it be designed to influence the backward and upward movement of the condyles. 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 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 caused by the stretching of the ligaments.

Two or more wafer recordings are necessary. The criteria for 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.[22]

Lucia's method of recording centric relation

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. 13-83.

*Kerr Mfg. Co., Detroit, Mich.
†The Motloid Co., Inc., Chicago, Ill.

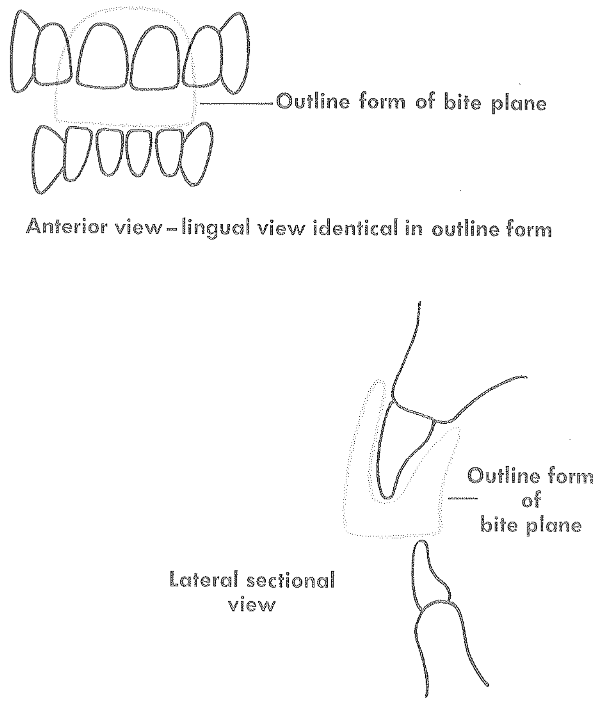


Fig. 13-83. Schematic drawing showing general shape and form of bite plane after initial phase of construction.

The bite plane then is placed in position in the patient's mouth, and the patient is closed in centric position 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 of 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 again is 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. Then the plane is removed from the mouth, and the resulting Gothic arch tracing is observed. Any interferences on the plane are corrected, and it is shaped so that it is rendered ineffective as a lateral or protrusive guide for the mandible upon closure against the plane. In most cases this would necessitate sloping the plane's occlusal surface in a slightly upward direction, both posteriorly and laterally from a central ridge, which would

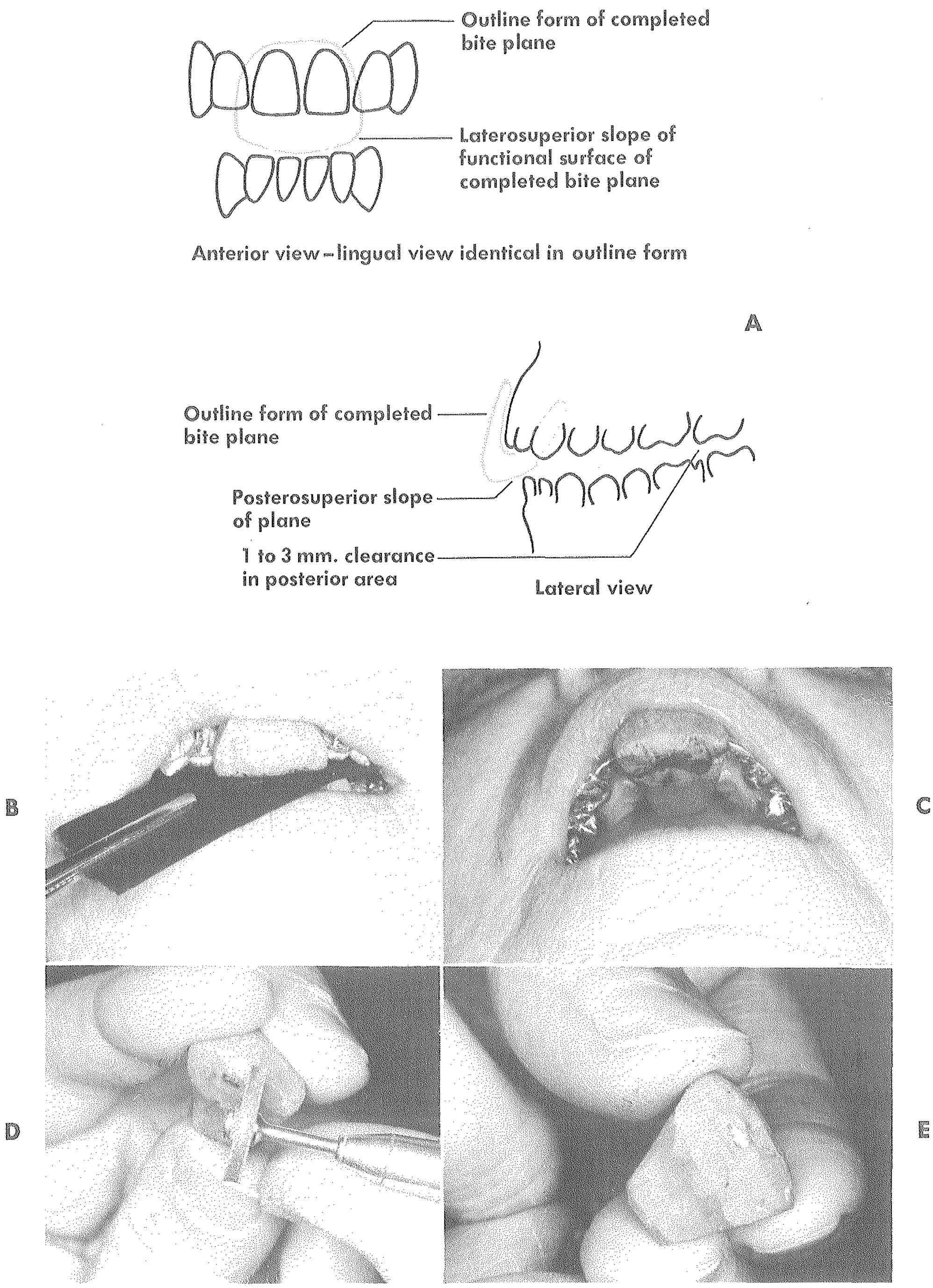


Fig. 13-84. A, Diagrammatic drawing showing general shape and form of completed bite plane. **B** to **E,** Preparing bite plane (Lucia jig) for taking three centric relation records for case being considered in this chapter.

now have but minimum contact with a single lower central incisor or, at most, two incisors. This can be understood better by consulting Fig. 13-84.

Next, indentations of the patient's maxillary cusps are made in a sheet of extra-hard baseplate wax. Then this occlusal pattern is 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 removed from the anterior part of this wax form in such a manner and of such size to allow both this wax form and the bite plane to be placed in the mouth at the same time with some space between them, as is illustrated in Fig. 13-85.

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. Then this wax tray is 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 is guided into a centric closure and then opened prior to complete penetration of the wax. The wax tray is removed, chilled, and repositioned in the mouth to check for distortion.

With the wax tray still in position the bite plane is inserted (some denture powder may be needed to secure the plane in the mouth), and the patient 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 displacement, caused by the stretching of the ligaments.

The wax tray, being completed, is dried thoroughly. The patient's teeth are lubricated with a petroleum jelly preparation, and a mix of Kydac, a zinc oxide–eugenol preparation, is properly prepared and placed in the maxillary and mandibular occlusal indentations of the tray. With the bite plane securely in position the wax tray is carried into place and the patient guided into a centric closure against the bite plane. At this time the tray is released (that is 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. 13-86.)

The wax tray with the occlusal record is removed then and placed in cold water. Then the second and third records are made, repeating the same process with the same bite plane

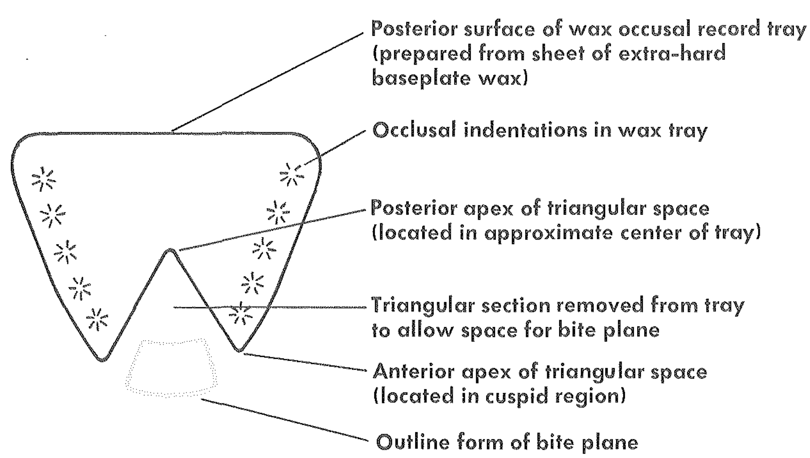


Fig. 13-85. Schematic drawing, superior view, showing relative positions of wax tray and bite plane when in place in mouth.

A

B

C

D

Fig. 13-86. A, Wax tray is softened in a thermostatically controlled water bath. B, Patient's teeth and castings are lubricated with a petroleum jelly preparation. C, A mix of Kydac, a zinc oxide–eugenol preparation, is properly prepared and placed in maxillary and mandibular occlusal indentations of tray. D, With bite plane securely in position, wax tray is carried into place and patient guided into a centric closure against bite plane. Hold patient's mandible in this centric position until Kydac has completed its set. Remove centric relation record.

to verify, by the Lauritzen split-cast method, the accuracy of the centric relation records on the articulator.

In the removal of these records from the mouth care must be exercised to avoid distortion. Place both thumbs on the patient's chin and the index fingers on the upper edges of the record; instruct the patient to separate the teeth slightly, and then exert carefully controlled pressure to release the centric relation record from the upper teeth but to keep it in position on the lower teeth. Have the patient close again. With the record held against the patient's upper teeth with the thumb and index finger of the left hand and with the lower jaw steadied with the right thumb, instruct the patient to separate his teeth slightly. This will loosen the record from the lower teeth with a minimum of distortion.

Trim the first record with a pair of surgical tissue shears, which will trim the Kydac without fracturing it (Fig. 13-87). This record then is checked in the mouth with and without the bite plane being used. Be sure that no chips of the Kydac are present in any of the indentations when the record is reseated. Check the second and third records, after trimming, in the same manner. Any slight distortion will be corrected if these steps are executed carefully.

Now the remount casts can be checked with these centric relation records. This is done without the bite plane.

In other words, we are attempting to establish a resistance between the anterior teeth, which forces the condyles up into their bracing position, so that muscular force can attempt to overcome the resistance between the anterior teeth. The mandible is guided, not shoved, back to its terminal hinge position.

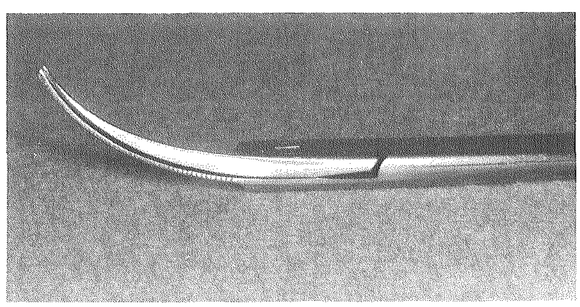


Fig. 13-87. Records are trimmed with a pair of surgical tissue shears, which will trim the Kydac without fracturing it.

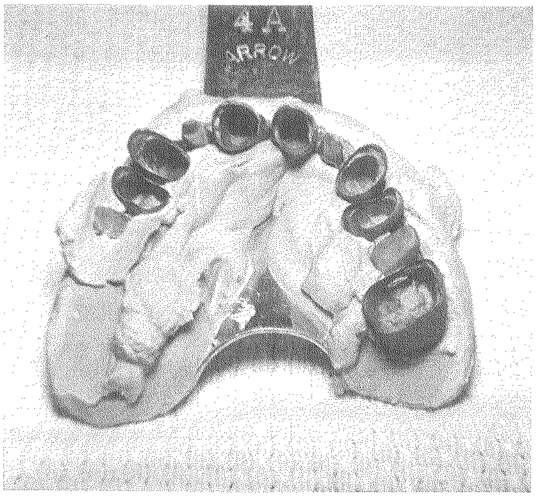


Fig. 13-88. Since all remaining teeth in upper arch had cast restorations in position, a plaster impression was taken.

Remount impressions

As I was examining the border outlines of the upper aluminum tray in the patient's mouth, a sudden change of plan took place. The patient informed me that a removable appliance of any kind would be most difficult for her to tolerate and would make her very unhappy, despite the fact that the patient had worn a removable appliance for several years. After the pros and cons of such action were explained to the patient, it was decided to respect the patient's feelings in this matter. A contributory factor in this decision could have been that we go to great lengths to avoid constructing a removable partial denture in periodontally involved mouths.

Upper impression

A plaster impression was taken, the method of choice when all remaining teeth in the arch have cast restorations in position (Fig. 13-88). It also was believed that, since the upper right pontic and upper left pontic had to be recarved, cast, and soldered to their adjacent retainers, a plaster impression afforded extreme accuracy.

Lower impression (technique developed by P. K. Thomas)

The lower impression was taken by using a combination of modeling compound cores relined with Kydac (zinc oxide–eugenol paste) positioned on the restorations, over which was taken a full alginate impression, including the lower anterior teeth, which had not been prepared for restorations.

With the restorations in place (the veneer surfaces are filled in with DuraLay or hard wax to prevent impression tears) softened modeling compound is placed around the coat hanger wire (previously prepared on the working casts) and seated over the restorations. Care must be exercised not to displace the restorations nor to move mobile teeth. When the compound has hardened, it should be removed, chilled, and trimmed. The sides of the cores are trimmed with a slight buccal and lingual overhang and notched. Be sure to mark cores R (right side) and L (left side).

An oversized rim lock tray, which will comfortably include the compound cores and anterior teeth, is fitted.

Make a thin mix of Kydac (use accelerator control liquid), line the occlusal third imprints of the compound cores with this mix, and seat them over the restorations (treat the occlusal surfaces lightly with a lubricant, Masque), holding them until the paste sets. Carefully remove any excess.

Mix the alginate material,* fill the tray, apply a small amount of the mix on the anterior teeth and around the cores with the finger to avoid trapping of air, and carefully position the filled tray into place. Hold the tray for exactly three minutes, and then remove it by applying pressure on the sides of the tray and not the handle. An accurate impression must result. The compound cores must come out in the impression (if not, start over), the mirror image of the anterior teeth must be read in the impression, and the Kydac imprints of the restorations must be clean-cut so that those castings that remain on the prepared teeth can be seated accurately. Use magnifying loupes to verify definitive seating of the castings in the compound cores and of the cores in the alginate impression. (See Fig. 13-89.)

Now the impressions are taken to the laboratory and carefully reexamined, and the restorations are sealed to each other with Tenax wax applied interproximally to prevent dislodgement when the casts are poured. In long retainers a

*D. P. Cream, Dental Perfection Co., Inc., Glendale, Calif.

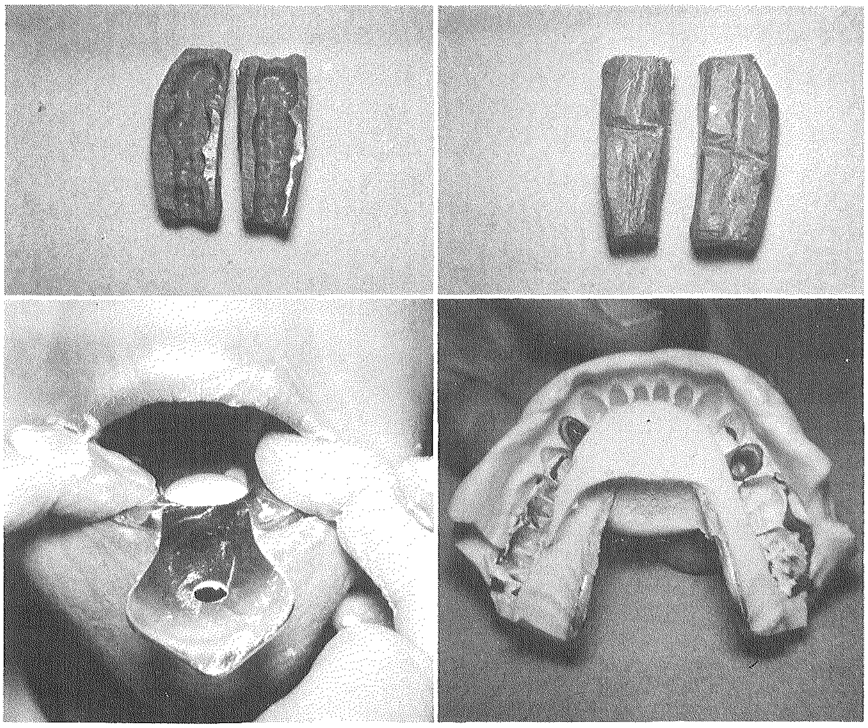


Fig. 13-89. A combination of modeling compound cores relined with zinc oxide–eugenol paste, positioned on restorations, over which a full alginate impression, including lower anterior teeth which had not been prepared for restorations, was taken.

thin layer of wax is applied to the side walls (not the incisal or occlusal areas) for ease of removal.

Treat the inner surfaces of all castings with Mucolube* before pouring model material into the impressions. A good stone can be used for this purpose if the technician is very careful, or a low-fusing metal (S.S.W. 160) may be the material of choice. If so, this low-fusing metal is melted in a water-filled ladle, which prevents the metal from overheating. When the metal has softened (160° F.), the water is blotted out of the ladle and the molten metal carefully poured into the impression, after which wire loops or screws (heads up) are inserted immediately to serve as retention aids to the stone to be used to form the base of the cast. I find Pri-Die† material to be excellent for making remount casts. (See Fig. 13-90.) When these materials (low-fusing metal or Pri-Die) have set, make a base of stone. Never vibrate stone into remount impressions.

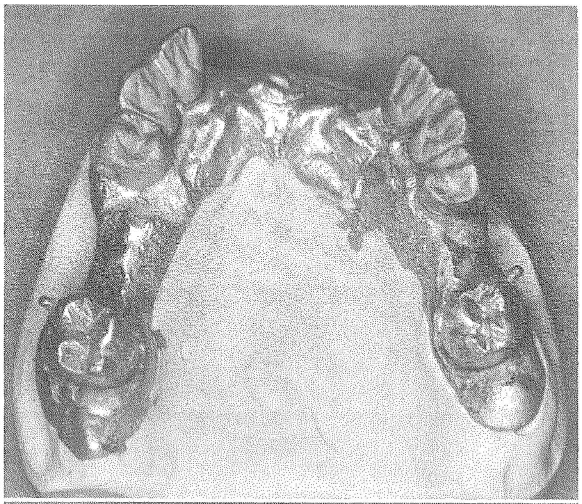
*Cosmos Dental Products, Inc., Long Island City, N. Y.
†J. F. Jelenko & Co., Inc., New Rochelle, N. Y.

After separation of the remount casts from the impressions, trim away surplus stone; examine the casts carefully for nodules or flaws and treat accordingly. Test accuracy of upper remount cast by fitting it into indentations of the bite-fork modeling compound block. If it definitely seats without a rock, it is an accurate cast. This upper cast is now mounted on the articulator by means of the hinge-bow transfer after it has been prepared for the split cast. It is related and attached to the articulator in the same arc of closure that is found in the mouth.

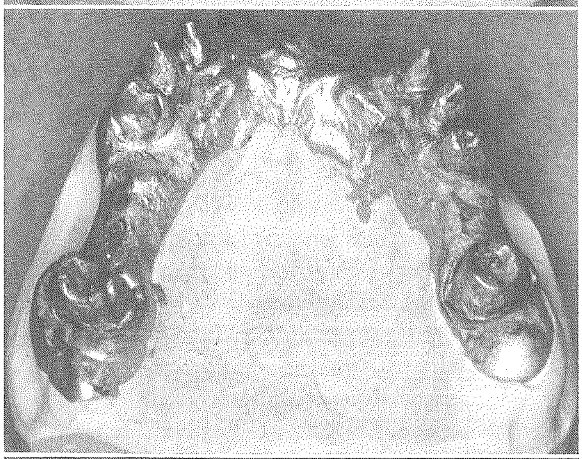
The lower remount cast is mounted in relation to the upper cast by using centric relation record 1 and checking records 2 and 3 to determine if they are duplicates of 1.

The articulator is inverted, centric relation record 1 is placed on the occlusal surface of the upper cast, and the lower cast is placed on the centric relation record. A mix of stone is made, and the attachment of the lower cast to the lower bow of the articulator is completed. The upper and lower members of the articulator must be in centric relation.

A



B



C

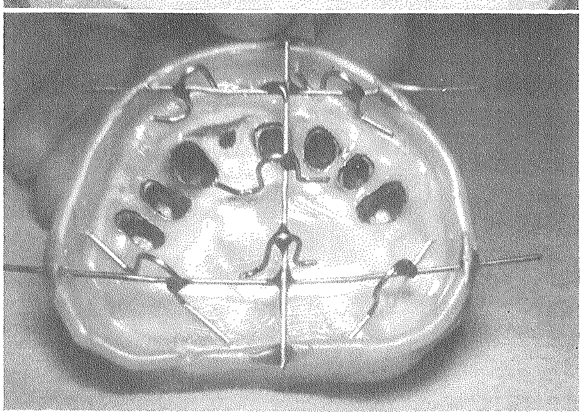


Fig. 13-90. A and B, Treat inner surfaces of castings with Mucolube before pouring model material into impression. "Long" castings should be relieved slightly with wax on lateral walls. Stone, low-fusing metal (S.S.W. 160), or Pri-Die may be used for pouring impression for remount cast. C shows impression readied for pour-up with Pri-Die. (Illustrations shown are not of case being described in this chapter; photographs were lost but procedural steps are the same.)

To test the accuracy of the mounting with record 1, remove the electrical tape that holds the two parts of the split cast together, lift the upper bow of the articulator, which carries with it the upper half of the split cast, reseat the upper remount cast into the centric relation record, and close the upper bow onto this cast. If the V-shaped projections of the upper half of the split cast (which is attached to the articulator bow) go to place accurately into the V-shaped grooves of the cast, the mounting was executed correctly.

Now check to confirm the mounting with records 2 and 3 (Fig. 13-91). Raise the upper bow of the articulator, remove the upper remount cast, replace centric relation record 1 by record 2, seat the upper cast on it, and close the upper bow of the articulator. If the two parts of the split cast come together perfectly, as seen with record 1, the two records are identical. Repeat the same procedure with record 3 to check its accuracy. All three records must be identical for the mounting to be correct. This was so with the patient that is under consideration in this chapter.

Centric relation record 1 is now reseated, the upper remount cast seated on it, and the upper bow of the articulator with the upper half of the split cast closed onto this cast and held firmly while the two parts of the split cast are united with a mix of stone.

We are now ready to examine the relationship of the restorations to each other and make necessary adjustments to perfect the articulation. Discrepancies may arise as a result of casting changes and other errors, mobile teeth may shift slightly as healing takes place, materials used in our various procedures can create dimensional changes, etc. Above all, it must be remembered always that all questions have not been answered as yet.

Refining the articulation

Despite the change in the plan of treatment and several other compromises, in the patient being described, the relationship of the cuspal elements was remarkably close to each other upon examination.

In the refining of an articulation, correct the protrusive position first then the lateral protrusive and the lateral positions, and finally the centric position.

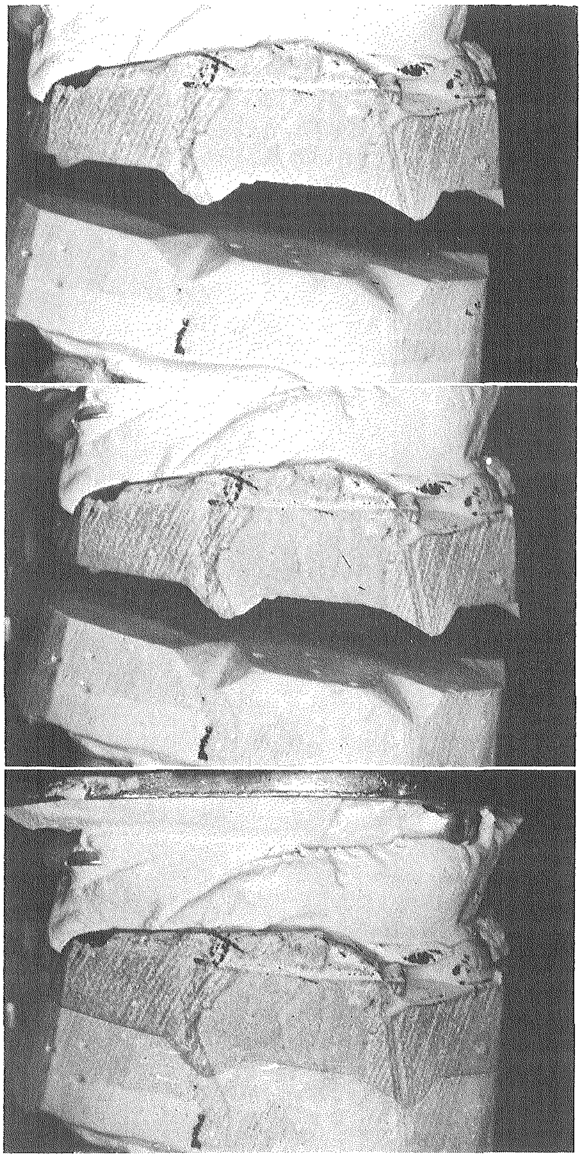


Fig. 13-91. Test accuracy of mounting with record 1, and then check to confirm mounting with records 2 and 3.

In the protrusive and lateral protrusive excursions, in the case under consideration (mutually protected articulation), the anterior teeth are in function or contact and the posterior teeth are out of contact.

In a protrusive position the anterior teeth, functioning as a unit, should make contact simultaneously. In some cases it is possible to maintain contact of the distal aspect of the upper cuspids with the mesial marginal ridge of the lower first bicuspid. All the other cusps are out of contact.

In the lateral protrusive position the anterior contact is on the central, lateral, and cuspid teeth whenever possible, the other teeth remaining out of contact.

In the lateral or working and balancing positions the contact is on the anterior teeth, particularly the cuspids. The sharing of this contact (cuspid) by the central and lateral teeth is helpful whenever possible. Sometimes the glide starts out on the central or lateral teeth and then is taken over by the cuspid—this is not an ideal situation, but a number of cases have worked out very well. All the posterior cuspal elements are out of contact in the working and balancing excursions.

When we say that the cusps are out of contact in the various excursions, we mean that there is a slight lack of contact. Because we endeavor to keep these "misses" to a minimum without any interference, which gives us a better chance to properly relate the cuspal elements in centric relation, the importance of which no one denies, is the reason precise registrations are necessary in the development of a mutual-protective articulation.

It is true that in some cases, including the one being presented, the clearance or "miss" is more than desired, but it seemed that it was the best that could be accomplished with the various factors at hand. Centric relation contacts are definitely in evidence, and this and other cases showing a little more clearance than desired are successful.

Centric relation contacts are examined now. These contacts are of such importance that great care, understanding, and judgment must be exercised in making these adjustments. Whiting dissolved in alcohol will permit accurate marking of the areas to be adjusted. If a premature contact is present, try to visualize the end result of the reduction process, and grind the area on an upper or lower restoration. If indicated, both the upper and lower surfaces may be reduced slightly. Remember the "rules of grinding" (see Chapter 5), and think twice before cutting away gold surfaces. Both dentist and technician are required to know when to grind a cusp, reduce a surface or ridge, or deepen a fossa.

When adjusting for centric relation in the re-

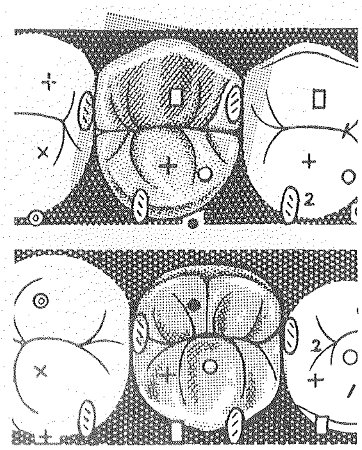


Fig. 13-92. Centric relation contacting areas of upper and lower second bicuspids after proper adjustment (mutually protected articulation). (From Lucia, Victor O.: Modern gnathological concepts, St. Louis, 1961, The C. V. Mosby Co.)

mount stage, put in unground side shifts and set them at 0 degrees (this procedure is also helpful in working out and checking the last stages of centric relation in the wax-up).

In centric relation we attempt to have tighter contact on the posterior teeth than the anterior teeth, which should have a slightly lighter contact. Have cellophane (1/1000-inch thickness) hold tighter on molars, a little less on the bicuspids, but still holding, and slightly less as one goes anteriorly. In other words, cellophane must hold with every cusp in the posterior region and just be able to be pulled out in the anterior region.

We seek tiny points of contact in centric relation, and a tripodal arrangement (three points of contact opposing each other) is of great importance. Lucia[10] shows well-delineated illustrations of centric relation contacting areas of the upper and lower posterior teeth after proper adjustment of a mutually protected articulation. For example take the centric relation contacting areas of the upper and lower second bicuspids. "(1) The buccal triangular ridge of the upper second bicuspid crosses and makes contact with the buccal aspect of the distal slope of the buccal marginal ridge of the lower second bicuspid. (2) The lingual triangular ridge of the upper second bicuspid contacts the inner aspect of the distobuccal marginal ridge of the lower second bicuspid. (3) The buccal triangular ridge of the lower second bicuspid contacts the inner portion of the mesial slope of the lingual marginal ridge of the upper second bicuspid. (4) The lingual triangular ridge of the lower second bicuspid contacts the lingual side of the mesial portion of the lingual marginal ridge of the upper second bicuspid. When there are two lingual cusps on the lower second bicuspid, the contact is made between the triangular ridge of the distolingual cusp and the lingual side of the mesial portion of the lingual marginal ridge of the upper second bicuspid. (5) The mesial marginal ridge of the upper second bicuspid crosses and contacts the mesial portion of the buccal marginal ridge of the lower second bicuspid. (6) The distal marginal ridge of the lower second bicuspid crosses and contacts the distal portion of the lingual marginal ridge of the upper second bicuspid. (See Fig. 13-92."*)

In the case being described very few adjustments had to be made. We had an excellent and cooperative patient. The taking of the registrations went smoothly, the centric relation records checked out correctly at all times, and the methods used fulfilled all known requirements of this type of record. The reduction of the distal marginal ridge of the lower second bicuspid on the left side and a slight reduction of the crest of the lingual cusp of an upper bicuspid on the right side were the major adjustments. Refinement of a few smaller interferences and development of better form through marginal ridges of soldered restorations and U's for developmental grooves and "sharpening up" of supplemental grooves also was necessary. We organized paths of disclusion, developed a nondeflective centric hold, and put a minimum of forces on the anterior teeth. It is believed that we came close to having a frictionless occlusion. The test glides were exactly alike in the mouth and on the instrument, and we agree that the patient does not chew as shown on the test glides (Fig. 13-93). The patient has a negative occlusal perception, and to date no wear is evident. It could be that the questionable bruxing habit has stopped, but for safety a night guard was constructed.

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*From Lucia, Victor O.: Modern gnathological concepts, St. Louis, 1961, The C. V. Mosby Co., p. 465.

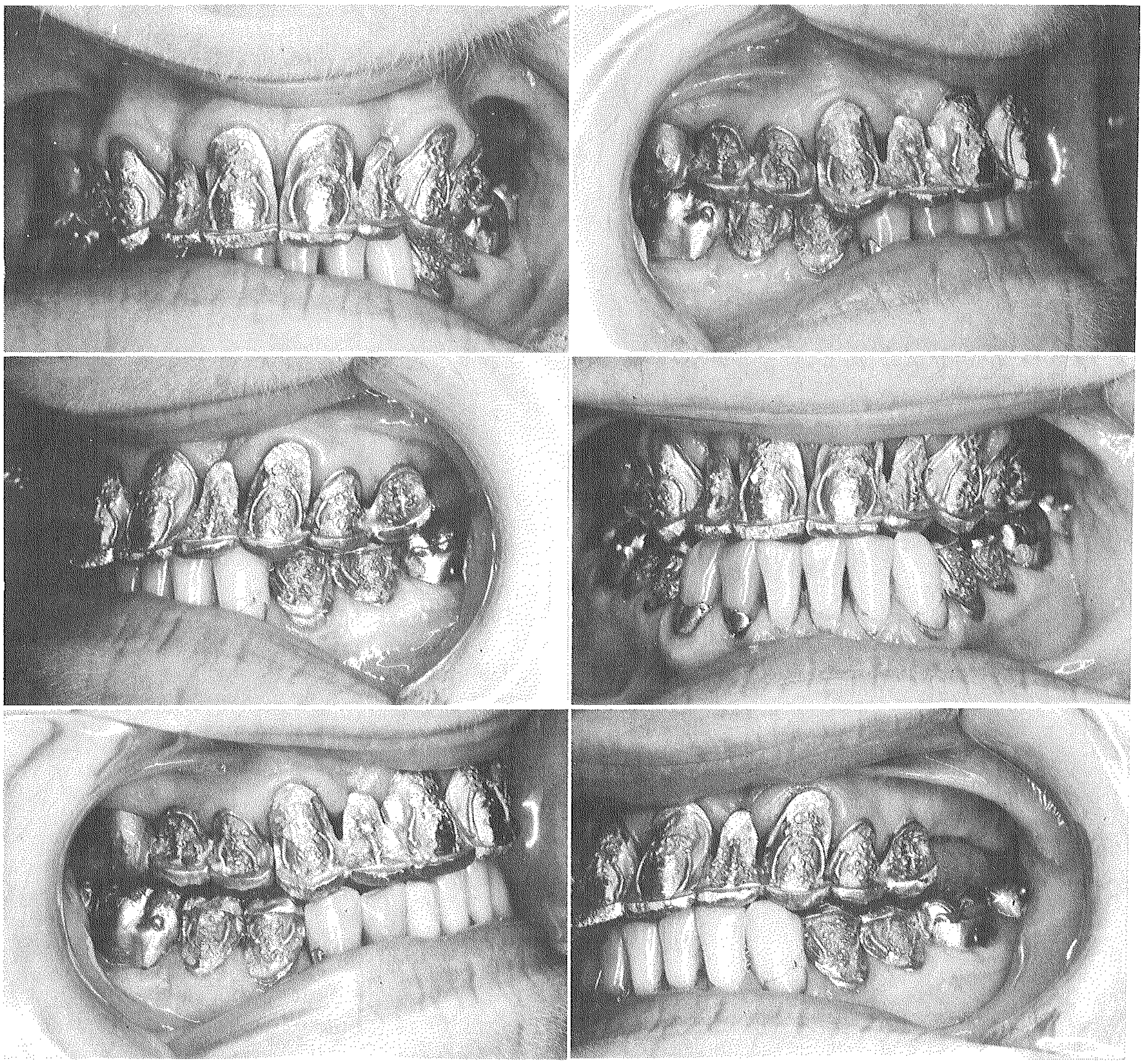

Fig. 13-93. Centric position and test glides in mouth after refinement of articulation. Test glides on articulator were same as in mouth (they are not functional movements).

The following are a few points to remember:

1. Learn to use adeptly a No. 37 inverted cone bur or diamond stone for occlusal adjustment.
2. Use a measuring caliper (Fig. 13-94) to measure the thickness of castings when grinding the thinner areas.
3. For the dull and fine finish in grooves and fissures take a quarter round bur; run it at an angle of 20 degrees on glass (a glass ashtray), and then run it on gold at the same 20-degree angle (P. K. Thomas).
4. In the wax-up or occlusal adjustment test the eccentric relations first to make sure that centric relation contacts are not destroyed in the eccentric excursions.
5. Round off marginal ridges.
6. The posterior teeth are disengaged by the patient's opening component of jaw movement, guided by the proprioception of the cuspid.

Veneering

After errors in articulation are corrected, the veneering of the labial and buccal surfaces is the next procedure demanding attention. The

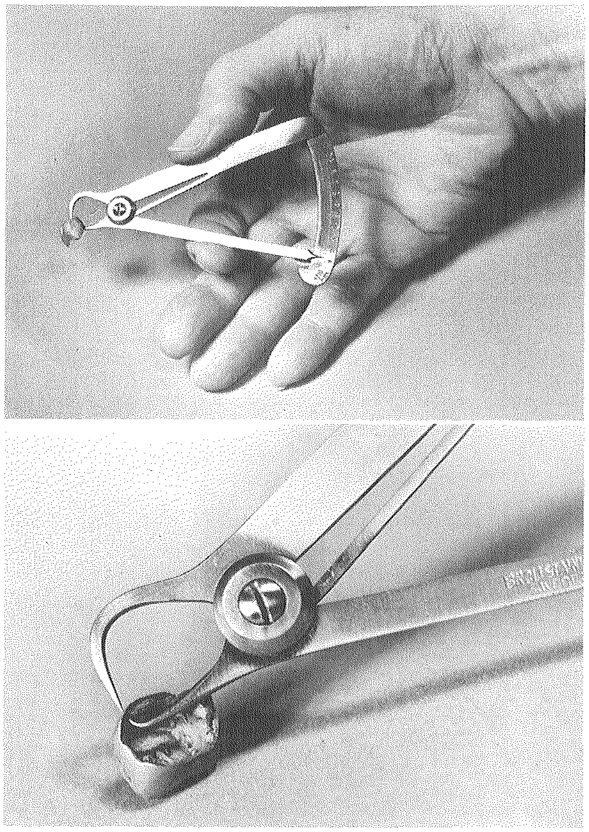

Fig. 13-94. A measuring caliper to measure thickness of castings when grinding for refinement of articulation.

preparation of these surfaces is most important from both retentive and esthetic standpoints. It was decided, in the case being discussed, to use acrylic resin veneers because of the mobility pattern present and the necessary splinting. However, if this case was under construction at the present time, after study and experimentation in multiple use of reverse pins and porcelain bonded to metal, I would make use of porcelain.

To prevent the acrylic from finishing to a knife-edge where it joins the gold at the proximogingival margins, it is important that the cut-out ends in areas in which width and depth both exist. Use of loops and beads for retention is indicated also.

After preparation of the surfaces to be veneered, the castings are cleansed thoroughly after polishing of indicated surfaces. The next step is the application of D-Paque masking material (Diamon-D[*] was the acrylic of choice), and this is done before the waxing of the facings. Do not clog the retentive loops, etc. The waxing of the facings is completed now, observing proper coronal form, embrasures, and the critical cervical third areas. Proper thickness for good esthetic effects (facial and mesial and distal line angles) was provided in the preparations. (See Fig. 13-95.)

Equipment necessary for good results are (1) flasks in assorted sizes, (2) a good press, (3) adjustable heat lamps, and (4) mixing jars.

Investing and flasking

Choice of materials

Stone, plaster, or a combination of both may be used for investing, but plaster, if used for the top half of the flask, can break down and cause a loss of detail in the anatomic form and a loss of compression. One-half stone and one-half plaster was used for investing the case under consideration. A Kum-A-Part[†] flask was used for investing the upper restorations, and a small flask in conjunction with Acra-Press[‡] was used for the lower restorations (Fig. 13-96).

The Diamon-D technique necessitates grinding incisal blends away after body has been preprocessed. Always place case in investment without covering incisal edge with investment. By keeping incisal edge exposed, you can now grind incisal blends without destroying mold.

Use wet foil[§] after wax has been boiled out—at this time investment is warm. Wet foil will penetrate investment, requiring the use of two or three thin coats.

It is very important that the correct amount of liquid be used in all Diamon-D mixes. Too little liquid will create a doughy consistency that will be chalky and dry. Such a mix will not flow or pack properly. (See Fig. 13-97.)

Body mix. Use a small mixing jar with a well-fitting cap. Pour the required amount of powder into jar. Tapping the jar as the liquid is added will saturate the powder thoroughly. Continue the tapping until a shiny or wet surface appears. The mix should be a medium paste consistency and always have a wet, never chalky or dry ap-

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[*]American Consolidated Co. (Amco), Philadelphia, Pa.
[†]Buffalo Dental Mfg. Co., Brooklyn, N. Y.
[‡]Trio-Dent Co., Union, N. J.
[§]American Consolidated Co. (Amco), Philadelphia, Pa.

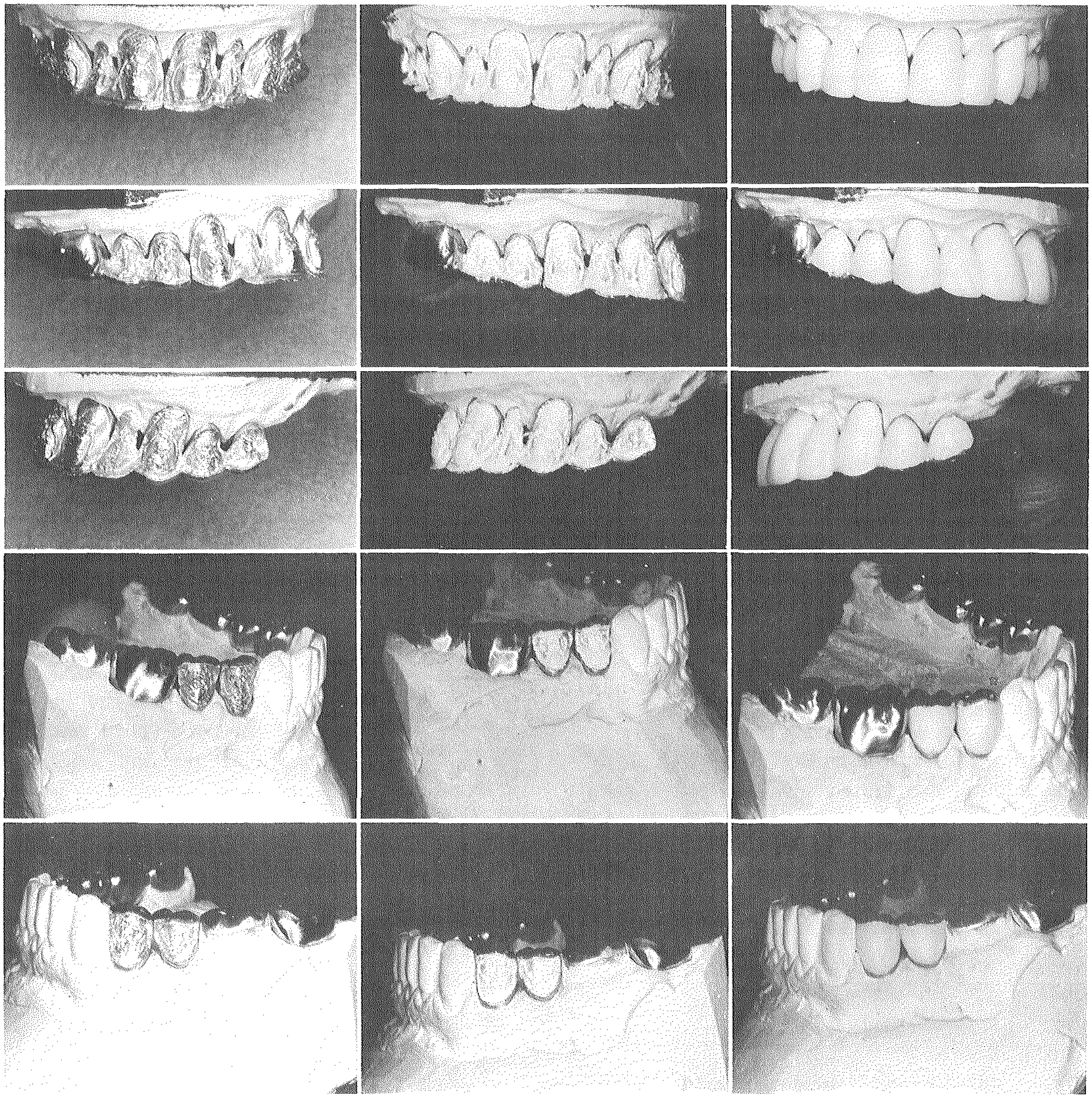


Fig. 13-95. Preparation of surfaces to be veneered, application of masking material (D-Paque), and waxing of facings.

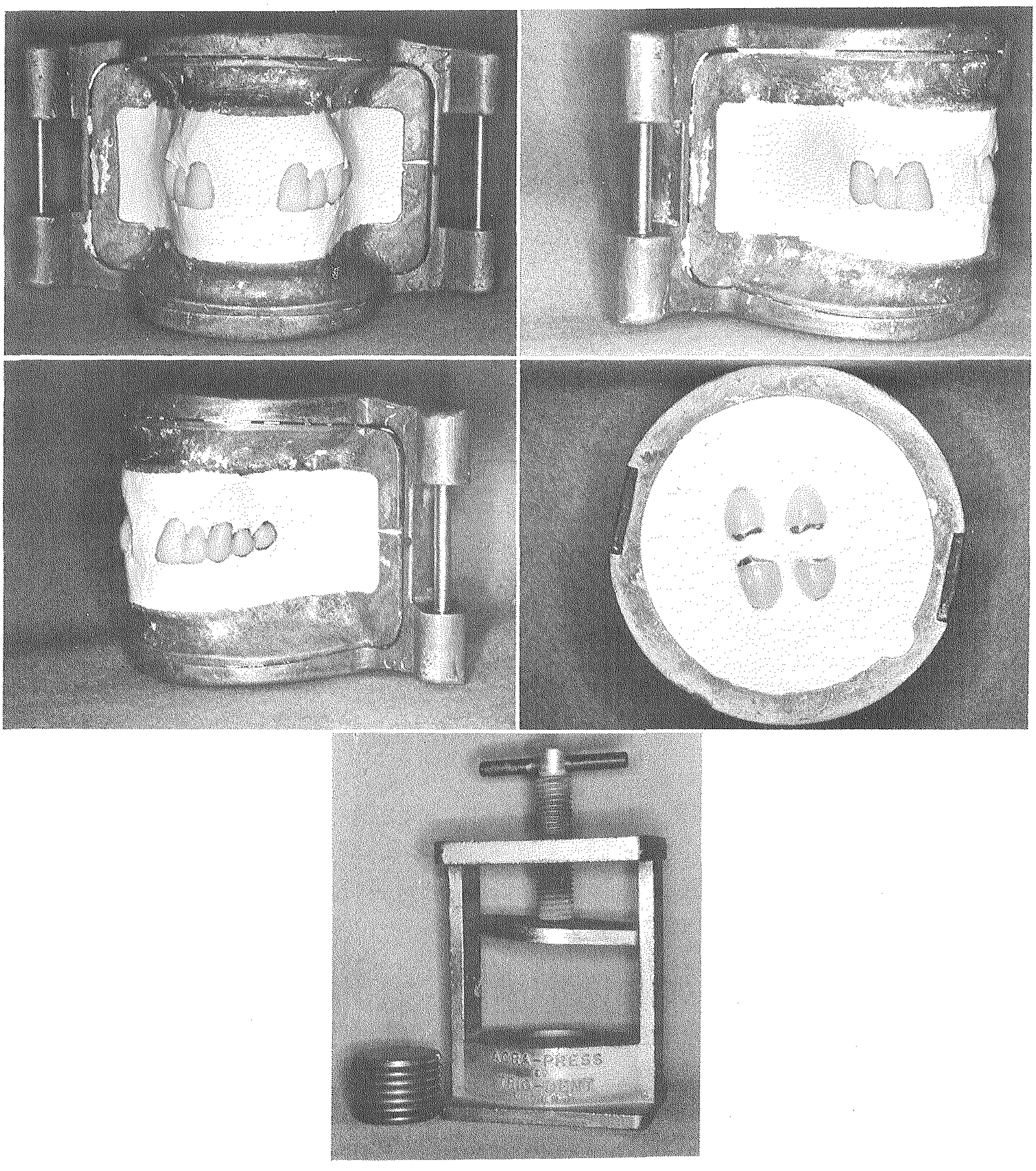


Fig. 13-96. A Kum-A-Part flask was used for investing upper restorations, and a small flask in conjunction with Acra-Press was used for lower restorations.

A B

Fig. 13-97. **A,** Amco wet foil is used after wax has been boiled out—when investment is warm. **B,** Diamon-D acrylic was used in this case. Correct amount of liquid must be used in all Diamon-D mixes.

pearance. Close the jar securely to prevent evaporation.

Place the sealed jar 8 to 10 inches from a 250-watt infrared or heat lamp for approximately three to four minutes. After this time a softening reaction will occur. Remove the jar from under the lamp (material should be in a smooth and creamy stage), and at this time mix the material thoroughly.

Incisal mix. Pour incisal powder into a small mixing jar, and tap the jar while adding the liquid to the incisal powder. Always use more liquid for incisal mix than for body mix. To check consistency, pick up mix on a spatula. It should flow slowly off the spatula.

Place the sealed jar 8 to 10 inches from a 250-watt infrared or heat lamp for approximately three to four minutes.

When Diamon-D liquid has completely penetrated the incisal powder, the mix will be very smooth and slightly runny. Mix thoroughly. If color concentrates or modifiers are needed for modification of body or incisal shades, use them when the mixes are smooth and wet, at which time they will blend and mix easily.

Application of heat to advance body and incisal to the dough stage

Place the sealed jar or jars 8 to 10 inches from a 250-watt infrared or heat lamp for approximately six to eight minutes. Be sure to observe the following:

1. Use a spatula to check the mix after six to eight minutes. Dough should be slightly tough; however, it should still stick to the jar. At this time turn off the heat lamp and remove the jar from under the lamp.
2. Allow warmth of the jar to advance the material to complete the dough stage. This will take two to five minutes, depending upon warmth of jar. Check the material with a spatula to be sure that it is at a complete doughy consistency. The material should pull clean from the jar.

Wrap this dough in a plastic sheet and knead it thoroughly. The correct dough texture for the body will be uniform in color and have a slight shine on the surface and for the incisal will appear slightly translucent and have a slight shine on the surface. Whenever the body or incisal is too dry or chalky, it should not be used. It would not pack or flow properly, and liquid cannot be added to overcome this condition.

Packing and preprocessing body

Place sufficient dough over the mold so that the case is overpacked. Cover with a plastic sheet, and close flask in the press. Open and remove flash. Repeat covering with plastic sheet, closing and pressing, opening and removing flash until test packing no longer creates flash. At this time cover with plastic sheet, close flask (locked in compress), and preprocess body for ten to fifteen minutes in boiling water. After this procedure remove the flask from the boiling water and chill with cold water until the flask can be handled. Then open.

Trimming incisal surface from preprocessed body

Trim away desired incisal area with a bur or a stone. Break glaze slightly on entire facial surface to ensure a bond of incisal area to body. Developmental lines can be made with a small bur. These lines prevent a demarcation line between the body and incisal area and also create a good incisal blend. Carefully blow away all excess grindings.

Packing incisal area

Before packing the incisal area, wet the processed body slightly with liquid. Place an excess amount of incisal dough onto the incisal edge.

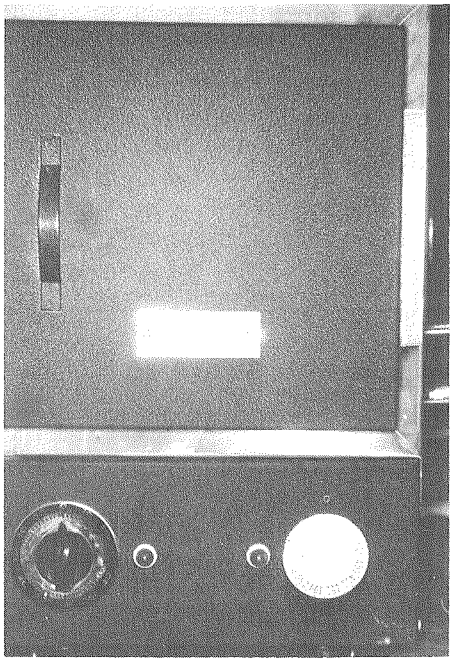


Fig. 13-98. Dry heat oven—Acro-Bake.

Cover with a plastic sheet, and close the flask completely. Allow flask to remain closed in press for two minutes to ensure flow of incisal blend. Open flask, remove flash, and press again. Repeat again, and remove all remaining flash. If blend is satisfactory at this time, close flask for final processing after positioning plastic sheet.

Processing

Place the case (locked in compress) in boiling water for a minimum of thirty minutes; larger flasks require forty-five to sixty minutes. Some technicians are of the opinion that slightly increased hardness will be obtained by boiling for fifteen minutes and then placing in dry heat oven at 550° F. for twenty minutes (Fig. 13-98). I am now of the opinion that placing the case in boiling water for the indicated period of time gives the proper result.

Deflasking

After the case is completely processed, remove it from the boiling water and chill it in cool tap water until the flask is cool enough to handle (Fig. 13-99). Cut a groove through the flash into the investment (as close to case as possible) all around the case with a bur or disk. This step prevents fracturing of delicate margins.

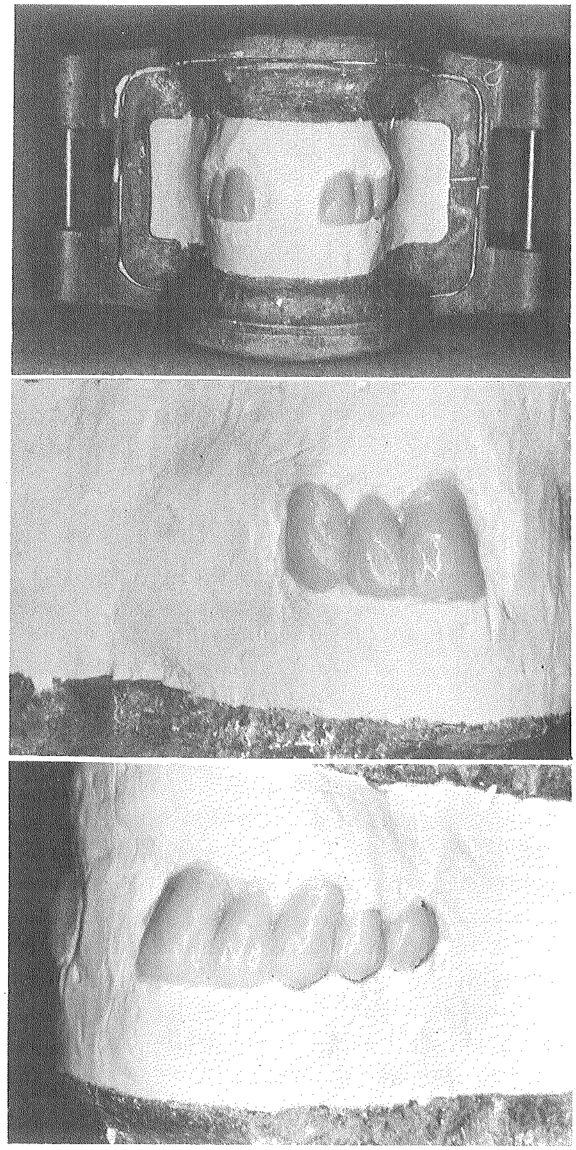


Fig. 13-99. Views of case after being completely processed (in flask).

Finishing and polishing

When contouring and shaping facings, always use fine stones or burs. Next, go over the complete surface with a fine, soft, rubber wheel to remove all scratches and other rough areas. This is very important in the interproximal or embrasure areas.

Polish the facing first with pumice and then tripoli, and bring it to a high luster with tin oxide.[23] Cleanse it thoroughly in an ultrasonic apparatus.

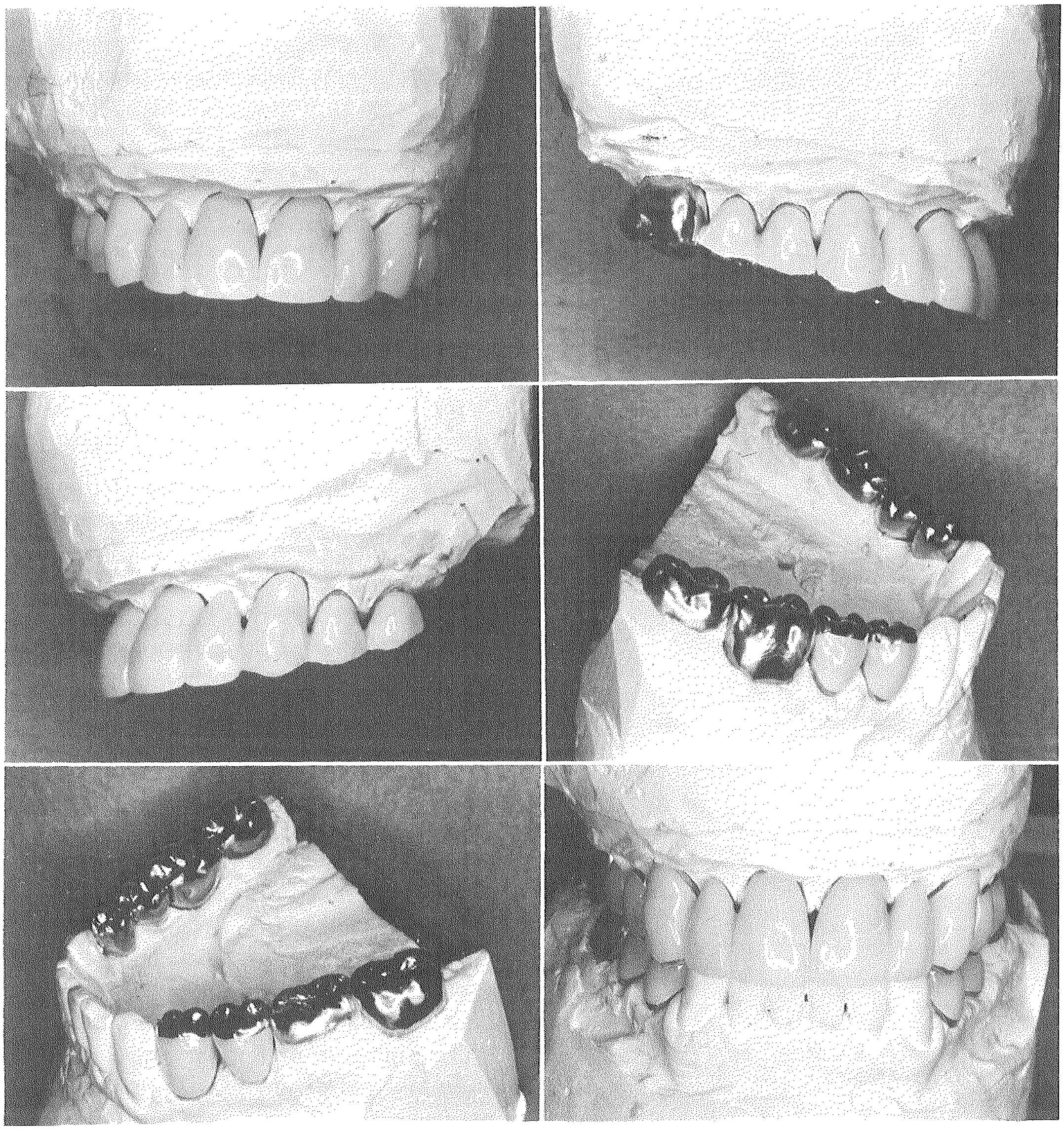


Fig. 13-100. Processed case was finished and polished, repositioned on articulator, and examined carefully for any possible changes caused by processing.

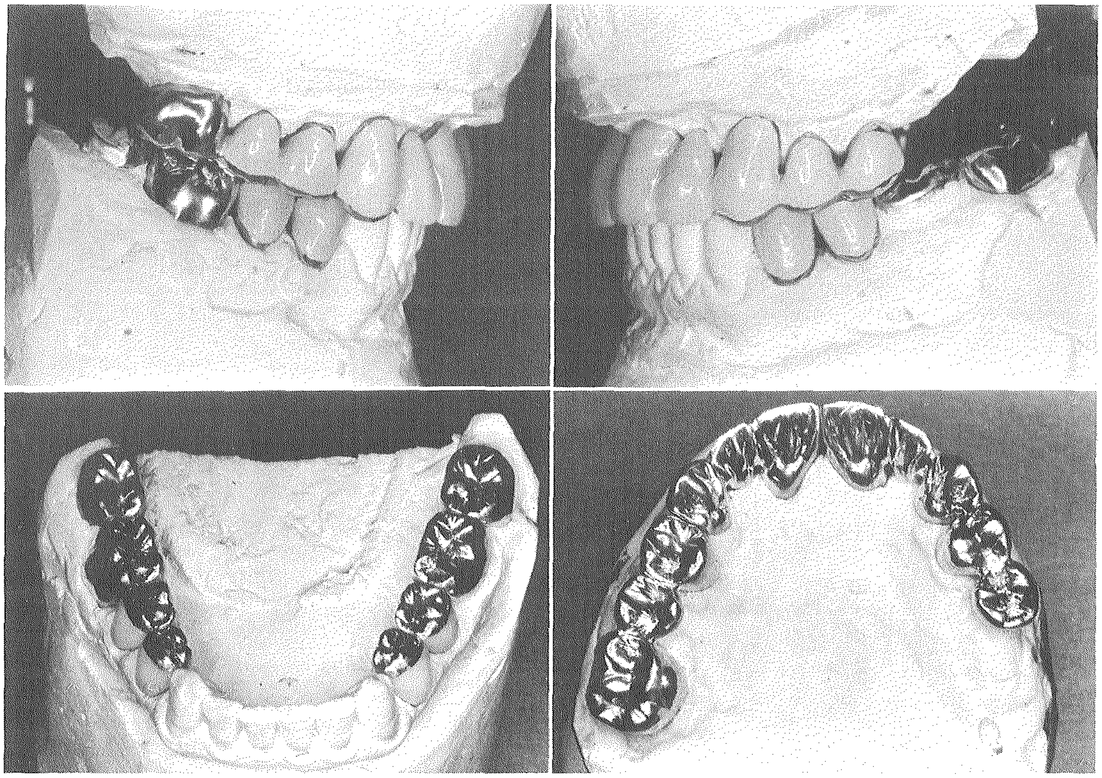


Fig. 13-100, cont'd. Note relation of upper and lower restorations and lower and upper occlusal views.

The processed case was then repositioned on the articulator and examined carefully for any possible changes caused by processing (Fig. 13-100). Test glides are made, and, if glides are similar to those before processing, we are ready to seat the case in the patient's mouth.

Cementation

Preliminary steps

All temporary restorations are removed carefully, and temporary cement is thoroughly cleansed from all tooth surfaces.

Now the new restorations are seated and examined with great care for marginal fit, coronal and embrasure contours, contact areas, pontic to ridge relationship, esthetics, and phonetics, after which test glides are made and centric holds determined, making use of cellophane (1/1000-inch thickness). Also voluntary jaw movements, which depend upon the neuromuscular mechanism to carry mandible between extremes of border movements, are observed. If desired specifications are met, the case is removed, dried, and reseated, using a mix of zinc oxide powder and petroleum jelly for a period of two weeks. At this time the case is again evaluated and, if not found wanting is cemented temporarily with a zinc oxide–eugenol cement (Moyco* or Opotow†) for two to three months. At the end of this period of time the case is "remounted" (with temporary cement remaining in castings) for possible minimal adjustments before cementation with oxyphosphate of zinc cement or EBA cement (if conditions are ideal).

The purpose of temporary seating with zinc oxide and petroleum jelly is for maximum seating if a number of teeth had demonstrated a mobility pattern and for testing if parallelism of retainers is correct. It also "proves out" the occlusal factor by showing a nice white liner of this paste in all retainers indicating no "washouts."

If we believe that the articulation has been correctly oriented to the patient's jaw move-

*J. Bird Moyer Co., Philadelphia, Pa.
†Opotow Dental Mfg. Corp., Brooklyn, N. Y.

ment and the periodontal tissues show signs of healing, permanent cementation can be considered.

Finishing and cementation are covered in detail in Chapter 10, but a few procedural steps will be repeated for purposes of continuity.

Margins of castings are finished with small stones (No. 39 Chayes stone), using them with a circular motion. Torit XX fine ½-inch garnet paper disks also are used. Both stones and disks are coated with petroleum jelly during use. Gingival areas are finished with strips.

For pin cementation use is made of a thumb reamer of suitable size, which has had the point removed, to carry the cement into the pinholes. After carrying the cement into the holes, the reamer is removed by rotating it counterclockwise, thereby avoiding the trapping of air in the holes and carrying the cement to the bottom of the holes.

Procedural steps in "hard" cementation

No dental cement is capable of true adhesion to the tooth structure. It is an adjunct to retention, but not the sole source. A retentively shaped abutment preparation and a well-fitting casting in conjunction with the correct cement properly handled make a long-lasting restoration.

1. If the patient manifests a copious flow of saliva, give him two 50 mg. Banthine tablets thirty minutes before operation.
2. If teeth are overly sensitive, it is best for all concerned to use a local anesthetic.
3. Cleanse preparations of debris and adherent remnants of zinc oxide–eugenol cement, using chemically pure benzine or carbon tetrachloride. Examine the gingival crevices carefully for particles of temporary cement. Be sure the soft tissue is retracted enough so that it is not impinged upon by the gingival edge of the crown when being cemented.
4. Flood the gingival crevice with epinephrine solution, 1:100, to eliminate seepage from the gingival tissues. Allow it to remain three minutes, after which wash away with warm water.
5. Isolate preparations and maintain them in complete dryness by means of cotton rolls or a rubber dam in conjunction with a saliva ejector (Fig. 13-101). The presence of moisture interferes drastically with the crystallization of the cement. Excessive desiccation of the dentin with air blasting must be avoided.

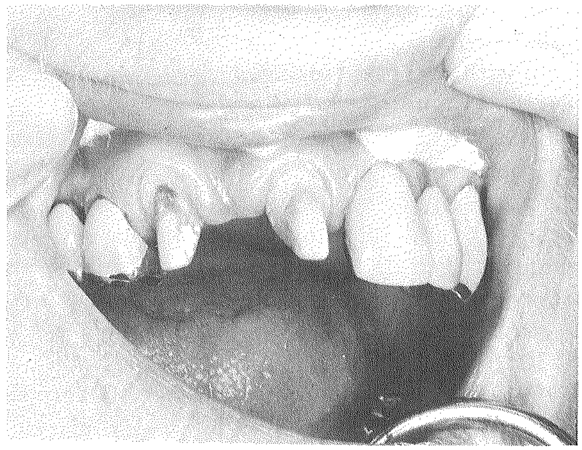


Fig. 13-101. In "hard" cementation (oxyphosphate of zinc cement) isolate preparations and maintain them in complete dryness by means of cotton rolls or rubber dam in conjunction with saliva ejector.

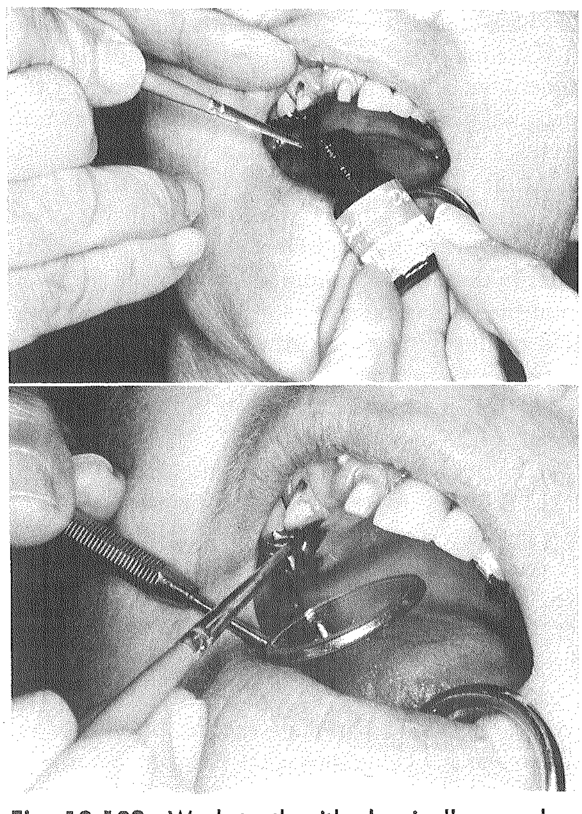


Fig. 13-102. Wash teeth with chemically pure benzine and chloroform, and then swab teeth with Metimyd ophthalmic suspension. After three minutes apply a preparation consisting of 25% parachlorophenol, 25% metacresylacetate, and 50% U.S.P. camphor (with or without 1% prednisolone). Dry very carefully with warm air, after which remove oily film of medicament with carbon tetrachloride.

6. Wash the teeth again with chemically pure benzine and chloroform, and then swab the teeth with Metimyd* ophthalmic suspension. Allow the suspension to remain three minutes, after which apply a preparation consisting of 25% parachlorophenol, 25% metacresylacetate, and 50% U.S.P. camphor (with or without 1% prednisolone), and allowing it to remain for two minutes. Then dry the teeth very carefully with warm air, after which use carbon tetrachloride to remove the oily film of medicament. (See Fig. 13-102.) Again dry very slowly and carefully.

7. Coat the teeth with a copal varnish (Copalite†) short of the finishing line or margin, and dry carefully with a blast of warm air. A continuous coating (three coats) is essential for maximum protection. (See Fig. 13-103.)

8. Paint with a suspension of calcium hydroxide (Hydroxyline‡ or Dropsin§) using a No. 1 contra-angle sable brush. Thin this suspension of calcium hydroxide slightly in a dappen dish to achieve a nice thin coating. Paint short of the marginal finishing line—it is self-drying and leaves a thin, insoluble film on the dentin.

Logically, the calcium hydroxide should be applied first, but the Copalite varnish dissolves it. Many investigators believe that the use of calcium hydroxide is mandatory to protect the pulp from the damaging effects of the orthophosphoric acid of the cements and that varnishes alone are not effective for this purpose.[24]

9. Use a cement that meets A.D.A. specifications.

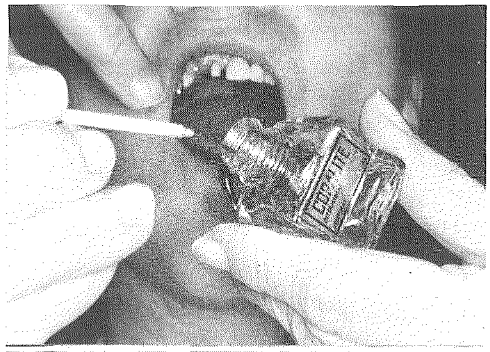
10. Before starting the mixing of the cement, it is necessary to prepare the internal surface of the castings for cementation. Slightly roughen the surfaces on the inside of the casting with a No. 33½ inverted cone bur just short of the margins—this procedure contributes to the efficacy of the cement bond.

11. Make the cement mix on a thick glass or ceramic slab. The slab should be chilled to 60° to 70° F., being sure that it is not below the dew point. (See Figs. 13-104 and 13-105.)

12. The liquid must be placed on the slab just prior to starting the mix. To permit adequate working time in making multiple cementations, the setting time may be retarded by spatulating a small quantity of powder into the liquid and by allowing this to stand for two or three minutes before adding the remainder of the powder. Four or five drops of cement liquid for each casting should be sufficient.

13. After two or three minutes have elapsed, add small increments of powder to the liquid, using a rotary motion to incorporate it thoroughly. Adding large amounts of powder will hasten the set and render the operator's working time unpredictable. Utilize as much of the slab as possible, keeping the mass under control at all times. (See Fig. 13-106.)

14. When the mix of cement is at approximately the halfway mark, "the dentist should pause to wipe the spatula blade dry with a piece of lintless gauze. The spatula blade often has free acid along its sides and upper reaches. This may enter the completed mix when all the cement is gathered in, thereby inadvertently including free acid in the finished cement. Once the spatula blade is wiped dry, the dentist will see an immediate change in the character of the



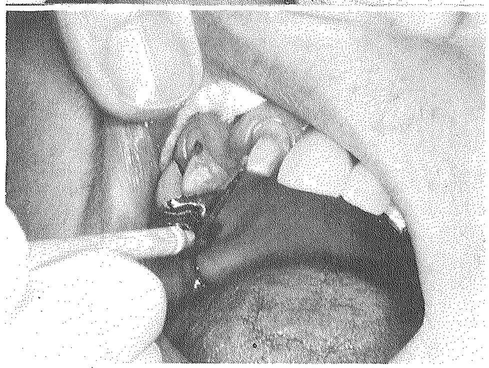


Fig. 13-103. Coat teeth with a copal varnish (Copalite) short of finishing line or margin. Apply a continuous coating (three coats) for maximum protection. Dry carefully.

*Schering Corp., Bloomfield, N. J.
†William Getz Corp., Chicago, Ill.
‡George Taub, Inc., Jersey City, N. J.
§Svedia, Enkoping, Sweden.

Fig. 13-104. Make cement mix on a thick glass or ceramic slab. Chill slab to 60° to 70° F.

Room temperature	Relative humidity (%)	Slab cooled to: (°F.)
90°	40	64°
	50	71°
	60	76°
	70	80°
	80	85°
	90	88°
85°	40	55°
	50	66°
	60	71°
	70	77°
	80	80°
	90	83°
80°	40	55°
	50	60°
	60	66°
	70	71°
	80	75°
	90	78°
75°	40	50°
	50	56°
	60	61°
	70	66°
	80	70°
	90	75°
70°	40	46°
	50	52°
	60	56°
	70	61°
	80	65°
	90	68°

Fig. 13-105. Humidity or "safe" dew point chart for dental cements. Mixing surfaces below specified temperature tend to condense moisture, which weakens cement. (Courtesy Dr. Chester J. Henschel, New York, N. Y.)

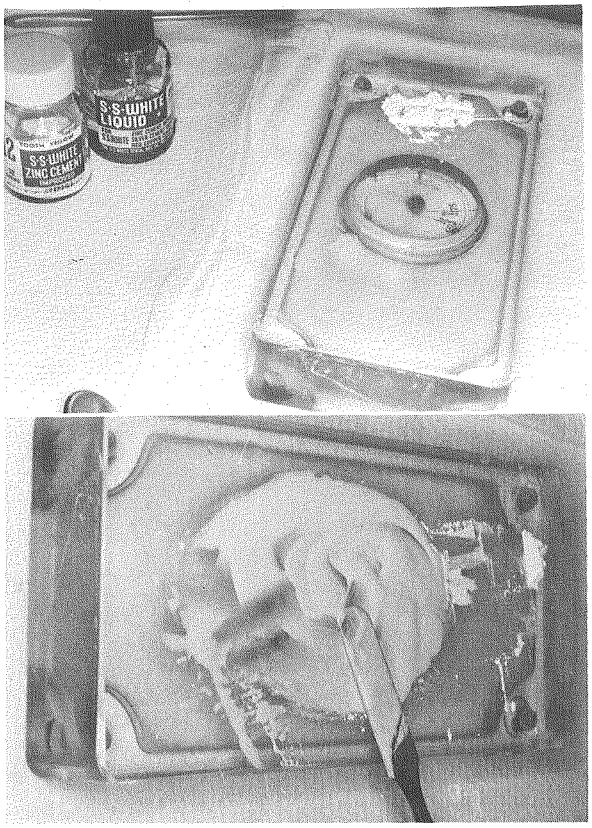


Fig. 13-106. Liquid is placed on slab just prior to starting mix. Add small increments of powder to liquid, and use a rotary motion to incorporate it thoroughly. Incorporate maximum amount of powder into a given quantity of liquid—have mass plastic enough to allow castings to seat properly. A thin mix with a maximum amount of powder in it is desired.

cement mix, because free acid no longer enters the mix from the spatula blade."*

15. Incorporate the maximum amount of powder into a given quantity of liquid but keep the mass plastic enough to allow proper cementation of the castings. For good consistency a strand of cement should follow to a height of $\frac{1}{2}$ to $\frac{3}{4}$ inch. Also, solubility is directly related to the amount of powder used. The mix should be very smooth.

16. The time of mixing should be approximately one and one-half to two minutes.

17. After the cement has been mixed properly (a thin mix with a maximum amount of powder in it), coat the casting (or castings) with a film of cement first (in the creamy consistency recommended) because of the disparity between mouth and room temperature, and then fill or cover the preparations with the cement mix. Next seat the restoration with finger pressure immediately followed with heavy pressure, using an orangewood stick and mallet. Use a vibratory motion (with orangewood stick) to help express surplus cement, after which keep the seated restoration under a sustained pressure with the orangewood stick, or a Medart's inlay pressure applicator, until the cement has set, which is usually from five to seven minutes. (See Fig. 13-107.)

A good cement offers an excellent flow characteristic to ensure positive and complete adaptation of locking cement to opposing surfaces of tooth and restoration. The locking film of cement is so thin that it is impossible to detect any lifting of the restoration. In addition to low film thickness other important characteristics, or properties, essential for complete placement of restorations are (1) smoothness of mix, (2) extra strength resulting from high powder-liquid ratio, (3) high resistance to solubility in mouth fluids, and (4) adjustable setting speed—fast, medium, or slow, as needed in each operation.

I use the camel's-hair brush technique developed by McEwen[25] for the application of the cement to the casting and the tooth preparation for the elimination of air bubbles and for a constant and adequate cement coverage. The cement is brushed into the crown and onto the preparation in a thin layer, and, if several crowns are to be cemented at the same time, several brushes are used. One brush for two crowns is a good ratio.

Many times it is advisable to allow the assistant to hold the restoration with an orangewood stick or steel rod while the dentist burnishes the accessible margins before the initial set of the cement takes place because excellent marginal adjustment can be obtained while the cement is in a plastic state. Slight disking with fine cuttle disks is done immediately after all accessible margins have been burnished with a broad burnisher to force margins of gold castings, which may be displaced slightly by hydraulic pressure, against the tooth structure.

*From Berman, Martin H.: Preservation of pulp health during complete coverage procedures, J.A.D.A. 70:83-89, 1965.

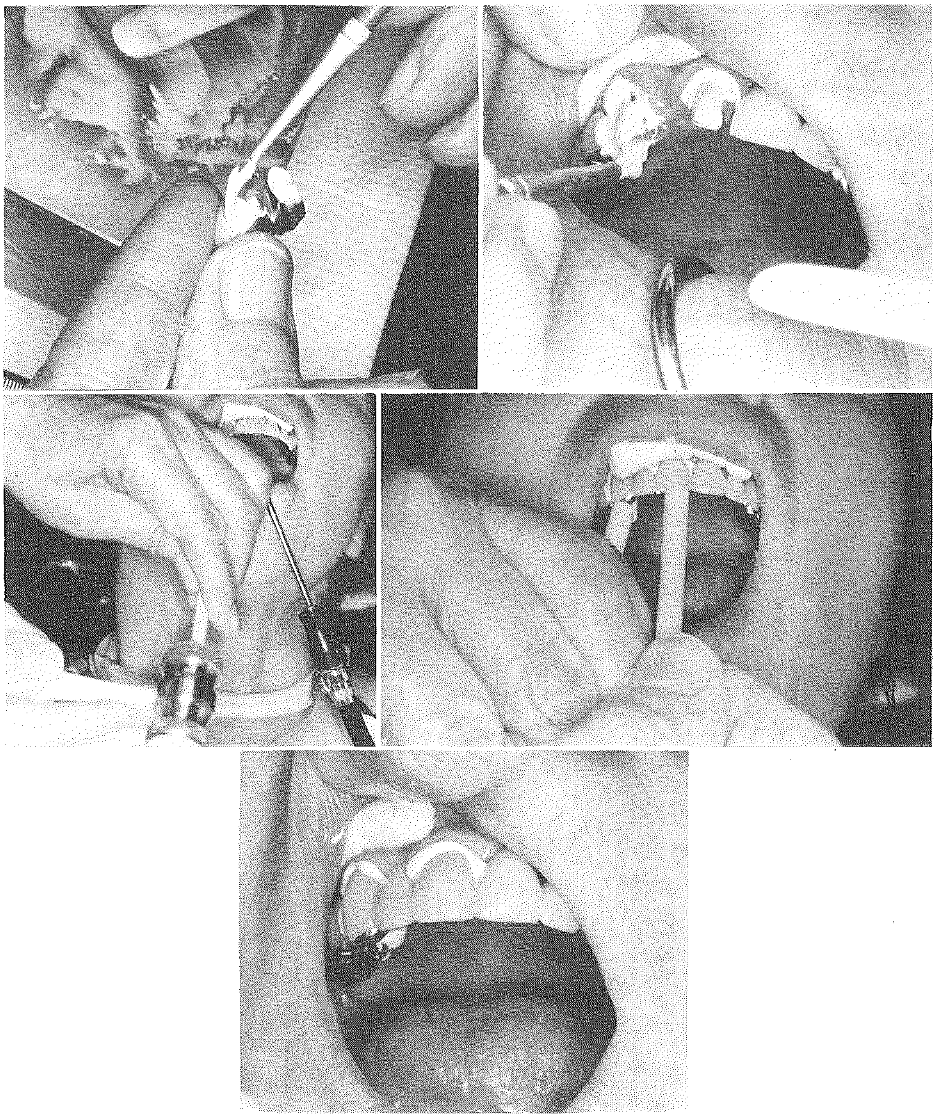


Fig. 13-107. Coat cavity side of casting first, and then preparations are filled, or covered, with cement mix. Restoration is seated with finger pressure, immediately followed with heavy pressure using orangewood stick and mallet. Use a vibratory motion, with orangewood stick, to express surplus cement. Seated restoration is kept under a sustained pressure until cement has set.

This procedure can eliminate the finest cement lines.

18. When the cement has set thoroughly, remove excess cement, being very careful to do so subgingivally, in contact areas and under pontics. Bite-wing roentgenograms will be of great help in checking for vestiges of cement, the removal of which is so important for gingival health.

19. Check occlusion—centric and eccentric positions. Although castings have been stripped or vented and the cement mix has been made correctly, the gingival margin, at best, is scant 0.0005 inch. This could necessitate a slight occlusal adjustment.

20. Polish restoration with a suitable moist polishing abrasive. The ones recommended by

Fig. 13-108. Postoperative roentgenograms of completed restorations.

Stibbs,[26] No. 303 Centriforce abrasive* and No. 309 W Centriforce abrasive (a finer polishing abrasive) used with a soft rubber cup, are excellent.

The entire finishing process must be executed with extreme care so that the abutment teeth are not overheated.

The gingival tissue will heal quickly from any mutilation incidental to the production of the complete restoration, provided tooth morphology is correct, subgingival margins are accurate, and gold surfaces are polished properly.

At the next appointment examine occlusal surfaces very carefully, and, if minute variations of mandibular movement impossible of registration by present means cause a small shiny facet or two, reduce them with the flat surface of a No. 37 inverted cone bur. This type of adjustment is minimal if all steps have been executed accurately.

Take postoperative roentgenograms of completed restorations (Fig. 13-108) and postoperative photographs (Fig. 13-109), and correctly orient postoperative models on the adjusted articulator (Fig. 13-110) for study, evaluation, and future reference and documentation.

Results

Correct masticatory relationships were established. The patient has a negative occlusal perception. Gingival tissues now have returned to a normal, healthy color and tone. Anterior teeth have lost their marked mobility; all other mobile teeth have tightened up. Esthetics is satisfactory, and the patient is functioning well enough for her to feel that refusal to wear a removable appliance is not harming her masticatory organ. (See Fig. 13-111.)

*American Optical Co., Southbridge, Mass.

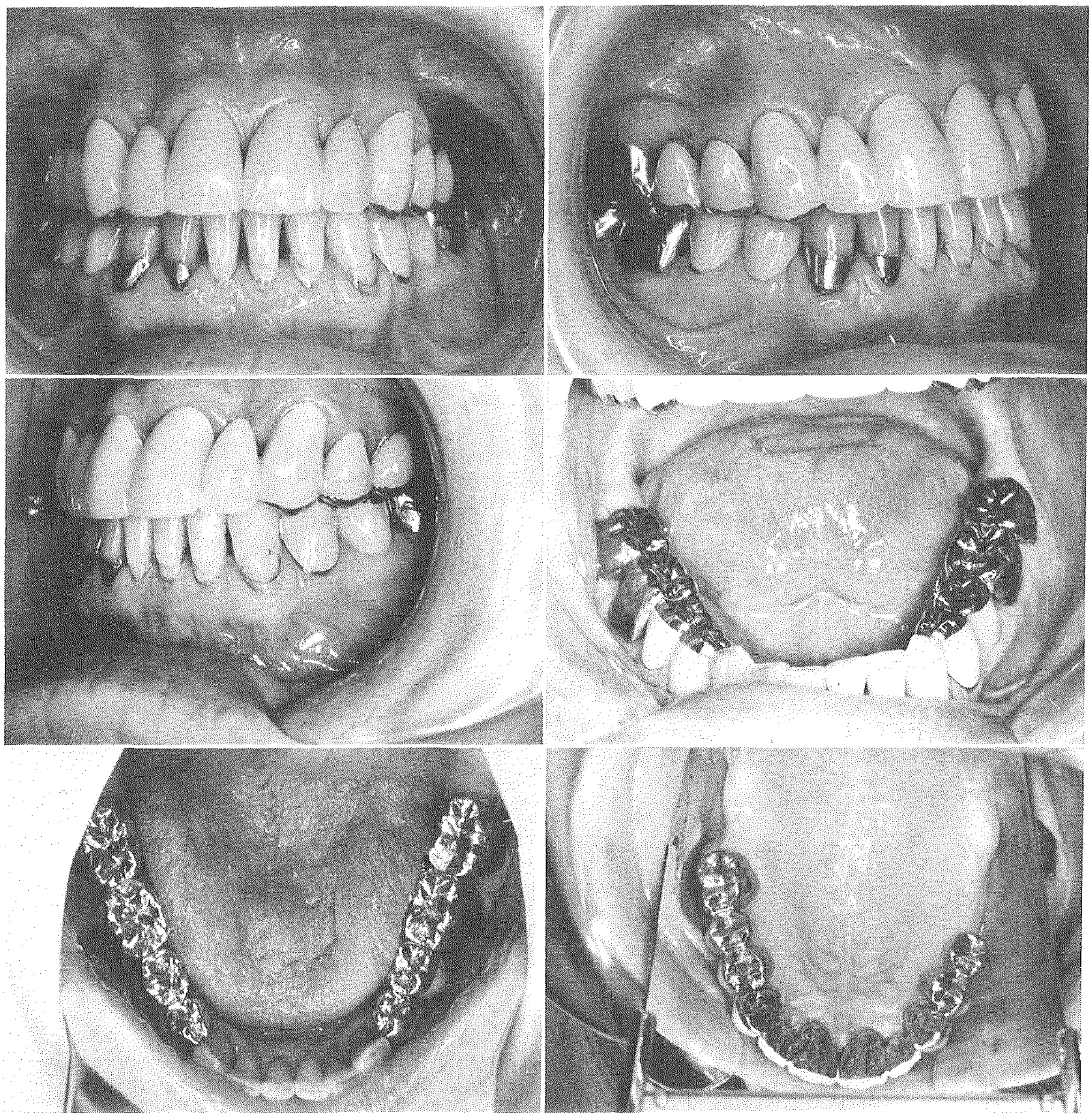


Fig. 13-109. Postoperative photographs of case being considered. Stabilization of lower anterior teeth has taken place, and fillings can be replaced now for better cervical third contour and esthetics.

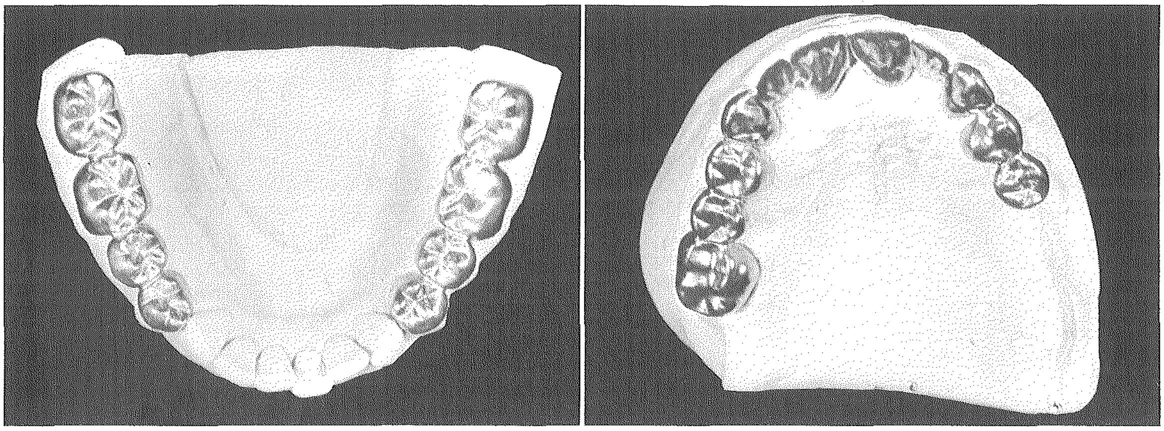


Fig. 13-110. Occlusal views of postoperative models. A precise technique, not an empirical one, was considered in this chapter.

Fig. 13-111. My laboratory.

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Chapter 14

Case histories

In the final analysis the value of mouth rehabilitation can be proved only by response of the tissues. Any concept of mouth rehabilitation, if it is to serve a useful purpose in oral health, must demonstrate clinical and radiographic evidence of its value as an adjunct in the treatment of periodontal disease. Roentgenographically, the objective is for the periodontal ligament space, lamina dura, and density of bone to be restored to normal. Mobile teeth should become firm, and the restored color, texture, and tone of the gingival tissues, which are gained from periodontal therapy, should be maintained.

All the cases presented in this chapter had periodontal involvement; the majority were involved severely, and some were considered terminal cases.

Case 1

Vital statistics

Male, a business executive, 43 years of age when first seen.

Medical history

Patient was in good general health. The only unusual past medical history was a septicemia, caused by a dog bite, which almost claimed his life at age 25. He experienced no serious illness of any kind before or since this episode.

Dental history

Fear of dental treatment prevented adequate dental care. The only time the patient voluntarily appeared in a dental office was when he was in severe pain, necessitating extraction of a number of posterior teeth, which were never replaced. Home care was badly neglected.

Chief complaints

Complaints included bleeding of gums, difficulty in chewing, packing of food between teeth, looseness of a number of teeth, and a change in the esthetic pattern of the anterior teeth.

Clinical examination

A carelessly kept mouth was evident at a glance. A severe mobility pattern was evident, and the periodontal involvement of the remaining lower molars and the lower central and lateral incisors was such that removal of these teeth was indicated. Besides a loss of vertical dimension and the upper right and left first bicuspids showing a rotation probably necessitating minor tooth movement, the remaining teeth showed periodontal involvement. Varying degrees of pocket formation were present throughout the mouth. A secondary occlusal traumatism was causing some "fanning" of the upper anterior teeth. Lips, cheeks, palate, tongue, floor of the mouth, and throat appeared normal. The few restorations in the remaining teeth were executed poorly. Pulp tests showed that all teeth were vital at time of initial examination.

A full-mouth roentgenographic examination was done, followed by cast orientation on an adjustable articulator for diagnosis, treatment planning, construction of clutches for registrations, etc. Photographs were taken also.

Examination of roentgenograms correlated with clinical examination and study of correctly oriented casts verified a lack of coincidence of centric occlusion and centric relation, poorly related teeth, hopelessly involved lower central and lateral incisors and remaining molars, a serious periodontal condition, and many biomechanical difficulties, including an insistence on the part of the patient that a lower removable appliance was not to be considered as part of the treatment plan. He was positive that he could function and chew well enough without lower molars.

Diagnosis

Occlusal periodontitis.

Treatment plan

The plan included removal of all hopeless teeth, initial subgingival curettage followed by advanced periodontal surgical procedures, temporary and permanent splintage using full coverage, and some minor tooth movement if conditions warranted this procedure.

Prognosis

The patient was told very positively that his was a terminal case worthy of heroic measures, but without any promise as to its longevity. If home care was not to be well executed, he was to forget the whole plan. A roentgenologist and an oral surgeon strongly advised the removal of all remaining teeth and the construction of full dentures. However, the patient was determined to follow my plan of treatment and to take his chances.

Therapy

After removal of hopeless teeth and initial subgingival curettage, the preliminary preparation of the remaining teeth was completed and temporary splintage executed in preparation for the advanced periodontal procedures to be performed by a periodontist.

Case 1-1. Preoperative roentgenograms showing extent of periodontal disease.

After healing and keratinization of tissues, delineation of marginal outlines of all teeth was completed, impressions were taken, and hinge-bow transfer and interocclusal records were made for orientation of working casts on an adjustable articulator for proper interarch and intra-arch relationships of the restorations. Form and function were the prime objectives. This case was done before the telescopic principle of splinting became available for this type of work, and, in trying to parallel the lower teeth to each other, a pulp exposure occurred in the lower left first bicuspid, requiring endodontic treatment.

Results

This case has been temporarily cemented for thirteen years, being removed periodically for examination, reevaluation, resurfacing of veneers from time to time, and recementation.

Correct masticatory relationships were established for good efficiency in function and have maintained themselves. The patient reports that he chews with ease and comfort. Gingival tissues have good color, texture, and tone despite the fact that home care is only fair. The mobility pattern has been reduced markedly, and a negative occlusal perception is present. A narrowing of the periodontal ligament width and reformation of lamina dura has occurred, with no further alveolar resorption. The teeth seem capable of functioning in health because of the alteration in mouth of periodontal climate greatly assisted by proper form and function of the restorations. (See Case 1-1 to 1-10.)

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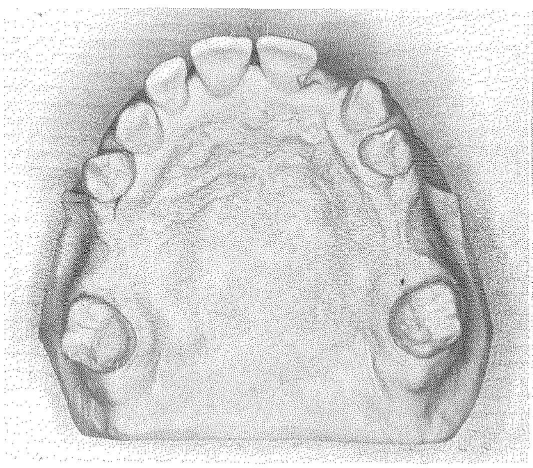

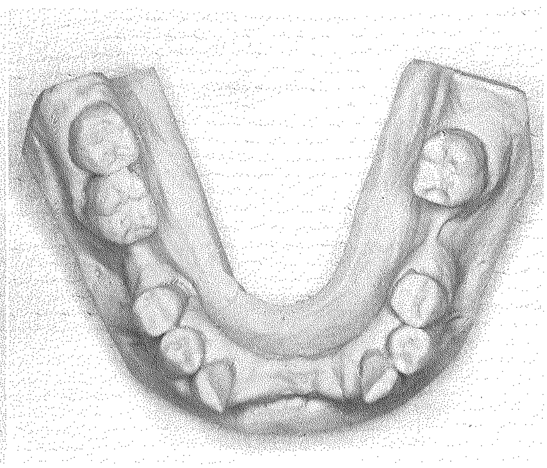

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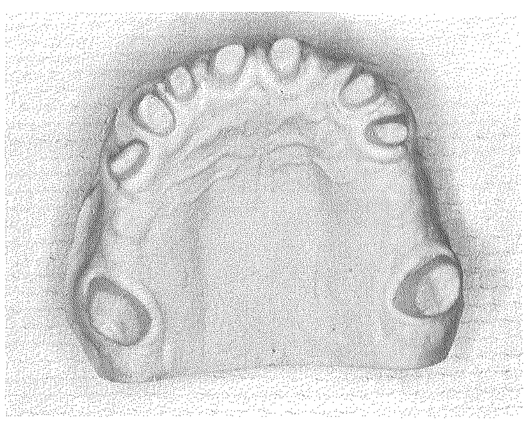
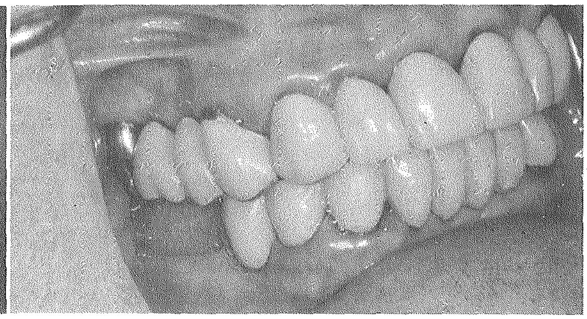
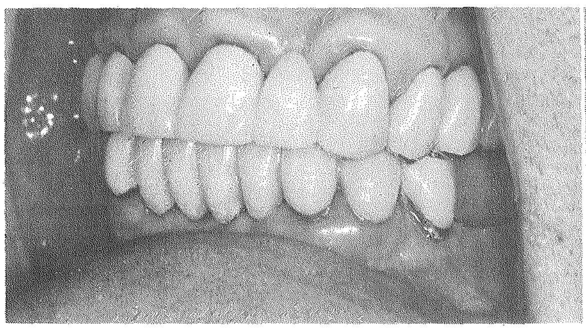
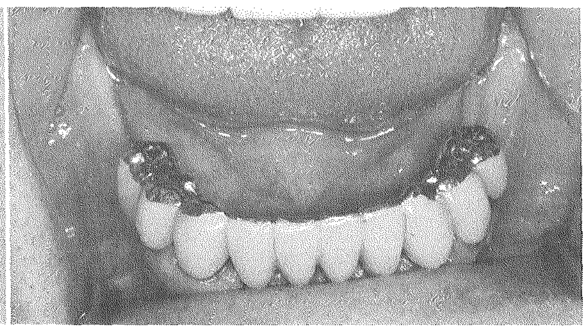
Case 1-2 and 1-3. Casts of upper and lower teeth (preoperative).



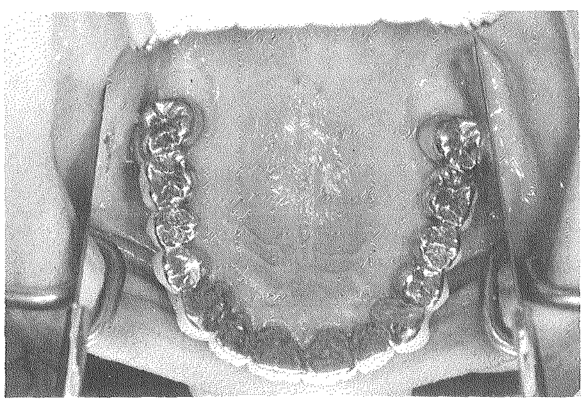
Case 1-4. Cast of upper preparations.

5   6

Case 1-5. Relation of upper and lower teeth (postoperative).
Case 1-6. Relation of teeth on right side (postoperative).

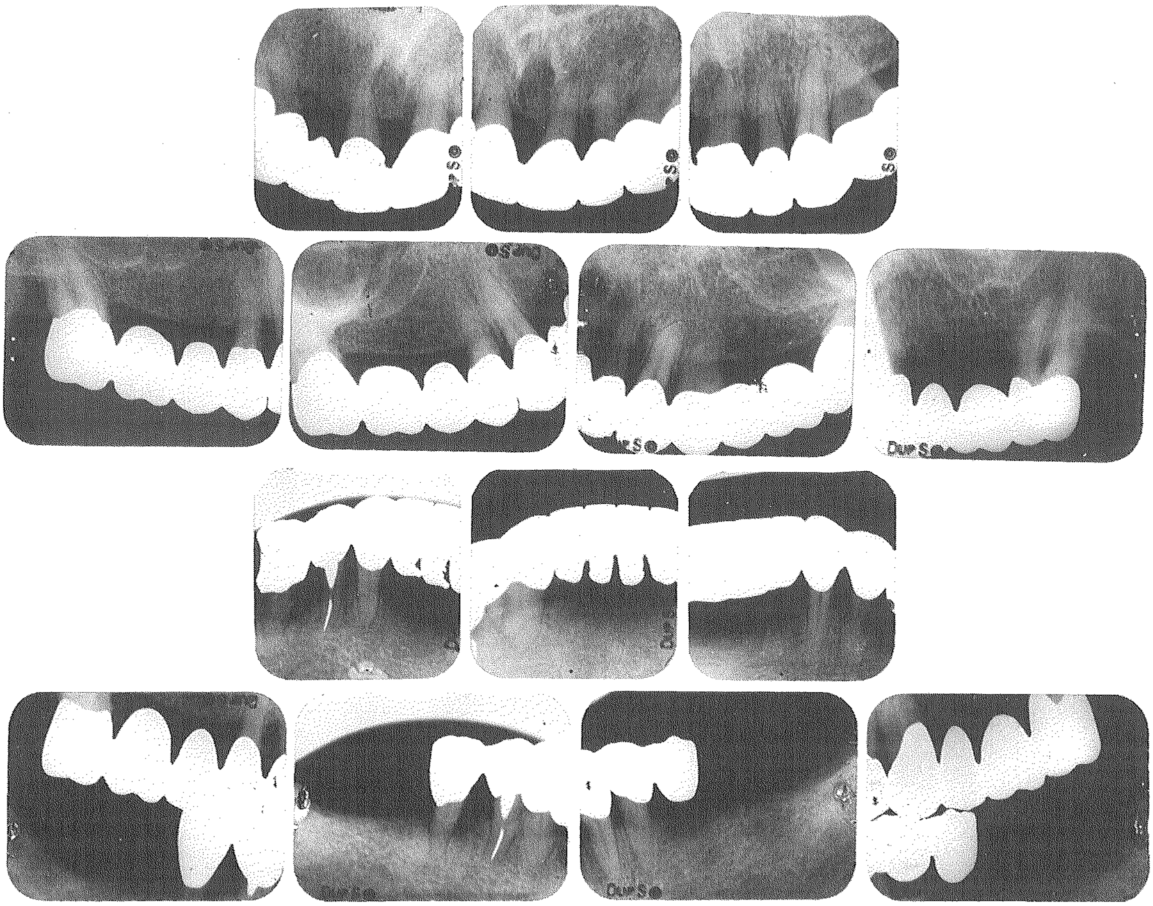
7   8

Case 1-7. Relation of teeth on left side (postoperative).
Case 1-8. Occlusal view of lower restorations (completed case).



Case 1-9. Occlusal view of upper restorations (completed case).

Photographs were taken twelve years postoperatively. Note coronal contours, embrasure form, amount of attached gingiva, tissue tone and form. Also note type of occlusal anatomy used in this periodontally involved case to fulfill therapeutic occlusal objectives. Bilateral splinting and full coverage were used. A cantilevered pontic replaced the lower right second bicuspid.



Case 1-10. Roentgenograms taken thirteen years postoperatively reveal a thinning of periodontal ligament space, reformation of lamina dura, and maintenance of the healed situation.

Case 2

Vital statistics

Male, a college administrator, 46 years of age.

Medical history

The physician reported that the patient was in comparatively good health, although afflicted with duodenal ulcers. The report also mentions an obvious psychogenic component, which was probably responsible for the ulcers and a bruxing habit.

Dental history

Apparently the patient's dental I.Q. was low up to the time that a thorough clinical and roentgenographic examination revealed a bad oral situation, at which time his sharp and searching mind discovered that dentistry was both an art and a science at a high level of development. The dental clinic of the university with which he was connected diagnosed his condition as occlusal periodontitis. It was believed that extensive periodontal therapy and oral reconstruction were indicated.

Chief complaints

Wearing away of the chewing surfaces of his teeth accompanied by a looseness of many of the teeth and a bleeding of the gums were the patient's major problems.

Clinical examination

Despite the patient's low dental I.Q. his oral hygiene habits were of the highest order, probably because of his compulsiveness. Periodontal disturbance was very evident. Pocket depth was formidable, and a severe mobility pattern necessitated the removal of the upper left first bicuspid immediately. In general, the oral mucosa appeared normal. Restorations were not well fitting or properly contoured.

A full-mouth roentgenographic examination was made, and from these roentgenograms, correlated with the clinical examination findings, the Department of Periodontology of the school with which he was connected decided that periodontal surgery was the first order of business. After healing and keratinization of the tissues had taken place, the patient was referred to me for the restorative phase of the treatment.

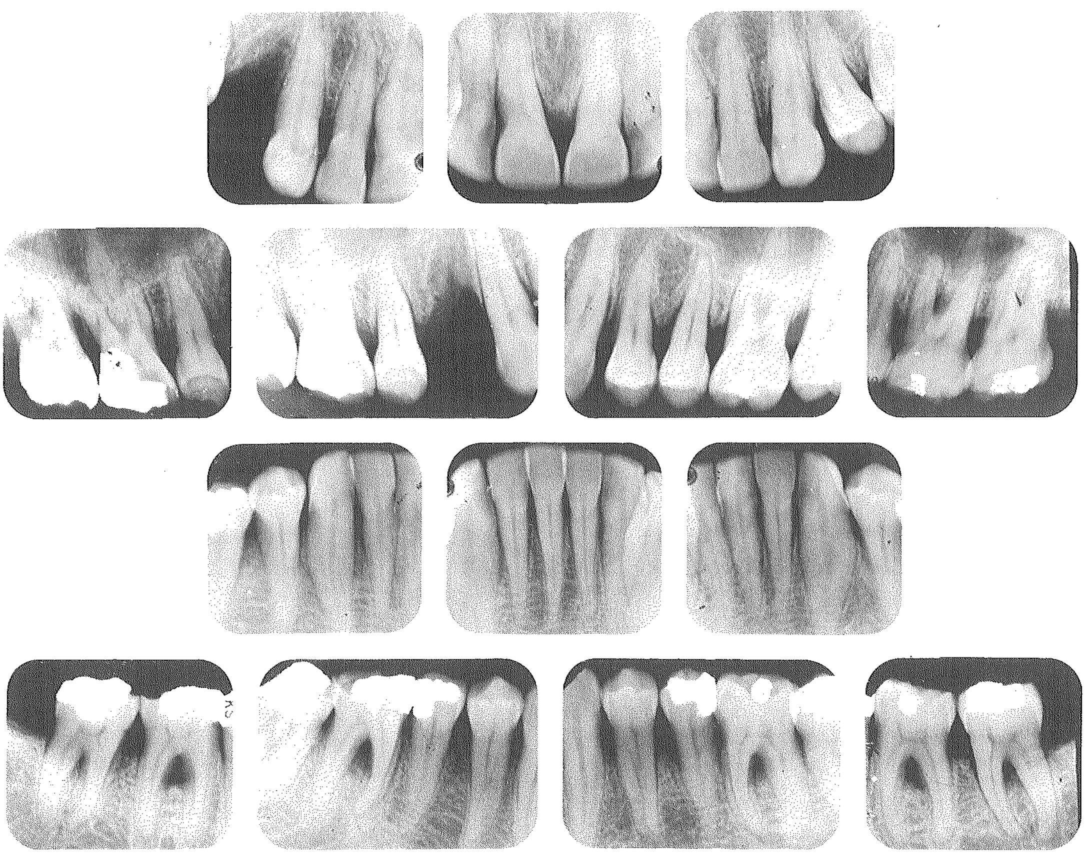
Photographs and correct cast orientation on an adjustable articulator were the first procedures that I completed after studying the reports and roentgenograms sent me by the school authorities.

Examination of the original roentgenograms and clinical findings, correlated with a study of the correctly oriented study casts, verified a lack of coincidence of centric occlusion and centric relation by at least one-half cusp. The right condyle moved from its hinge position approximately 1 mm., whereas the left condyle registered 2 mm. from its hinge position. Bifurcation and trifurcation areas were involved. The patient's posterior teeth were badly abraded in many areas.

Treatment plan

Aluminum clutches were constructed, registrations made, the instrument adjusted to these "writings," and study casts oriented to the correct axis for treatment planning.

Unilateral splinting of all posterior segments, remembering that disregarding the buccolingual component taken care of by bilateral splinting may handicap the end result, was decided upon. It was believed that the upper and lower anterior teeth were so well formed and positioned that



Case 2-1. Preoperative roentgenograms showing extent of periodontal disease.

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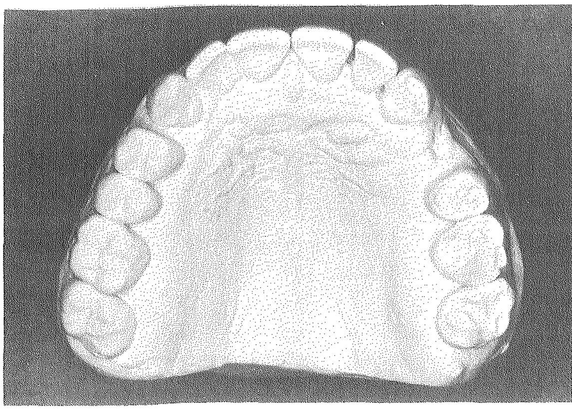
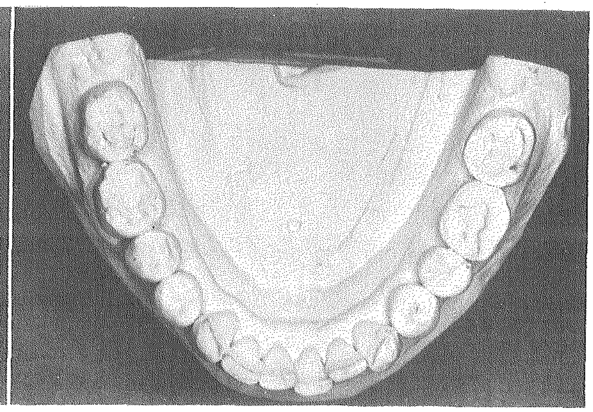
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Case 2-2 and 2-3. Casts of upper and lower teeth (preoperative).

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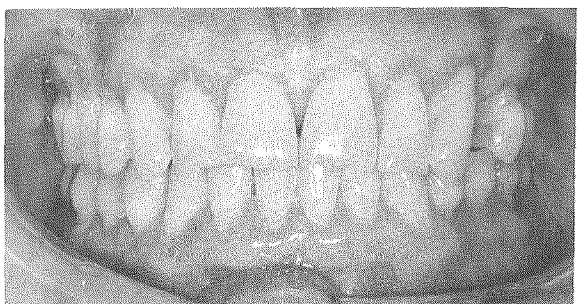

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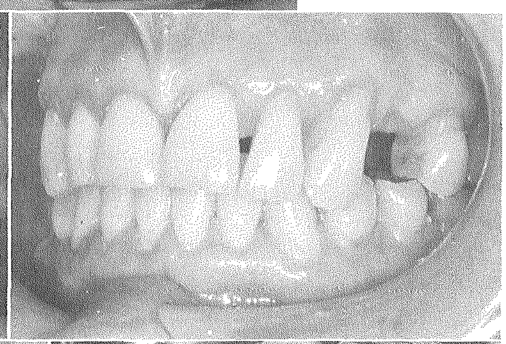
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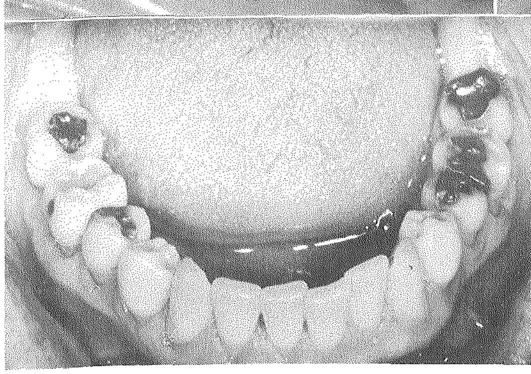
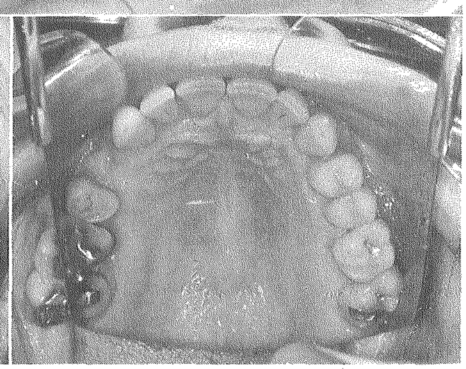
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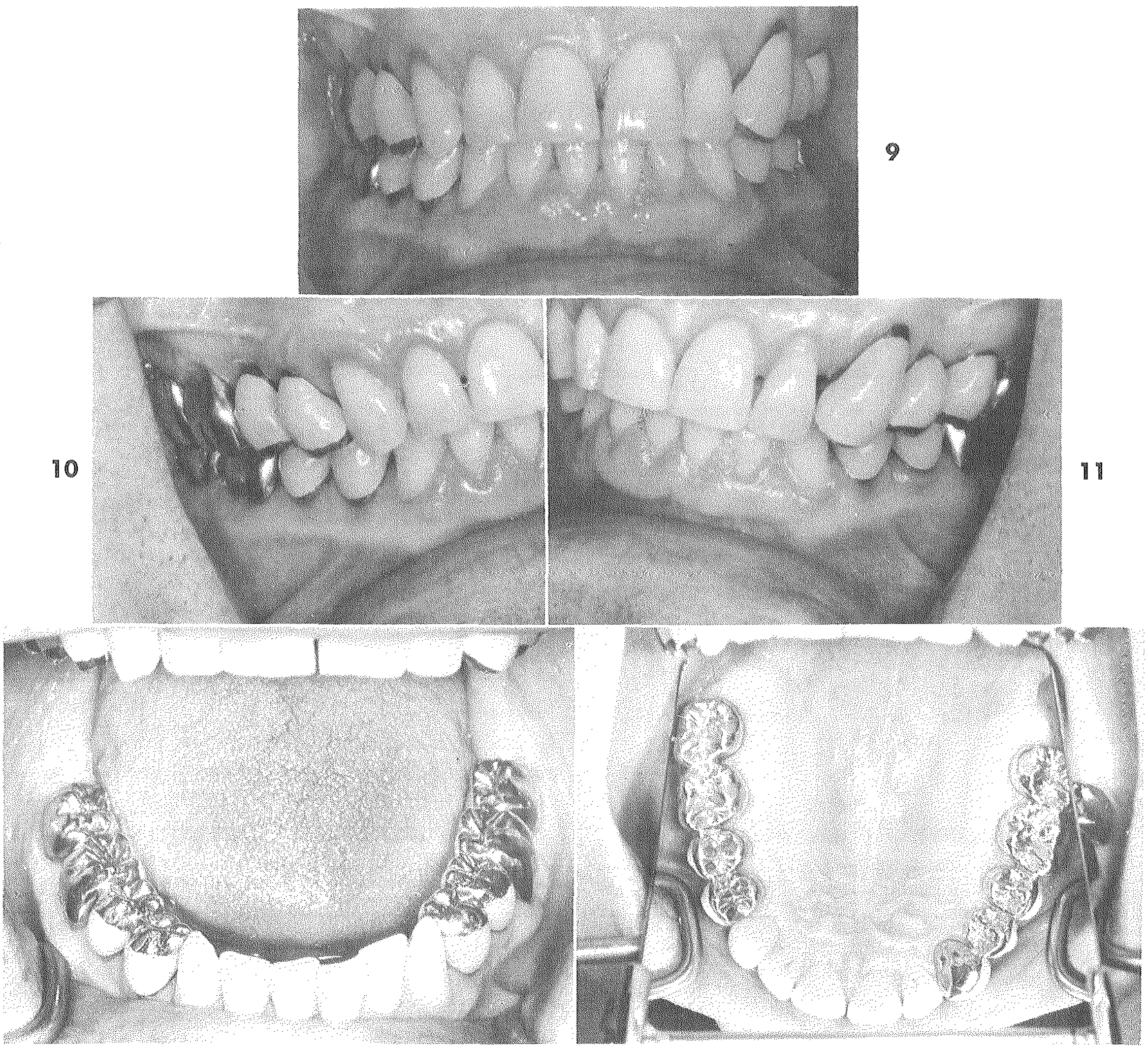
Case 2-4 to 2-8. Preoperative photographs of patient's mouth—anterior, right side, left side, and lower and upper occlusal views.

preparation of them for restorations would do more harm than good. The establishment of a correct centric occlusion–centric relation coincidence aided by a harmony of the eccentric excursive movements and the attainment of other goals would suffice for the case at hand. A night guard was to be constructed on completion of the restorative work.

The case was constructed with great care, following the prescription outlined from a study of all assembled data. It was temporarily cemented, and at the end of one year the case, fulfilling all possible attainable factors, was cemented with oxyphosphate of zinc cement.

Results

Correct masticatory relationships were established. Gingival tissues exhibit a normal-appearing texture, tone, and color. A reduction of the severe mobility pattern is evident, and, after five years of close observation and many roentgenographic examinations, an improvement of oral conditions is very much in evidence. The patient has moved to another city and has not been seen by us for two years, but a recent letter stated that he still chews with ease and comfort, has not lost any teeth, and continues to have a negative occlusal perception. (See Case 2-1 to 2-16.)



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Case 2-9 to 2-13. Unilateral splinting was used. Note amount of attached gingiva, embrasure form, tissue tone, and type of occlusal anatomy used for fulfillment of therapeutic objectives.

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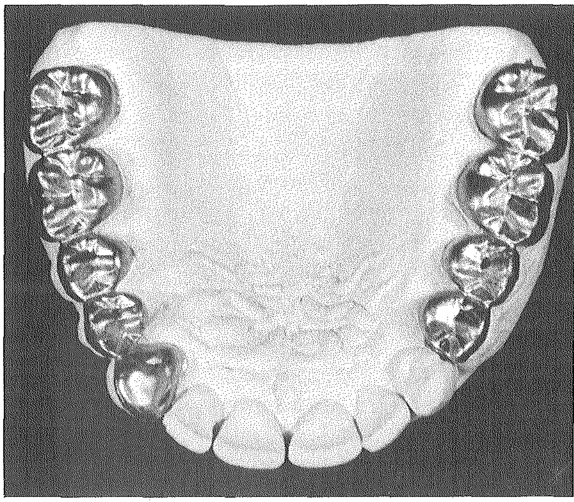

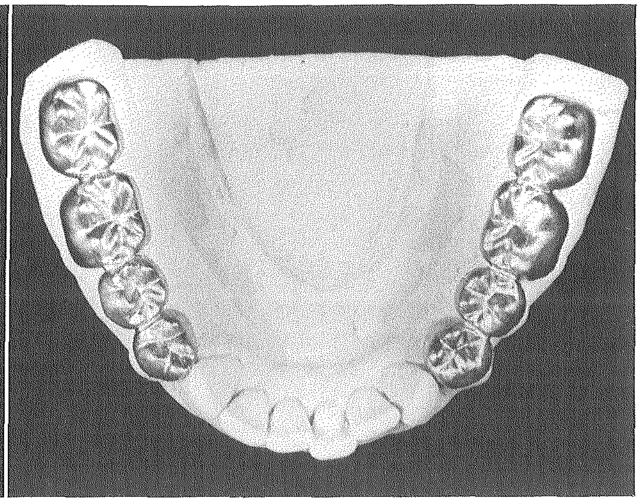

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Case 2-14 and 2-15. Postoperative upper and lower casts (completed case).

Case 2-16. Roentgenograms taken five years postoperatively. Note bifurcation and trifurcation involvements and maintenance of bone height. A thinning of periodontal ligament space is taking place, as is reformation of lamina dura. Teeth seem capable of functioning in health.

Case 3

Vital statistics

Male, an author, 51 years of age.

Medical history

The physician's report showed an individual in comparatively good health with the exception of a metabolic disturbance—gout.

Dental history

When the patient presented himself, he already had lost all upper bicuspids and molars, lower central and lateral incisors, second bicuspids, and all molars. He was attempting to accustom himself to upper and lower removable partial dentures, which were ill-fitting and creating gingival disturbance around the clasped teeth.

Chief complaints

The patient sensed that recently constructed removable partial dentures were creating pathology rather than preventing it and that his chewing efficiency was much less than he had anticipated. An inflamed gingiva around the lower right first bicuspid and an apparent looseness of this tooth aggravated the situation.

Clinical examination

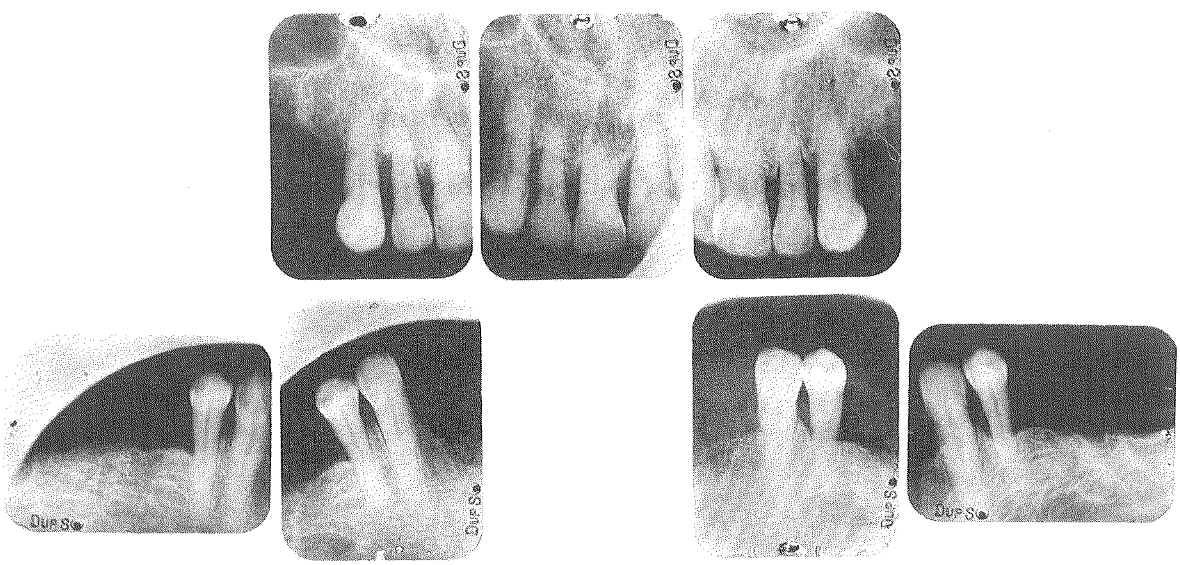
The remaining upper teeth (central and lateral incisors and cuspids) were very mobile, as were the lower right and left bicuspids. The pocket depth around these teeth was extensive, and the inflammation and swelling around the lower bicuspid (which had been surgerized) were unquestionably caused by the ill-fitting clasps and poorly adapted base, complemented with a total lack of necessary articulative factors.

A roentgenographic examination verified our clinical findings. Use of the periodontal probe seemed to indicate even more extensive pocket depth than appeared in the roentgenographs. Questioning of the patient verified a suspicion that the loss of so many teeth was iatrogenic, aided and abated by clenching and bruxing habits, probably created because of these iatrogenic factors.

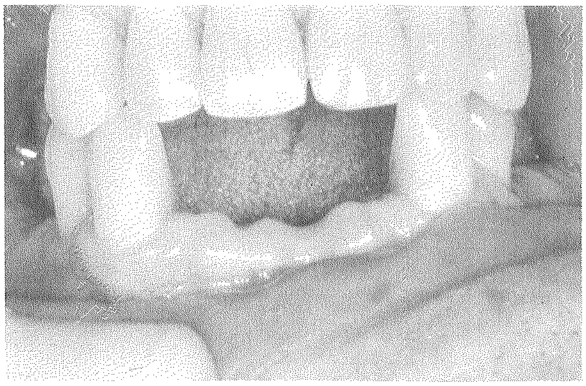
Treatment plan

From a periodontal standpoint gingival and osseous surgery was out of the question, especially in respect to the remaining upper anterior teeth. It was feared that the end result would be the loss of these teeth. Subgingival curettage carried out with great care and thoroughness was indicated.

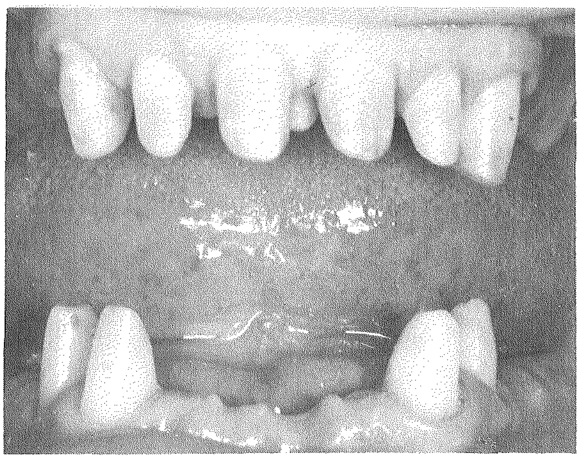
It was believed that the situation was definitely bad, but fixed splinting of the upper anterior teeth, a fixed bridge splint extending from the lower right first bicuspid to the left first bicuspid, and well-executed upper and lower precision removable partial dentures might help



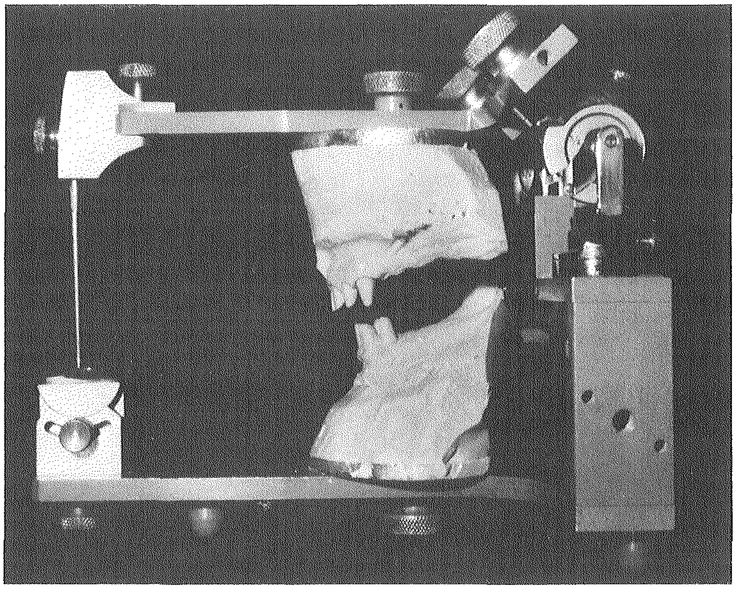
Case 3-1. Preoperative roentgenograms.



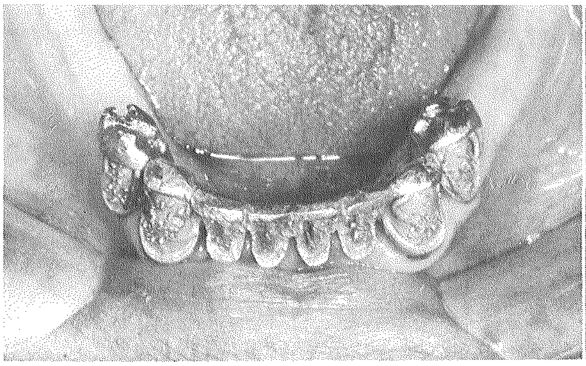
Case 3-2. Preoperative photograph of anterior view of patient's teeth.

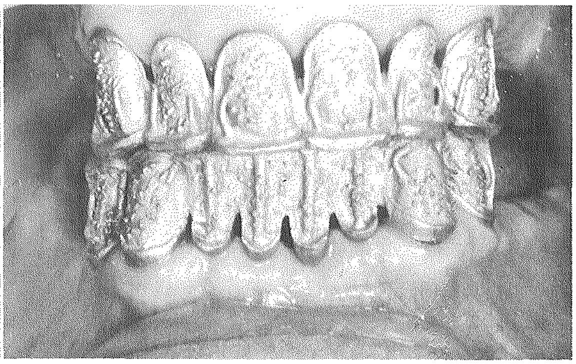


Case 3-3. View of preparations for full coverage.



Case 3-4. Working casts mounted on gnathoscope.

5 

 6

Case 3-5 and 3-6. Fixed splints seated on prepared teeth in readiness for remount impressions, hinge-bow transfer, and centric relation records.

this individual retain his few remaining teeth and psychologic composure for a little while longer. Because of the alignment of the upper anterior teeth, elective endodontics had to be resorted to regarding the upper right cuspid.

Therapy

Clutches were constructed and registrations made under trying conditions. The instrument was "set," after which preparations were made, impressions taken, hinge-bow transfer and interocclusal records completed, and working casts mounted on the adjustable articulator.

Fixed splints and precision removable partial dentures (mucostatic impressions) were constructed, fitted, and adjusted with great care. Porcelain denture teeth, carefully carved for proper relationships of cuspal elements, were used.

Fixed splints were temporarily cemented and periodically removed, and teeth and tissues were examined, after which they were recemented with zinc oxide–eugenol cement. After a period of three years, they were hard cemented with oxyphosphate of zinc cement.

Results

Correct masticatory relationships were established. Bases of removable partial dentures are well adapted and stable. Removal of temporarily cemented splints after a period of time showed that the teeth have tightened up—a markedly reduced mobility pattern. Gingival tissues have responded quite satisfactorily. Roentgenographic and clinical evidence at the end of six years shows improvement worthy of the effort expended in the construction of this case. Home care is above reproach. The patient functions well and is not conscious of his teeth—a negative occlusal perception. (See Case 3-1 to 3-16.)

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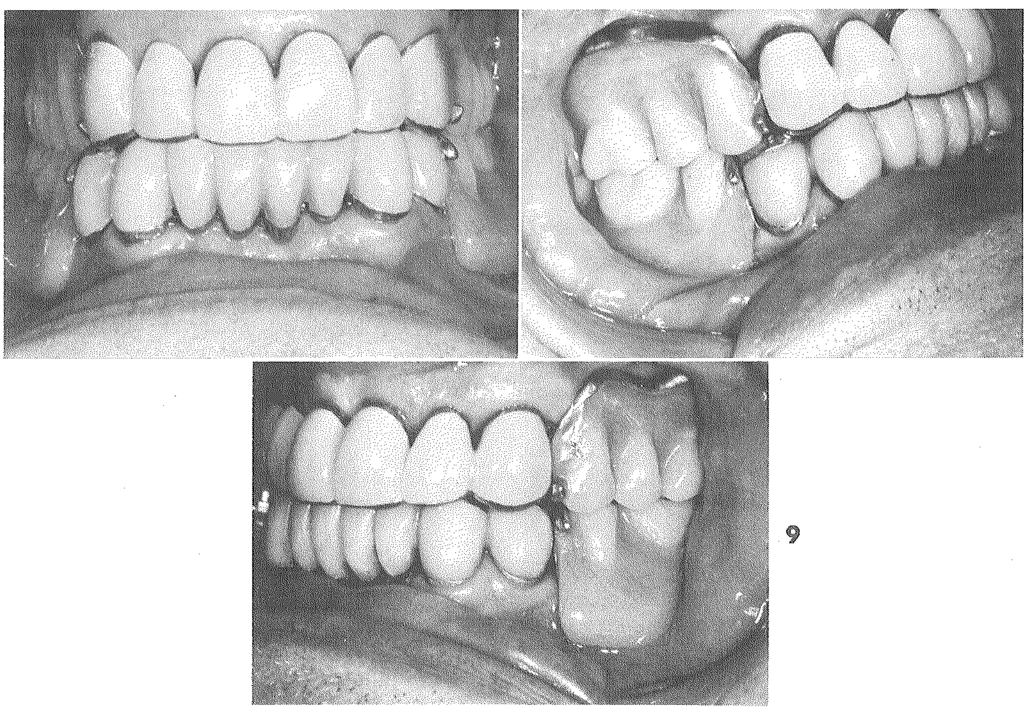

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Case 3-7 to 3-9. Postoperative photographs—anterior, right side, and left side views. Some periodontal surgery was executed on remaining lower teeth, but was contraindicated on remaining upper teeth because it was feared that osseous exposure and resorption would be disastrous. Note embrasure form, coronal contours, improved tissue tone and form, finger removal spurs for ease, and correct removal of precision removable partial dentures.

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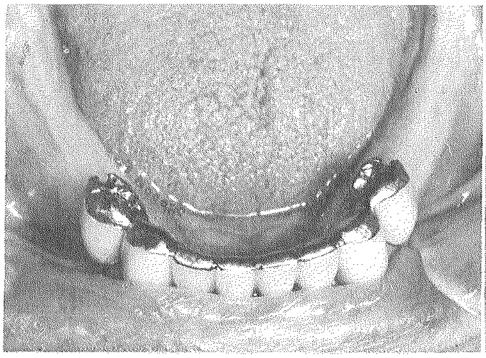
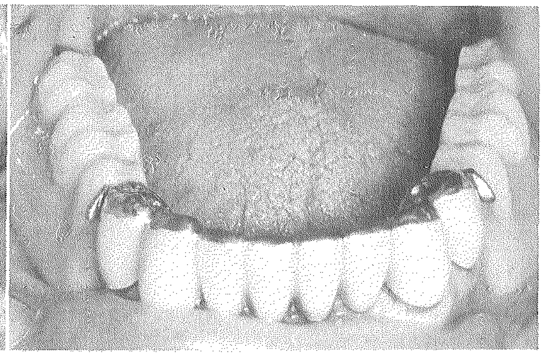
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Case 3-10 and 3-11. Lower fixed splint and precision removable partial denture.

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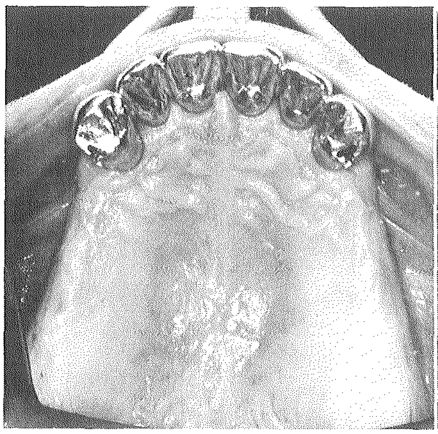
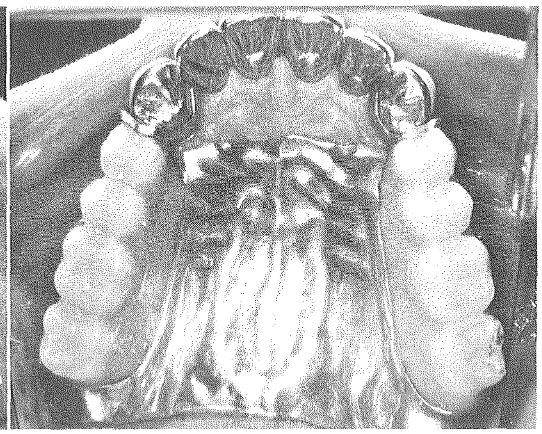
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Case 3-12 and 3-13. Upper fixed splint and precision removable partial denture.

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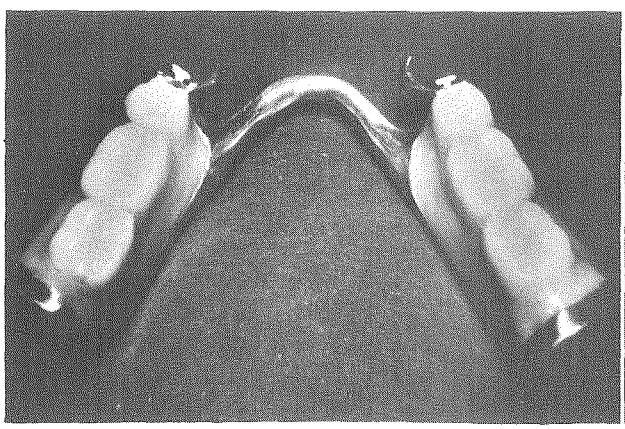

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Case 3-14 and 3-15. Upper and lower precision removable partial dentures constructed from mucostatic impressions and relational impression with fixed splint. Note lingual "straps."

Case 3-16. Roentgenograms taken six years postoperatively. Elective endodontics was resorted to in upper right cuspid. Roentgenographic evidence points to an improvement in quality of attachment apparatus.

Case 4

Vital statistics

Female, a secretary, 48 years of age.

Medical history

The patient was in good general health and had had no serious illness in her lifetime.

Dental history

The patient had been subjected to a great deal of dental service, but unfortunately, despite a desire on the part of the professional men involved to do all they could for her, she lost some teeth and developed periodontal disease and some joint pain. She had her mouth reconstructed two years before appearing in my office.

Chief complaints

Her problems included an inability to chew efficiently, bleeding of the gums, and packing and trapping of food particles. She was very much concerned about possible odors emanating from her mouth because of these conditions.

Clinical examination

Home care habits were fairly good, a mobility pattern of a large number of her teeth was evident, poorly fitted and contoured restorations were creating a bad situation, the esthetic effect was poor, and it appeared that she could be "out of centric" at least one-half cusp. The oral mucosa appeared normal.

A roentgenographic examination verified many of the clinical findings, and these findings (roentgenographic and clinical), correlated with a study of the correctly oriented study casts on an adjustable articulator, emphasized an occlusal periodontitis, the correction of which would require the utmost in technique and a definitiveness in its execution.

The upper left lateral incisor and third molar were hopelessly involved and required extraction. There was a lack of coincidence of centric occlusion and centric relation.

Treatment plan

After removal of the aforementioned teeth, all previously inserted restorations were to be removed, subgingival curettage carried out with extreme care and thoroughness (the patient informed me that her physician ruled out periodontal surgery, the reason for this decision being unknown, but the problem created by it preventing the desired result), and a cusp-fossa occlusion established. It was necessary to do some splinting, establish correct occlusal relations leading to a negative occlusal perception, and obtain an acceptable esthetic pattern.

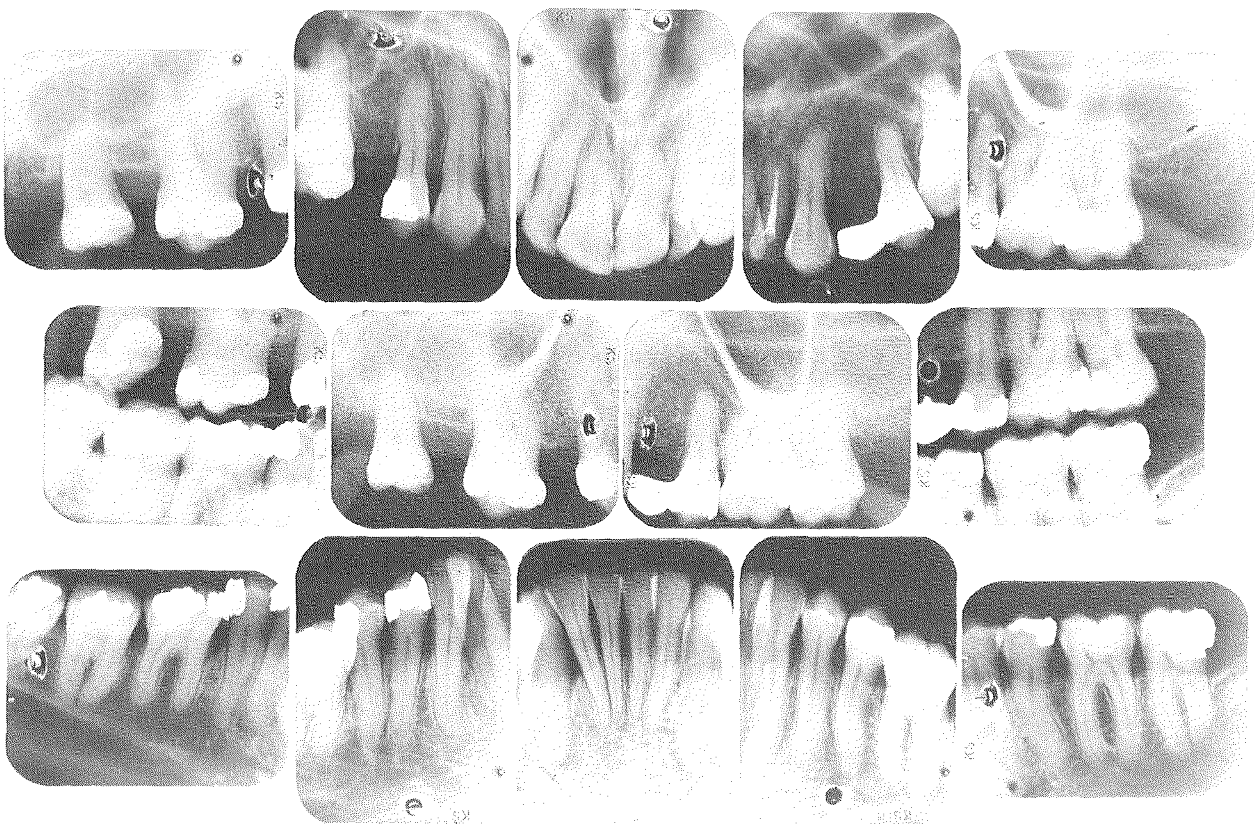
Prognosis

Because of pocket depth and osseous involvement (and no authorization to surgerize) together with an unfavorable interarch and intra-arch relationship, a guarded prognosis was presented.

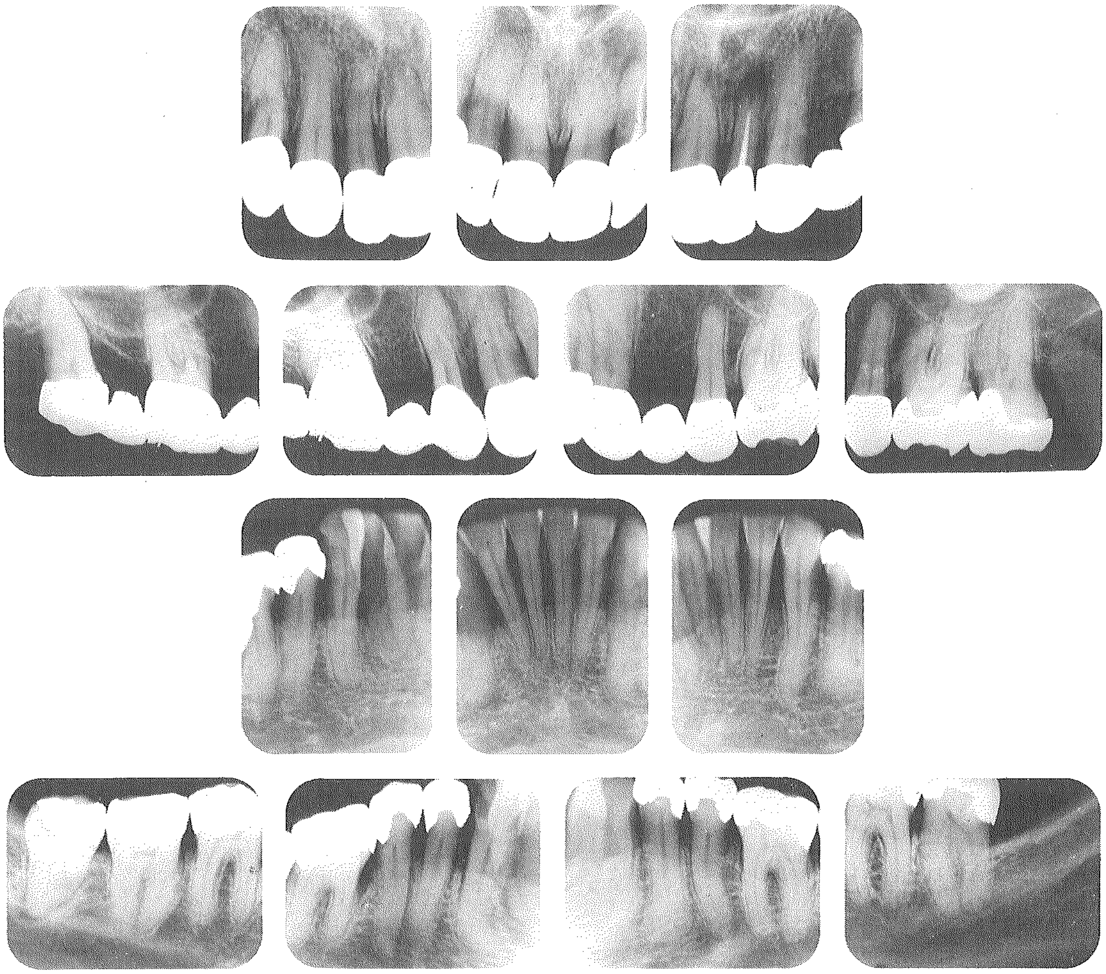
Results

A number of unforeseen situations occurred during treatment, which created more complications, but a very cooperative patient and much effort by the operator brought forth a result reasonably acceptable to both the patient and the dentist.

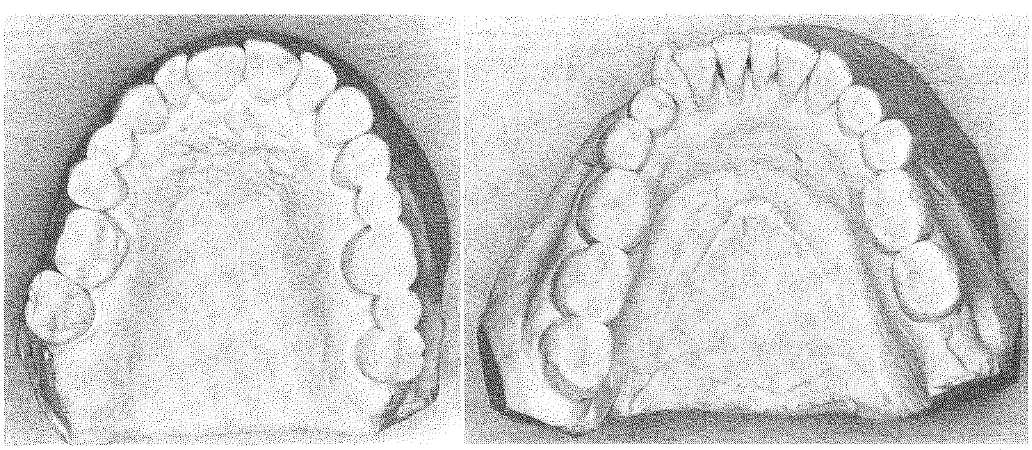
Correct masticatory relationships have been established, gingival tissues have exhibited acceptable texture, tone, and color (oral hygiene care is commendable), and mobility pattern has been definitely reduced. Esthetics is satisfactory, and the patient reports she is not conscious of the teeth, a negative occlusal perception. This case is now six years old and is functioning well. (See Case 4-1 to 4-18.)



Case 4-1. Preoperative roentgenograms.



Case 4-2. Roentgenograms taken two years after first reconstruction (taken at her first appearance in my office).

3  4

Case 4-3 and 4-4. Casts of upper and lower teeth (preoperative before rehabilitation of present date).

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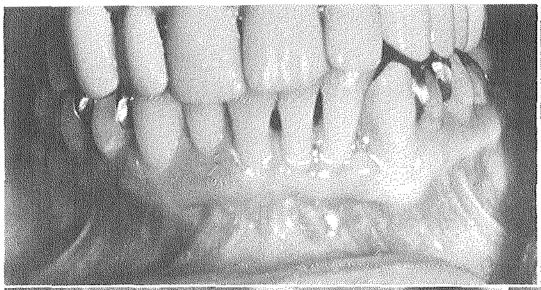


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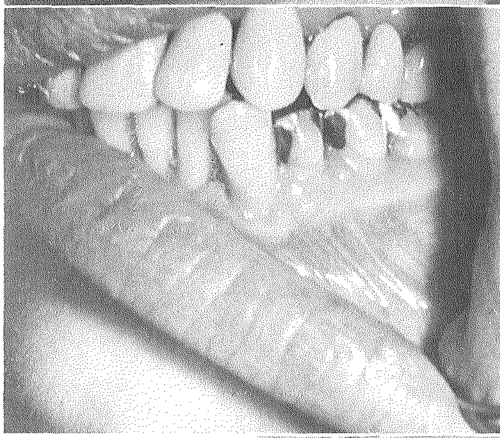

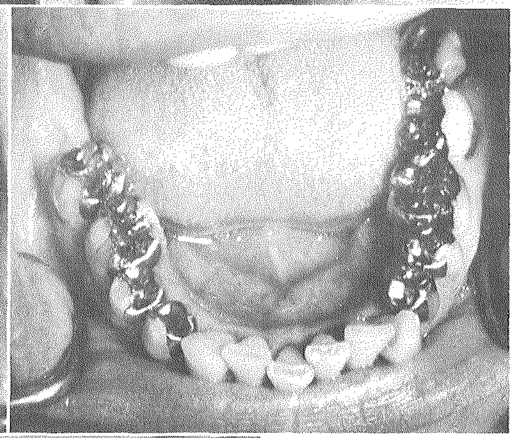
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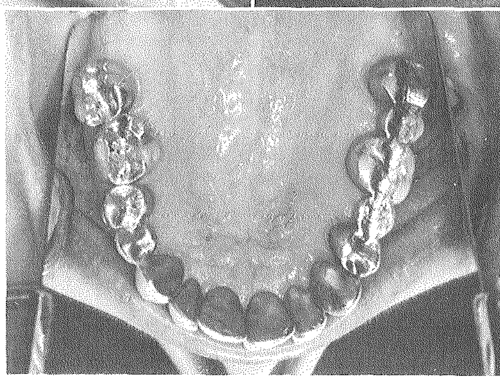
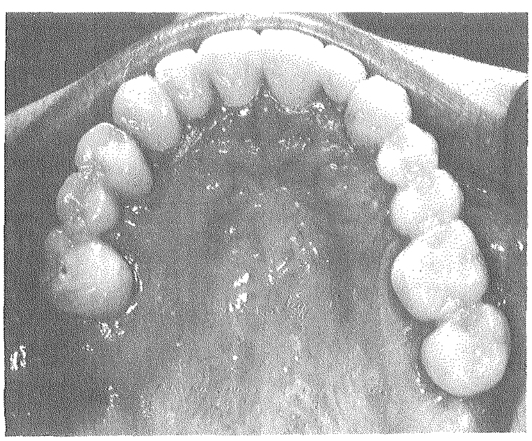


Case 4-5 to 4-9. Preoperative photographs of patient's mouth—anterior, right side, left side, and lower and upper occlusal views—after first reconstruction.



Case 4-10. Upper provisional restoration.

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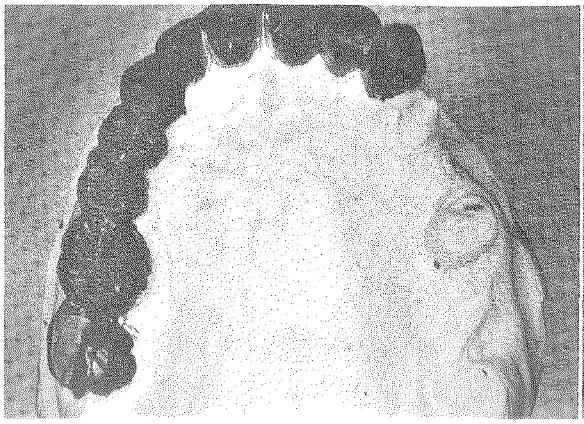

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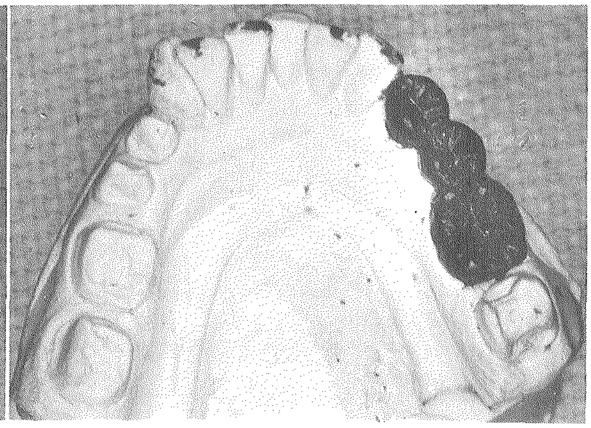

Case 4-11 and 4-12. Applying Thomas waxing technique on right side—upper and lower bicuspids and first molars. Upper anterior preparations waxed roughly to establish correct vertical dimension and allow for lateral and protrusive excursions.

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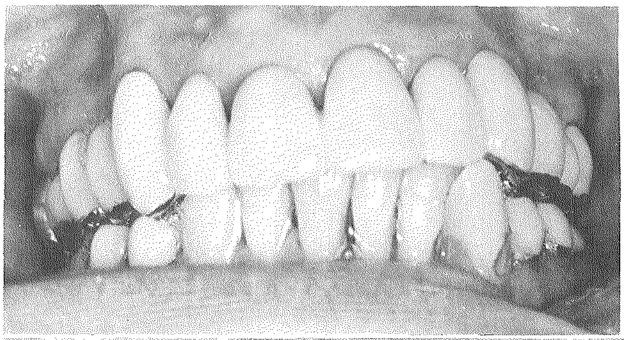

Case 4-13 to 4-17. Postoperative clinical photographs—anterior, right side, left side, and lower and upper occlusal views. Gingival tissues exhibit acceptable tone and texture. Authorization to do periodontal surgery would probably have ensured a greater longevity to case. Embrasure form, coronal contours, marginal adaptation and fit, and fulfillment of therapeutic occlusal objectives have helped carry this case for six years to date, and it is functioning in health.

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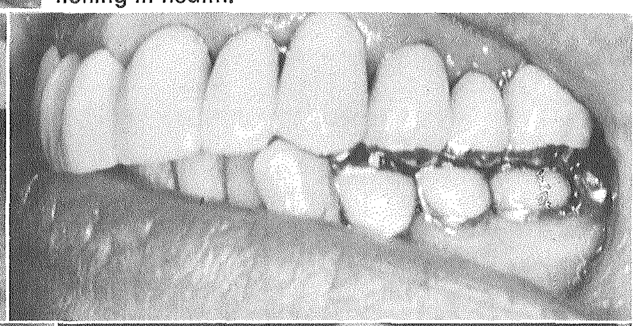

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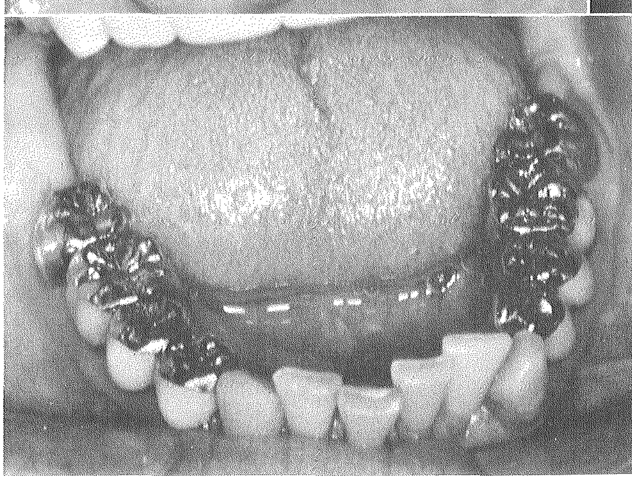

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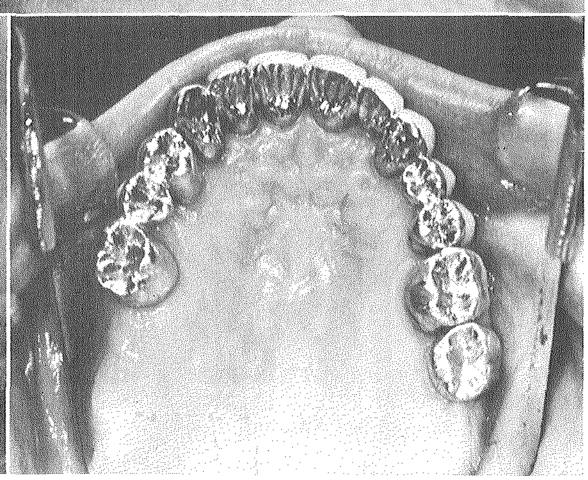

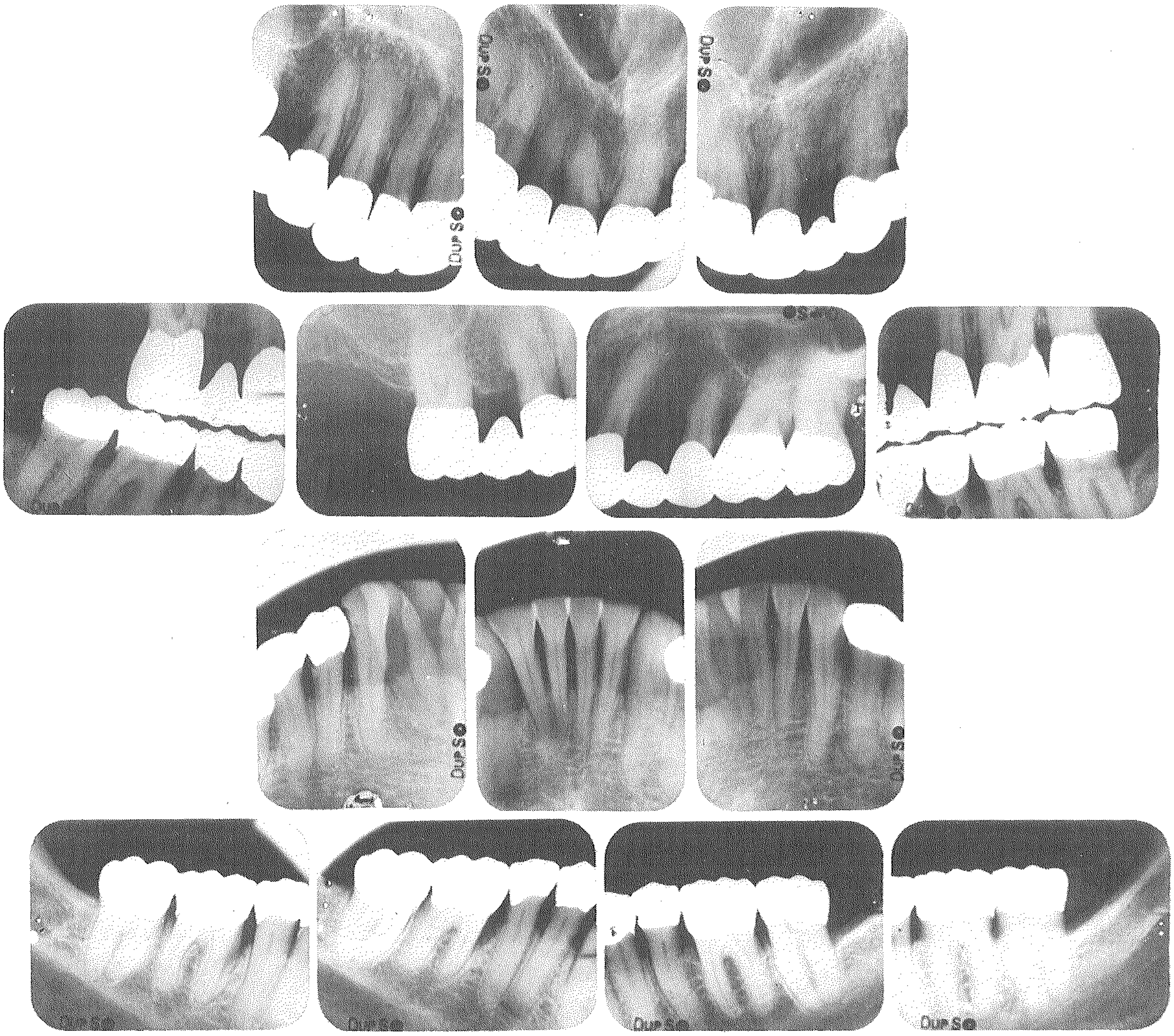

Case 4-18. Roentgenograms taken six years postoperatively. Bone height has been maintained. Authorization to do periodontal surgery would have been most helpful.

Case 5

Vital statistics

Male, a business executive, 52 years of age.

Medical history

The patient was in excellent general health with the exception of a psychogenic component responsible for tensions causing clenching and bruxing of a rather severe nature. His wife reported that the noises created by the night bruxing made her wonder how her husband still retained any of his teeth.

Dental history

Being an obsessive-compulsive type of individual with a perfectionistic component, this patient was not only an exceptionally good tooth brusher but also had a great desire to have the best medical and dental care available and was able and willing to give of his time and money to attain this objective. Despite this, the situation became worse until he believed that the removal of his teeth and the construction of full dentures was the only answer to his problem.

Case 5-1. Preoperative roentgenograms showing extent of periodontal disease.

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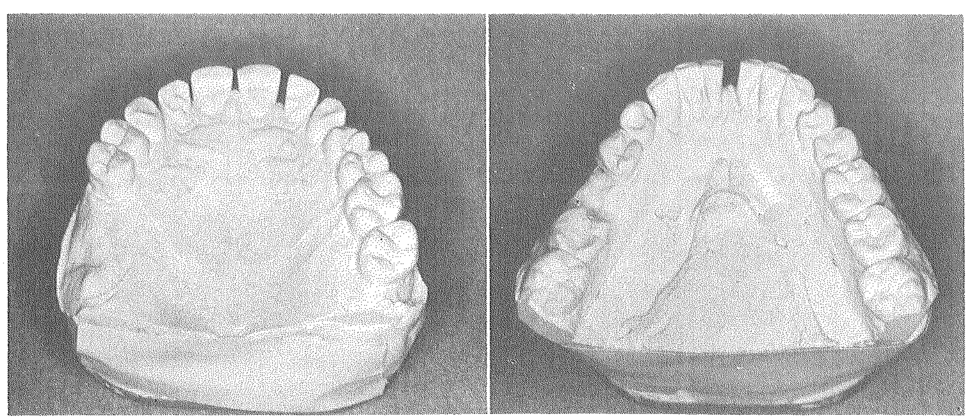

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Case 5-2 and 5-3. Casts of upper and lower teeth (preoperative). Note excessive wear of upper anterior teeth (lingual view).

Chief complaints

Sore teeth and jaw muscles, food impaction, separation and "fanning" of teeth in the anterior region, loose teeth, vague radiating pain on left side, and a unilateral removable appliance that was making him very nervous were the chief complaints.

Clinical examination

The patient definitely lacked a coincidence of centric occlusion and centric relation. Pocket depth, poor tissue tone and color, bleeding of the gums, and poorly executed dental restorations were obvious and discouraging. Separation and some "fanning" of anterior teeth were evident, and the wear pattern was definitely causing damage.

Photographs and roentgenograms were taken. Roentgenographic evidence, correlated with clinical and cast orientation findings, not only verified our observations but also created much doubt regarding the outcome of this case. We had to deal with a case of periodontal trauma aggravated by a psychogenic component.

Treatment plan

The upper right second bicuspid was to be extracted. Periodontal surgery was to be performed, and correct masticatory relations, aided by the judicious use of therapeutic splinting, were to be established. A night guard was to be constructed and the case carefully observed under temporary cementation for a period of time. The lower anterior teeth, for a while at least, were to be reshaped slightly but not restored. The lower left third molar was to be used as an abutment despite its position in the arch. Temporary splintage was to be completed before periodontal surgery was done (see procedural steps in Chapter 5).

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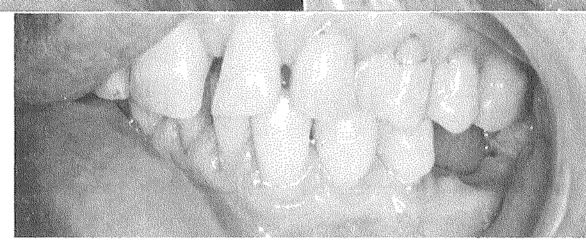

Case 5-4 to 5-6. Preoperative photographs of patient's mouth—anterior, right side, and left side views.

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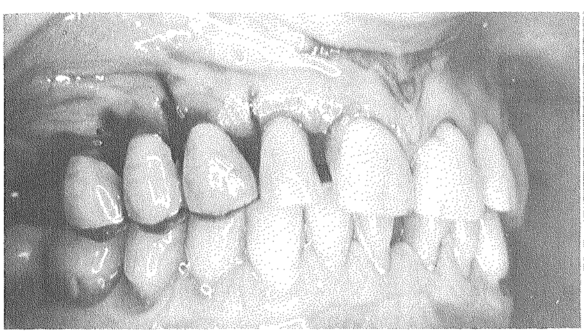

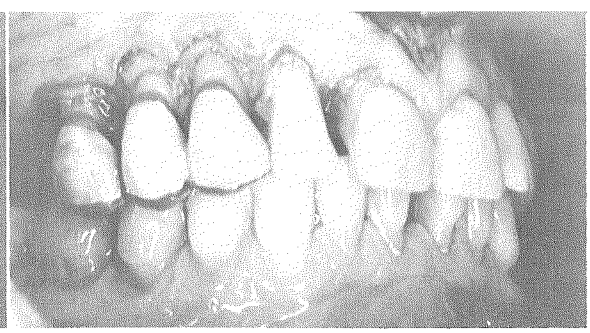

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Case 5-7 and 5-8. Two illustrations of periodontal surgery (right upper region).

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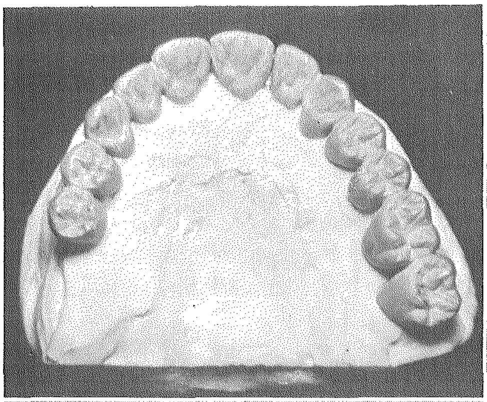
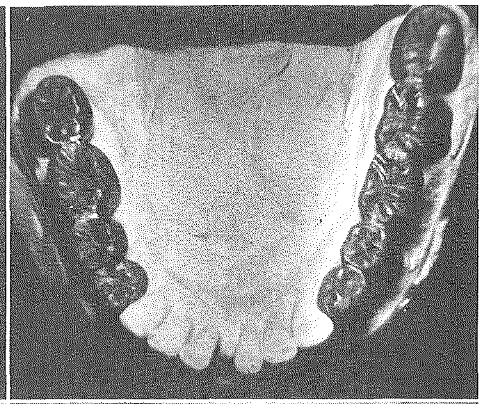
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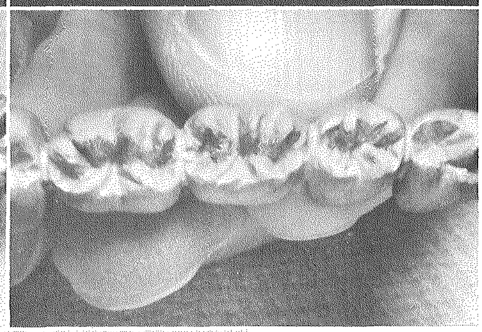
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Case 5-9 to 5-13. Upper and lower remount casts and close-up illustrations of several sectional areas.

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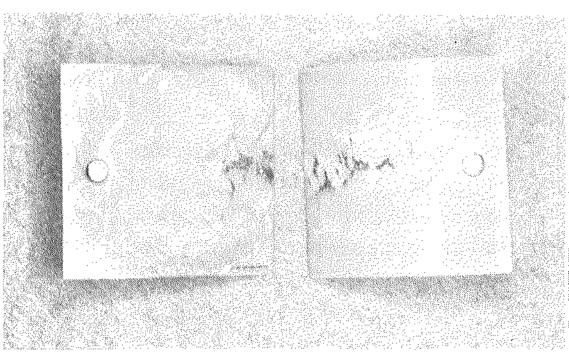
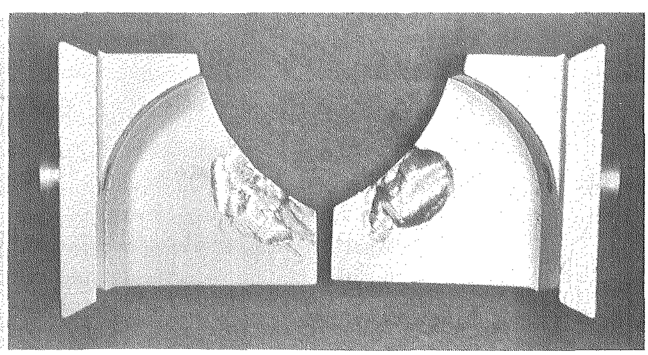
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Case 5-14 and 5-15. Eminentiae and side shifts for this particular case.

Prognosis

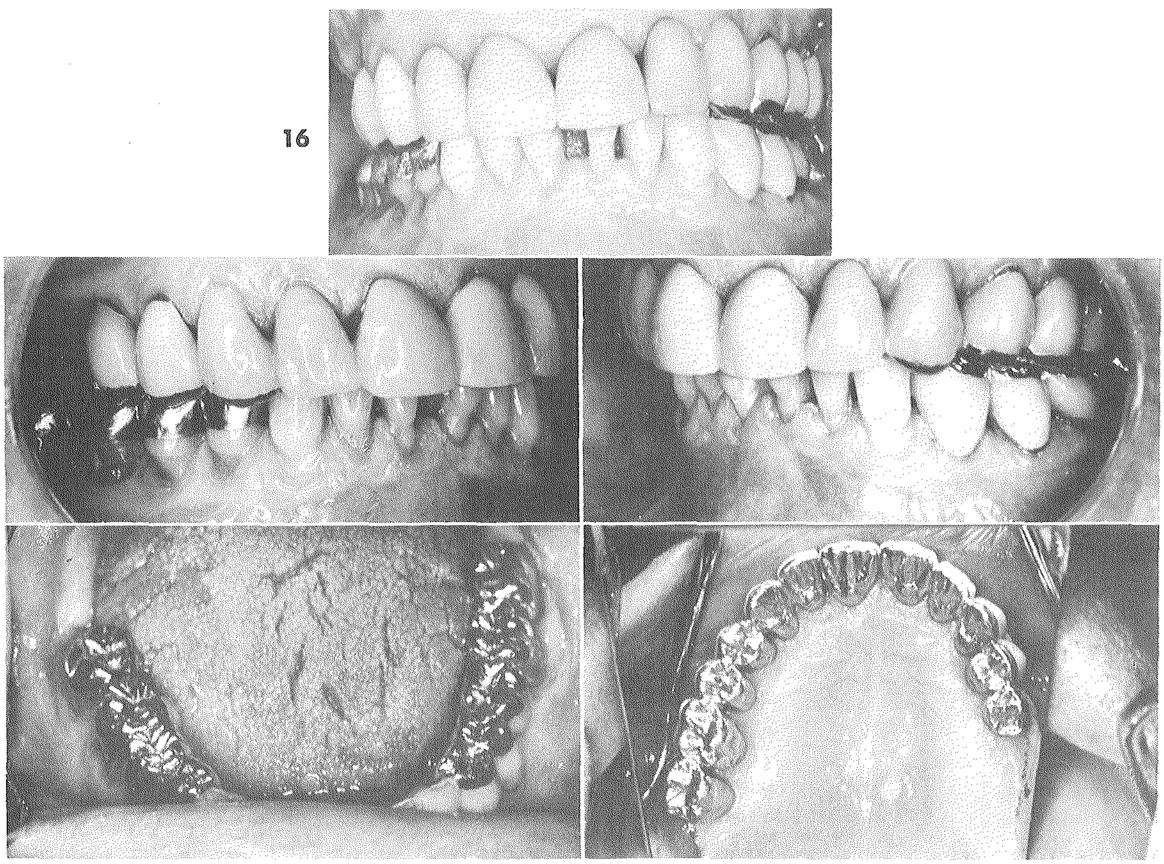
A very guarded prognosis was made with the strong belief that this was a terminal case of short duration.

Results

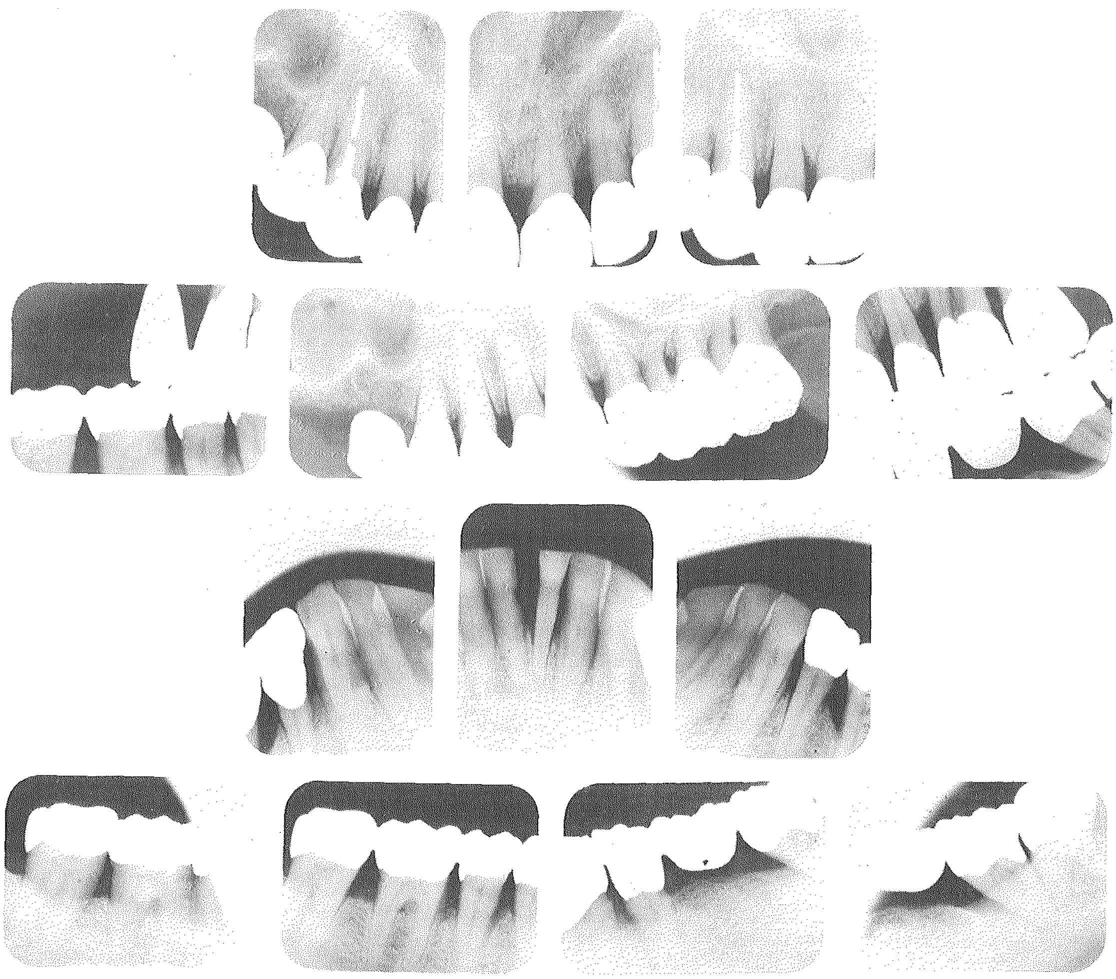
This case has functioned well for a number of years. The home care is excellent. Masticatory relationships are good, and the gingival tissues appear healthy. No evidence of a mobility pattern within the realm of reality is present in this case. No further alveolar resorption has occurred in this long period of time, and the patient has a negative occlusal perception. Patient's wife reports that bruxing noises are nil.

The results of root canal therapy in the upper cuspids have been very satisfactory. One of the teeth had to be devitalized because of a "wash out," which went unnoticed during surgical procedures. A little more vigilance on the part of the team probably could have avoided the need of endodontic intervention in this tooth.

It was believed that the lower left second molar would have to be removed within the year, but the prediction was wrong. However, an alternate treatment plan is held in abeyance for any contingency. Establishment of a more favorable periodontal climate has helped immensely in the retention of the patient's teeth. The lower anterior tooth situation now is being improved upon. (See Case 5-1 to 5-21.)



Case 5-16 to 5-20. Postoperative photographs—anterior, right side, left side, and lower and upper occlusal views of completed case. Both unilateral splinting and bilateral splinting were used in this case. Some full-coverage and some modified M.O.D. onlays were retainers of choice. Establishment of a more favorable periodontal climate has helped greatly in retention of patient's teeth. Masticatory relationships are good. Lower anterior teeth (lateral and central incisor teeth) are being improved esthetically at present time. Buccogingival pin-inlays have been placed in lower right bicuspids and first molar.



Case 5-21. Postoperative roentgenograms.

Case 6

Vital statistics

Female, a housewife, 55 years of age.

Medical history

The physician's report indicated an individual in excellent health, with the proper attitude toward life and its many complex problems—a person emotionally mature.

Dental history

The patient had visited the dentist regularly since childhood and, because of a high caries index, had developed excellent oral hygiene habits. However, by age 45 she had lost all of her upper teeth and many lower teeth. A number of full upper dentures and lower partial dentures had been constructed in the past ten years, but they never proved to be satisfactory from a functional and esthetic standpoint as far as she was concerned.

Chief complaints

The patient complained of an inability to chew with ease and comfort, a constant slippage of the full upper denture, and a twisting and torquing of the lower partial denture causing pain and soreness of the clasped teeth. She expressed a great desire to be rid of the partial denture, if any possible avenue of escape was feasible.

Clinical examination

Examination of the most recently constructed full upper denture showed a well-adapted base exhibiting excellent adaptation, fit, and retention but, despite these very important attributes, the denture would become dislodged in function.

The lower partial denture was ill-fitting and unquestionably causing her much discomfort. An overhang on the distal surface of the restored lower left second molar created an inflamed condition of the gingival tissue in this area. Poor marginal fit of the lower right bicuspid restorations was responsible for the sensitivity that the patient complained about in this region.

Treatment plan

Roentgenograms were taken. A complete lower fixed splint was constructed using the remaining lower teeth, right and left first and second bicuspids, and left second molar as abutment teeth for retainers. A cantilevered pontic was to be used in the right posterior region, supplying the first molar in a somewhat modified form.

It was believed that the full upper denture base and the anterior tooth arrangement, which seemed to please the patient esthetically, could be used. This decision was based on the fact that, since the fit and adaptation of the base to the tissues was satisfactory, as was the anterior tooth arrangement, all that would be necessary is to establish a coincidence of centric occlusion and centric relation to eliminate the slippage of the denture in function. Gold occlusal surfaces were to be used in the posterior areas.

Prognosis

Prognosis was good.

Results

After establishing correct masticatory relationships and eliminating the need of a lower partial denture, the whole situation was stabilized. Gingival tissues responded favorably, exhibiting good tone, texture, and color. Fear of the upper denture dropping during function was eliminated, and the patient now chews with ease and comfort. Esthetic and phonetic patterns are very good, and a negative occlusal perception has been attained. (See Case 6-1 to 6-7.)

Case 6-1. Preoperative roentgenograms.

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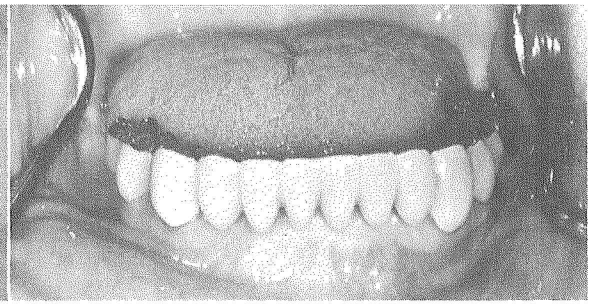

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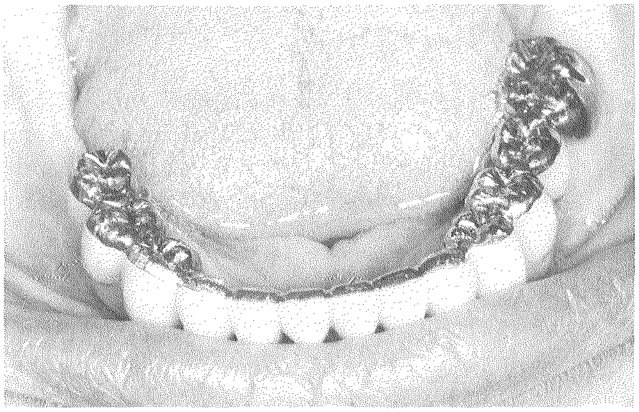
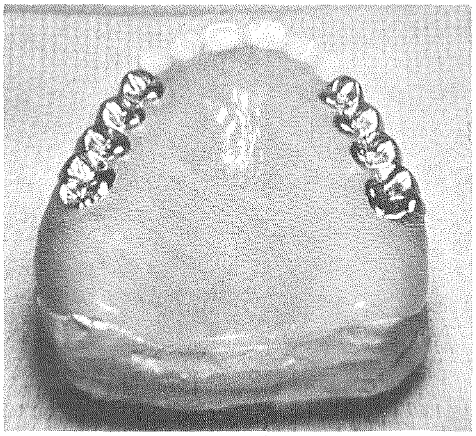
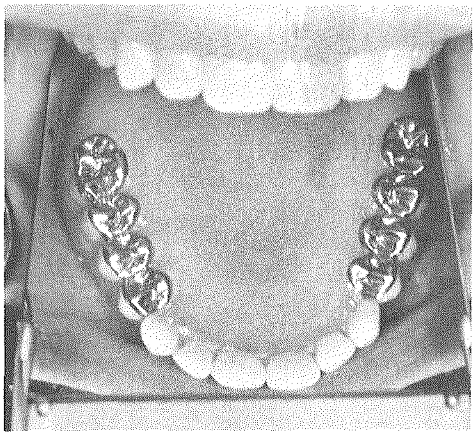
Case 6-2 and 6-3. Clinical photographs of completed case—relation of lower fixed splint to full upper denture. Note embrasure form, tissue tone and form, and relationship of pontics to residual ridge of lower fixed bilateral splint. Establishing correct masticatory relationships and eliminating need of a lower removable partial denture stabilized whole situation in this case.



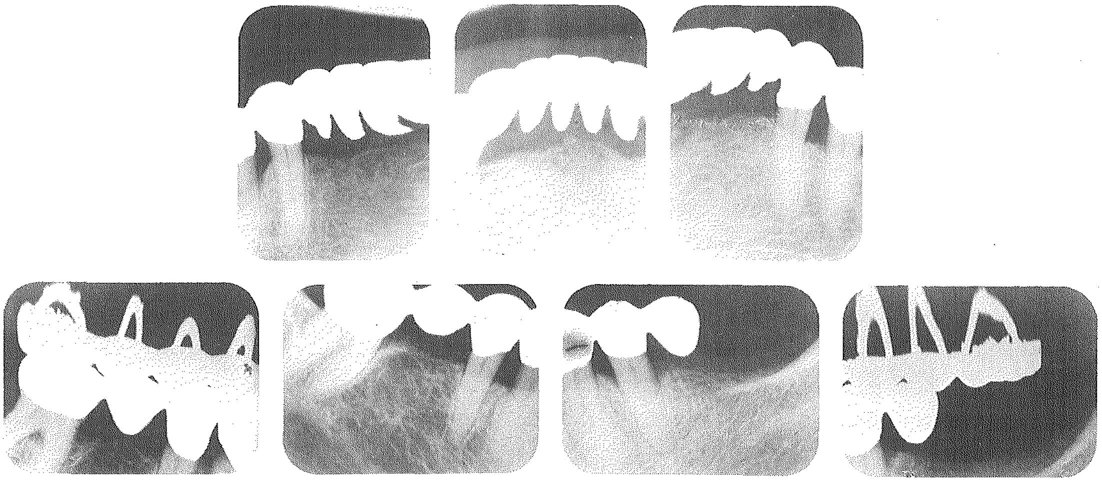
Case 6-4. Occlusal view of lower fixed bilateral splint. Cantilevered pontic on right side.



Case 6-5. Gold occlusal surfaces on posterior teeth of full upper denture.



Case 6-6. Occlusal view of upper full denture in mouth.



Case 6-7. Postoperative roentgenograms.

Case 7

Vital statistics

Female, a schoolteacher, 45 years of age.

Medical history

The patient was in good general health with no unusual past medical history.

Dental history

No unusual dental history was evident. The patient visited the dentist regularly for examination and prophylaxis and had an average amount of restorative work done over a period of years. Occlusal equilibration was advised and executed about two years before the patient presented herself in my office, and she believes that this was the beginning of her dental problems.

Chief complaint

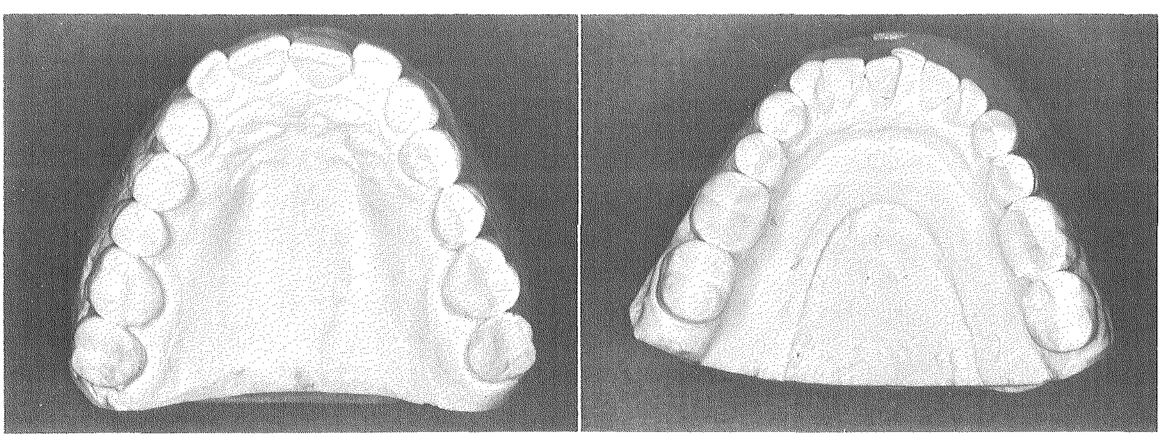
The patient had a severe radiating pain in the region of the right temporomandibular joint, which at times prevented her from opening her mouth with ease and comfort. The "clicking" and "popping" of the joint became aggravating and troublesome.

Clinical examination

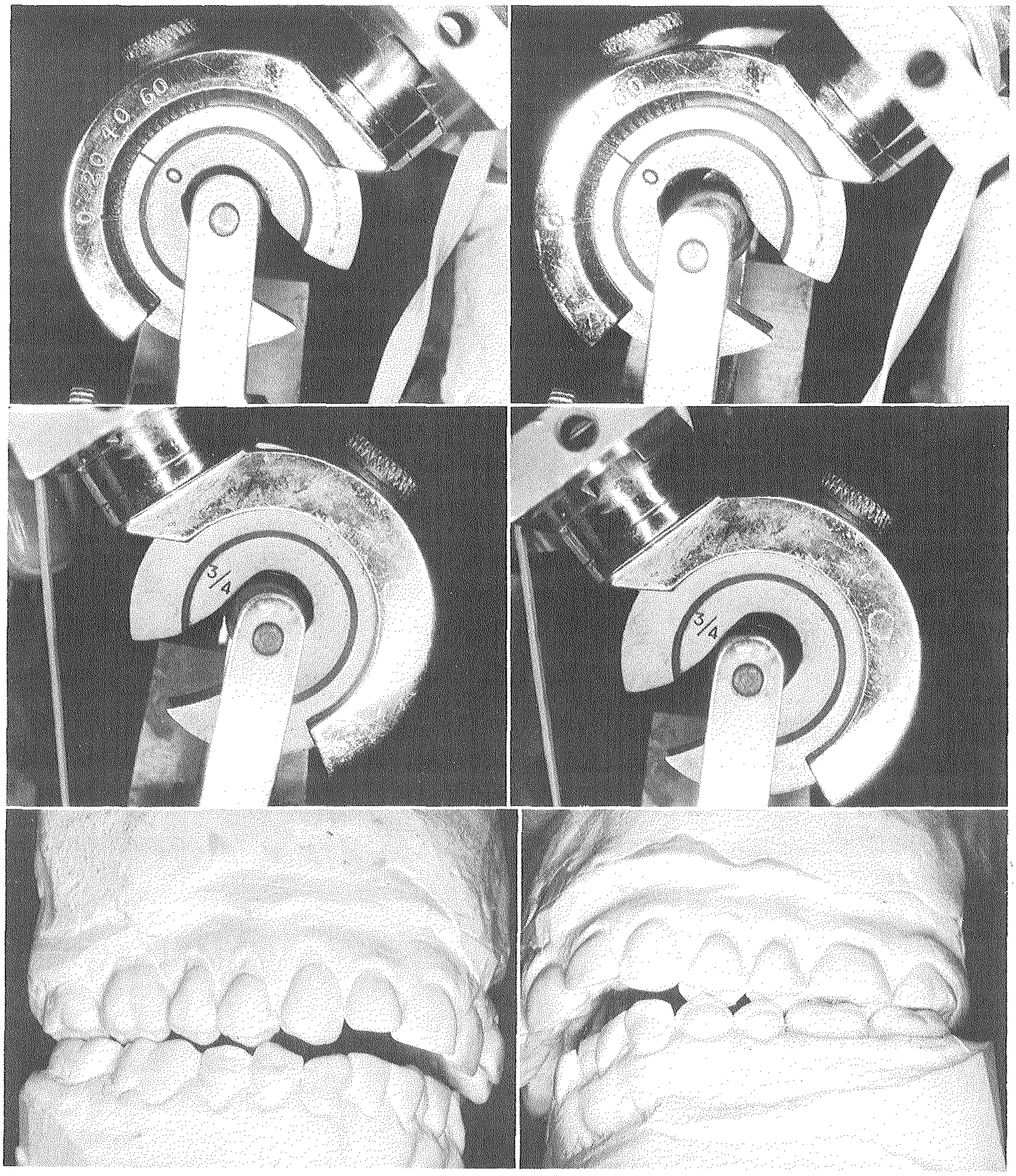
A clinical examination revealed a recently constructed full-mouth rehabilitation. Gingival tissues were injected, and a marked recession was noted around a number of teeth. The buccal mucosa, tongue, lips, palate, and floor of the mouth were normal. Prematurities were present in a centric closure, and it seemed as if the vertical dimension had been increased considerably.

Case 7-1. Preoperative roentgenograms.

Case 7-2. Postoperative roentgenograms (first rehabilitation case completed before appearing in my office).

3  4

Case 7-3 and 7-4. Casts of upper and lower teeth after first reconstruction.



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Case 7-5 to 7-9. Position of condyle (ball) when teeth are occluded in centric occlusion, and the condyle (ball) pulled forward to allow meshing of occlusal surfaces out of centric relation. Correctly oriented casts in centric position—right and left side views (9).

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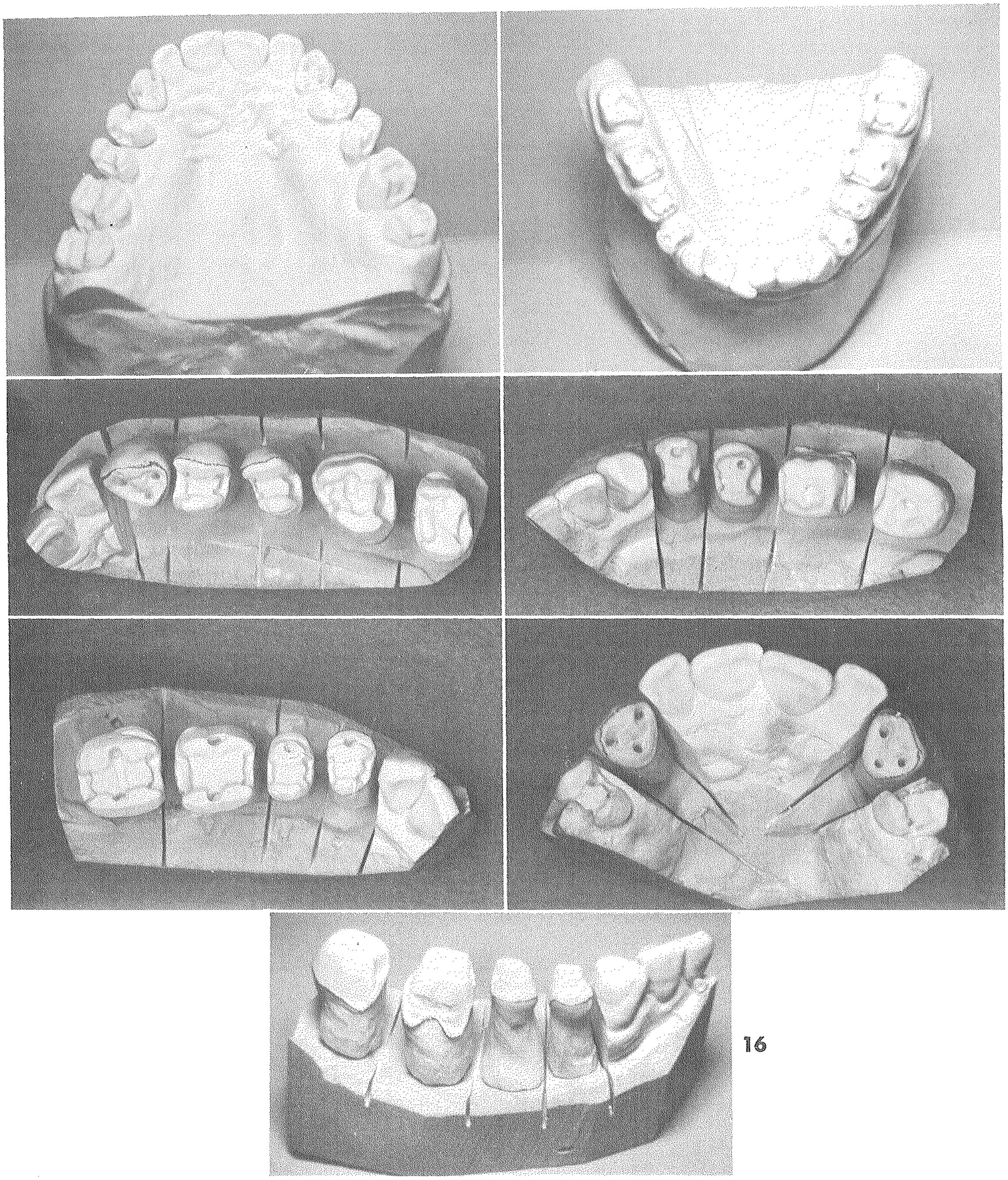

Case 7-10 to 7-16. Type of preparations that I used in this case after removal of previously constructed restorations.

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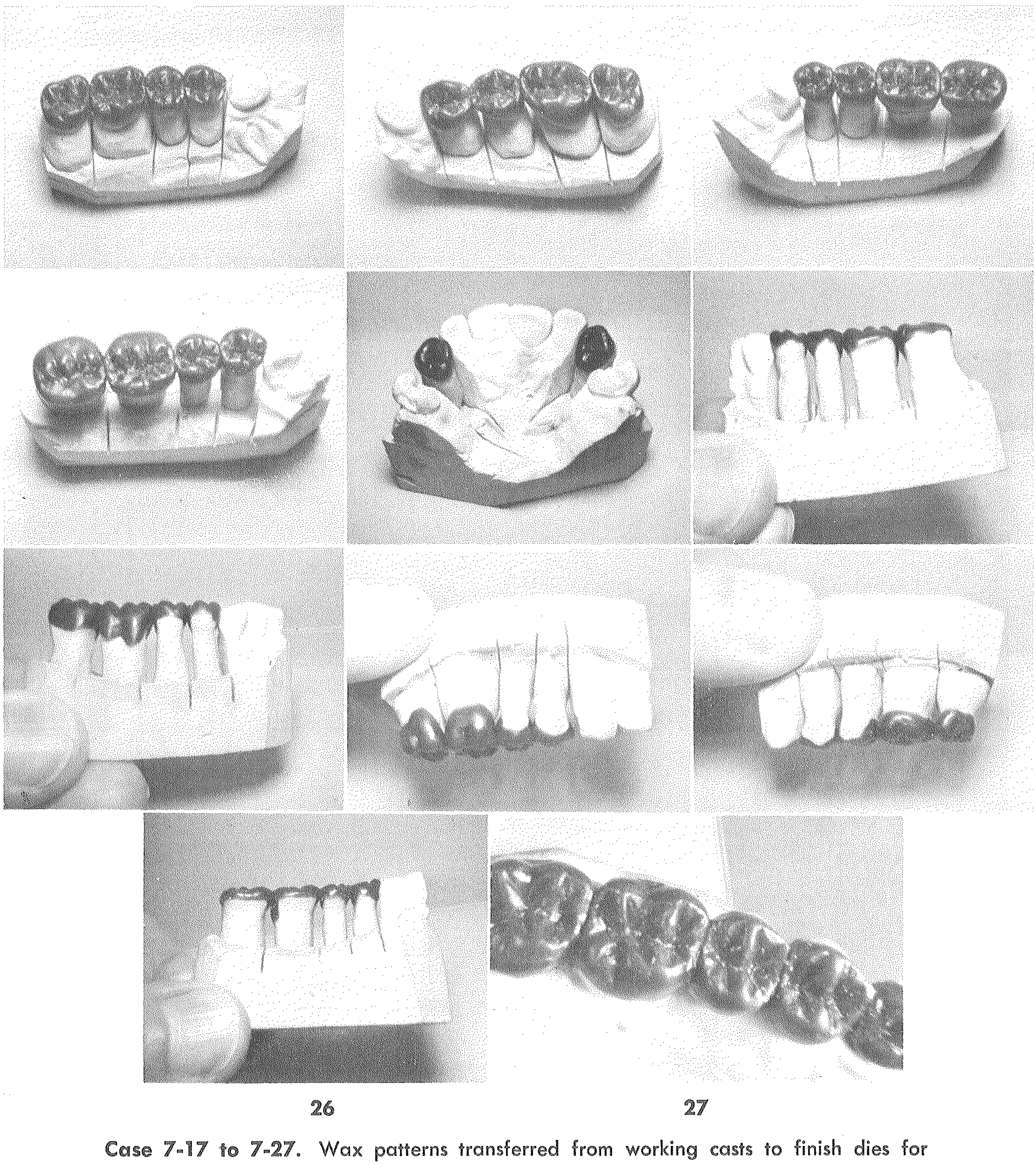

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Case 7-17 to 7-27. Wax patterns transferred from working casts to finish dies for marginal refinement and establishment of correct contact areas.

Marginal fit of recently constructed restorations was fairly good, but coronal and embrasure form and contact areas fell short of the goal.

Roentgenograms and photographs were taken, as were impressions for study casts, which were correctly oriented on an adjustable articulator for preliminary study and construction of clutches for jaw registrations. After jaw "writings" were made and the articulator was set to these registrations, the study casts were oriented to the correct axis. If one condyle is the causative factor of the dysfunction, a correct bilateral hinge determination is out of the question. In these type of cases it is necessary to make registrations over a period of time until the time when proper proprioception and function are established. An examination of these mounted study casts showed a lack of coincidence of centric occlusion and centric relation by at least one-half cusp or more. It was also evident that the vertical dimension had been increased too much.

Temporomandibular joint roentgenograms (open and closed) showed slightly increased spacing of the right joint, whereas the head of the left condyle was slightly flattened and the anterior joint space narrow. Possible partial erosion of the anterior portion of the left meniscus, was suggested. No apparent destructive bony pathology was present on either side.

In temporomandibular joints that are open—40 mm. anterior bite block—the excursion of the right condyle carried the head beyond the articular eminence, whereas on the left side there appeared to be moderate restriction in the forward excursion of the condyle.

Treatment plan

The decision was made to equilibrate the present restorations as well as possible to eliminate the prematurities and decrease the vertical dimension. This gave temporary relief but did not seem to be the answer to the problem.

When equilibration failed, the next step was to remove all the recently constructed restorations and remake the case on a temporary basis until joint healing took place. It was very interesting to note how far "out of centric" she was, which revealed itself by the amount of occlusal reduction that had to be done in regards to the first and second molars to establish correct occlusal spacing for interarch restorations and a harmony of the excursive movements.

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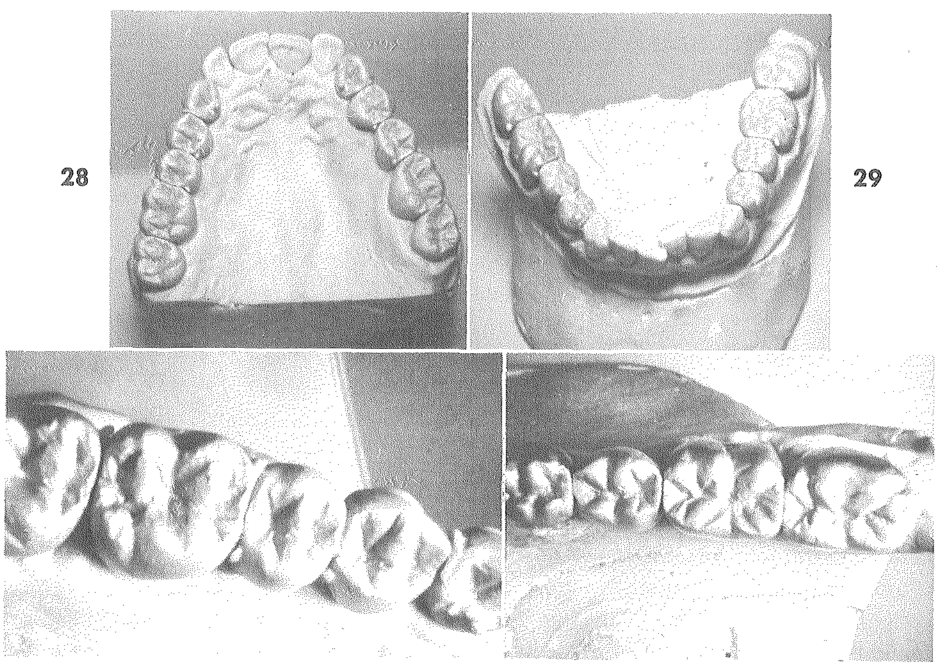

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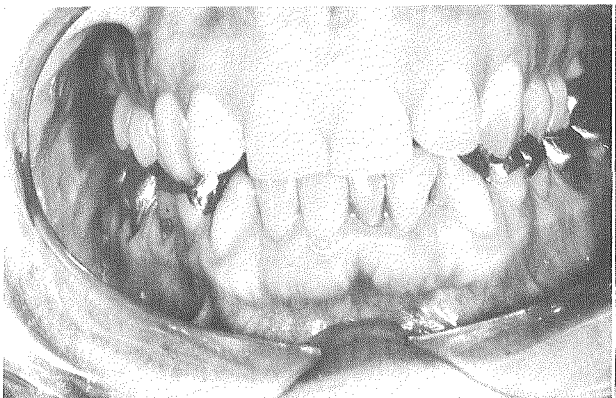
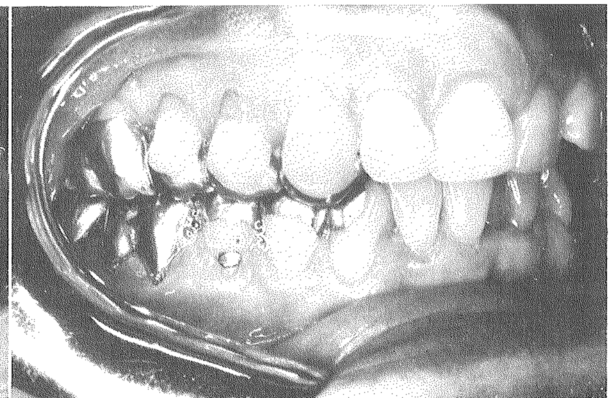
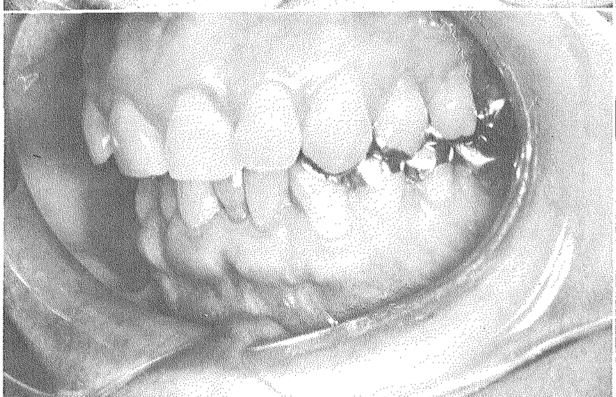
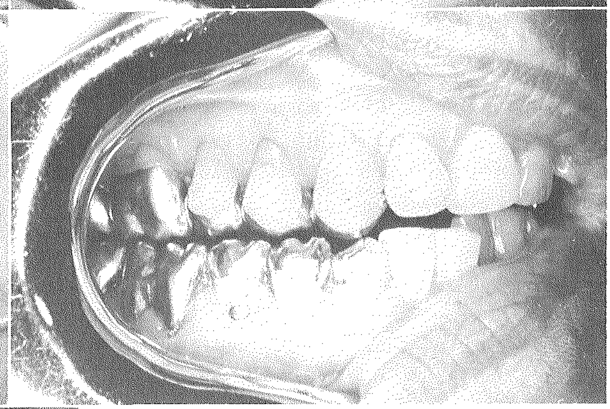
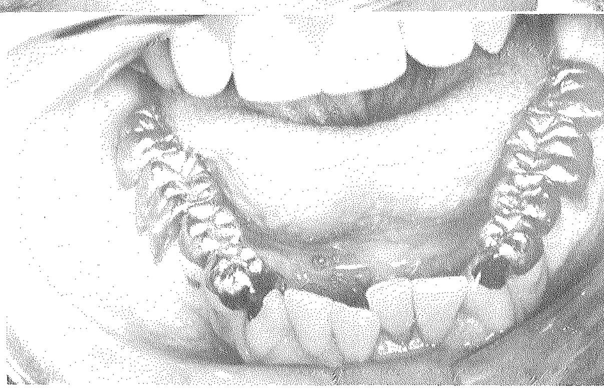
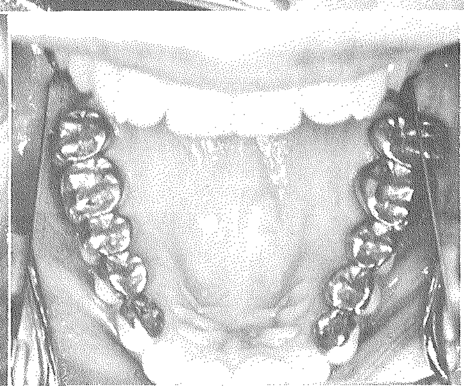
Case 7-28 to 7-31. Remount casts and close-ups of castings of upper and lower sections.

32   33

34   35

36   37

Case 7-32 to 7-40. Illustrations showing teeth (completed case) in centric relation (anterior, right, and left side views), a lateral test glide on right side, lower and upper occlusal views, and postoperative casts of case—lower and upper occlusal views, casts mounted on adjusted articulator. This patient presented herself with a severe temporomandibular joint disturbance. A coincidence of centric occlusion and centric relation was established. Patient is free of pain, and joint is healing. After further observation new registrations will be taken and new restorations constructed.

Subgingival curettage was executed carefully and thoroughly.

After removal of the restorations, all preparations were reshaped, keeping in mind the principle of tripodism. Impressions, hinge-bow transfer, and interocclusal records were made, and the working casts were oriented properly on the Stuart articulator. A cusp–fossa (mutually protective) occlusion was to be established, with no increase of vertical dimension. The finished restorations were to be remounted several times before being temporarily cemented and to be remounted, if indicated, as joint healing took place during the next year or two. Splinting was not indicated.

Results

It seemed that correct masticatory relationships had been established because the patient was free of pain and able to function very well. A negative occlusal perception was attained.

After a period of twelve months the case was remounted and found to be lacking once again in coincidence of centric occlusion and centric relation. It was believed that joint healing was taking place. The articulation was refined once again and recemented with temporary cement. Another remount procedure was executed six months later, but it seemed to reveal that jaw relations have stabilized. This case is still under observation. (See Case 7-1 to 7-41.)

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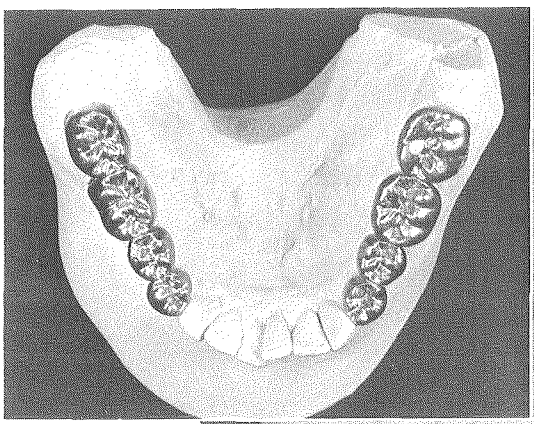
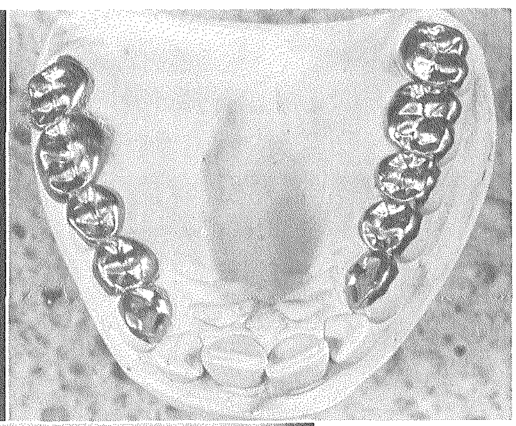
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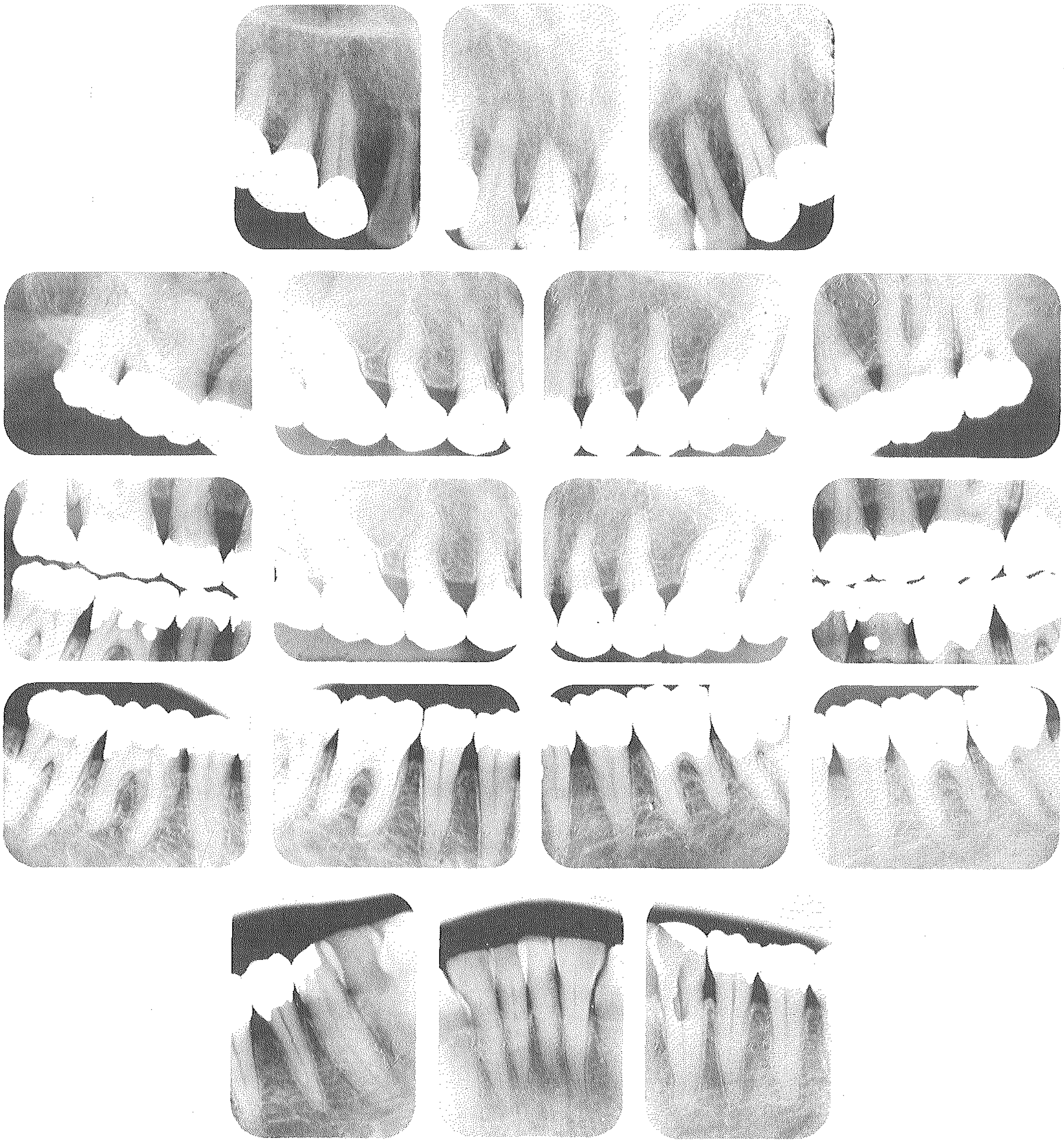
Case 7-38 to 7-40. For legend see opposite page.



Case 7-41. Postoperative roentgenograms.

Case 8

Vital statistics

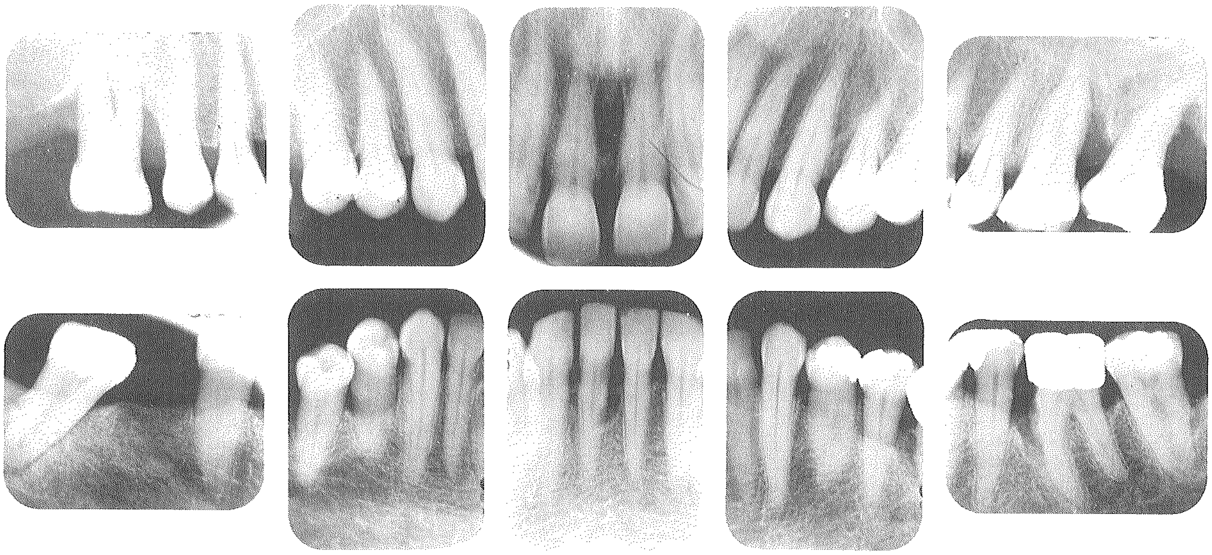
Female, a housewife, 62 years of age.

Medical history

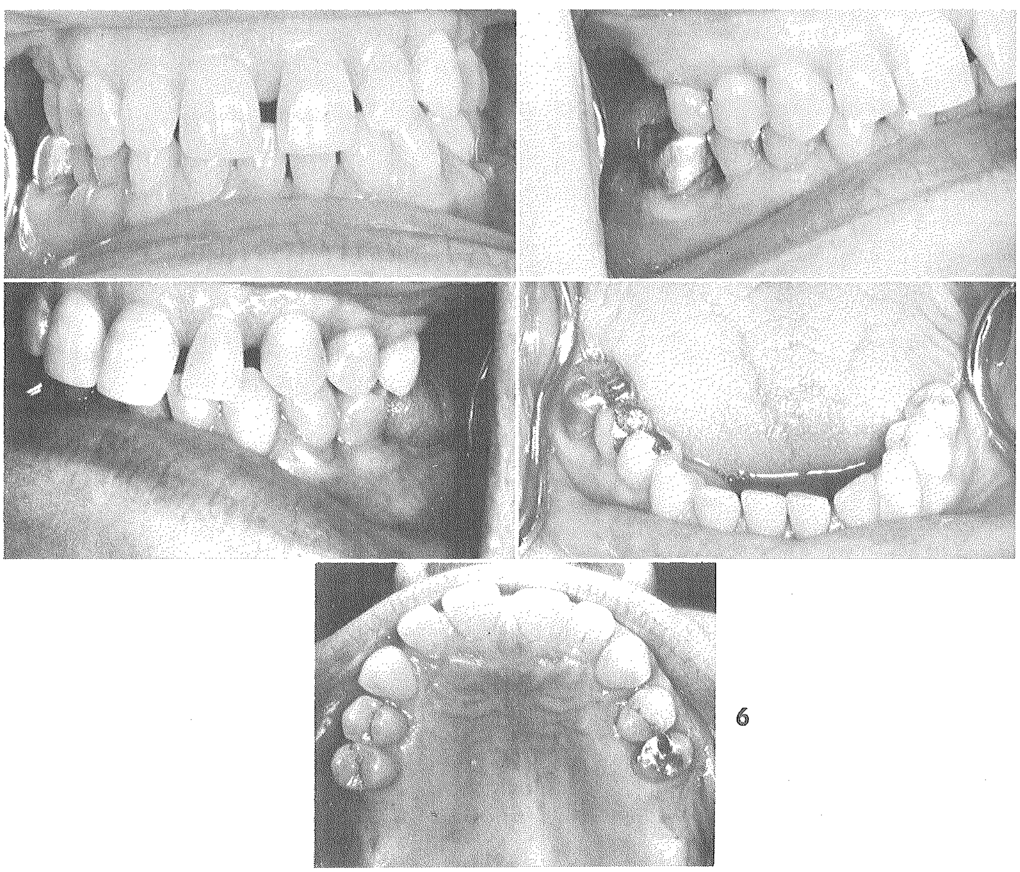
The physician's report showed a patient in good general health, without any unusual past medical history. No medicaments were being used with the exception of 1 Gm. of thyroid daily as a metabolic aid.

Dental history

The patient visited her dentist regularly every three months for many years. Dental restorations were of long standing, but the loss of a few molars had occurred in the last five years. The patient reported that she lost these teeth because of looseness and soreness, and, since she was getting older, the inevitable was happening and nothing could be done about it. During a visit to a vacation resort she developed a severe ache



Case 8-1. Preoperative roentgenograms showing extent of periodontal disease.



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Case 8-2 to 8-6. Preoperative photographs of patient's mouth—anterior, right side, left side, lower and upper occlusal views.

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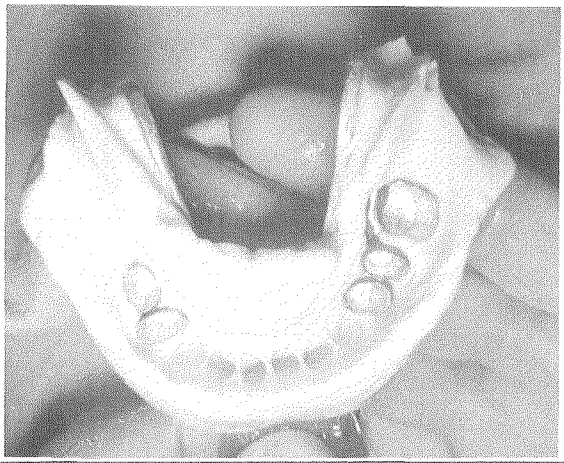

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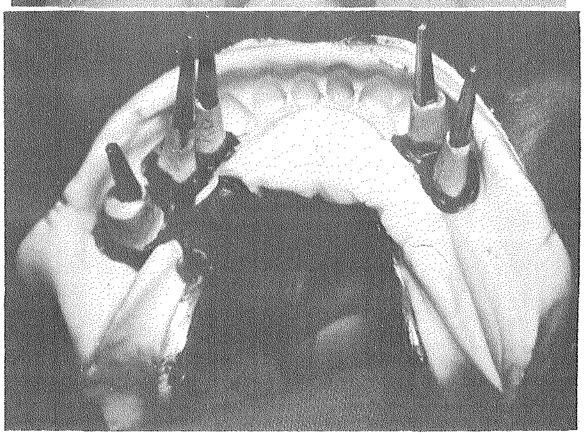
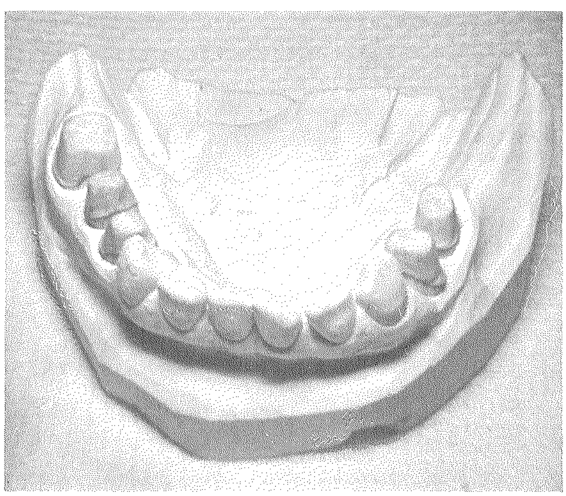


Case 8-7 and 8-8. Lower impression with DuraLay copings in position for correct positioning of dies.



Case 8-9. Lower working cast showing dies in correct position and marginal outlines penciled.

in her jaw accompanied by swelling, and a dentist was consulted. The tooth had to be removed because of periodontal involvement beyond the stage of treatment and repair. The patient also was informed that several other teeth would have to be removed. She was asked why she had allowed her mouth to get into such a deplorable state and why she never went to a dentist.

On her return to her home, in a state of shock and dismay, she consulted a periodontist who agreed with the diagnosis and treatment plan advocated by the resort dentist.

Chief complaints

The question asked was "Why was my mouth neglected to a state where all molars had to be lost and the anterior teeth had moved out of position, when I went regularly to the dentist and followed home care instruction meticulously and diligently all these years?" The answer, in this case, was not intentional neglect on the part of the dentist but ignorance regarding the many recent advances in the fields of periodontics and prosthodontics.

Clinical findings

The periodontist had roentgenograms made which, correlated with his clinical findings, indicated removal of the remaining molars (with the exception of the lower first molar), to be followed by periodontal surgery so as to return the supporting structures of the remaining teeth to a state of health. After healing and keratinization of the tissues the patient was referred to me for the prosthodontic phase, with the recommendation that the labial drifting of the upper incisor teeth and the closing of the diastema probably would be corrected when a coincidence of centric occlusion and centric relation was established. If it was not, minor orthodontic tooth movement would be instituted.

Presurgical roentgenograms showed pocket depth in some areas, infrabony pockets, and restorations that appeared to be contoured poorly.

Study casts were oriented properly on an adjustable articulator, and an analysis of the findings correlated with the clinical findings and roentgenograms revealed a lack of coincidence of centric occlusion and centric relation.

A mobility pattern was in evidence. Home care habits were excellent.

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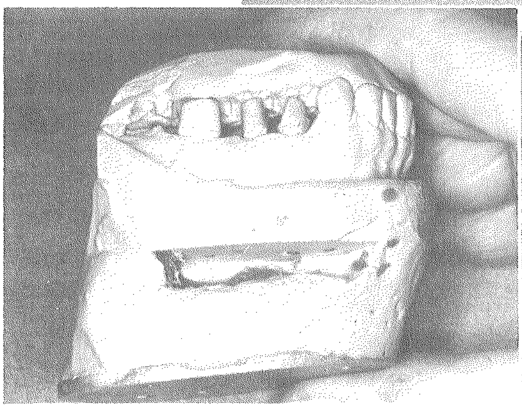

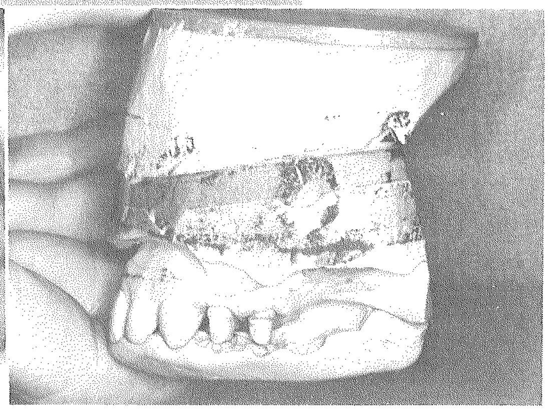

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Case 8-10 to 8-12. Stone index blocks made after wax-up of case to be used should there be a casting failure.

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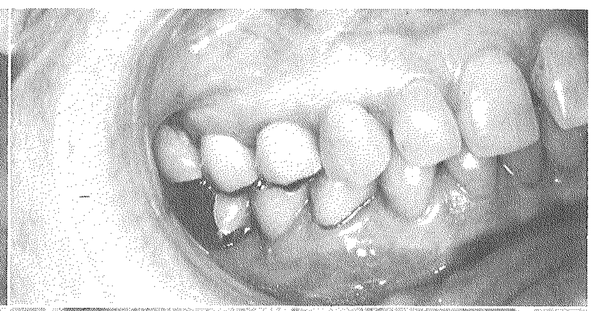

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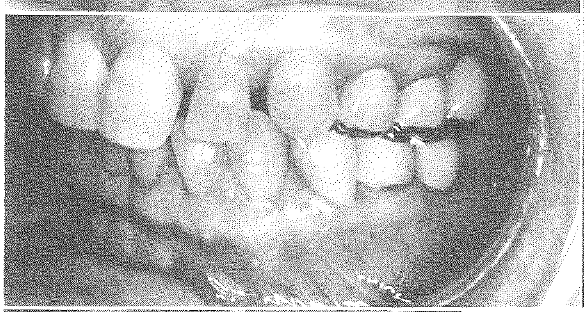

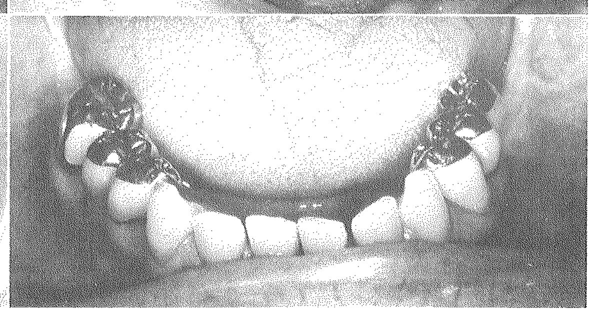

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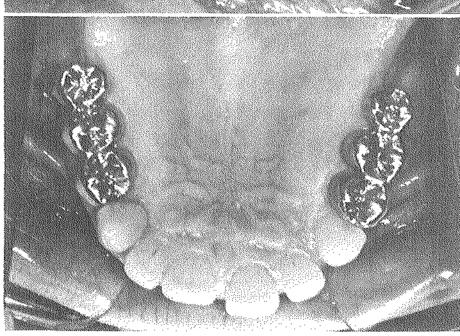


Case 8-13 to 8-17. Photographs of completed case. Gingival tissues show good tone and form. There has been a maintenance of healed situation for a number of years. The mistake in judgment was not insisting on employment of minor tooth movement in regards to upper and lower anterior teeth, even if pinledge splinting was necessary to maintain the end result. The esthetic pattern could have been improved greatly.

Diagnosis

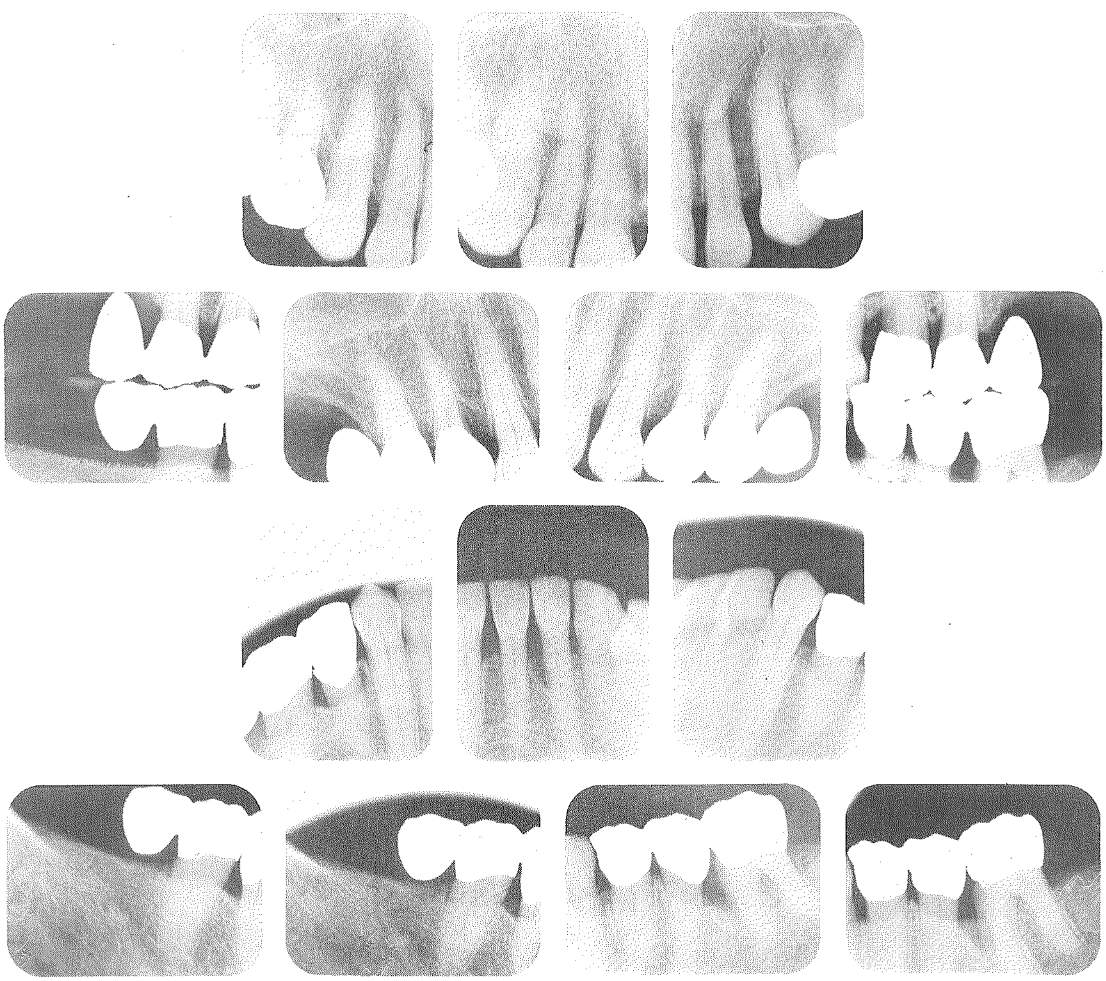
Occlusal periodontitis (periodontal trauma).

Treatment plan

Unilateral splinting of upper right and left bicuspids, lower left bicuspids with cantilevered pontics, and lower right bicuspids and first molar was recommended, accompanied by the establishment of correct interocclusal relations and a minimal increase in the vertical dimension.

Results

Correct masticatory relationships were established. The patient reports good efficiency in function accompanied by a negative occlusal perception. The mobility pattern has been reduced markedly, and gingival tissues show good tone, texture, and color. The periodontal ligament space has narrowed, no further alveolar resorption is present, and a reformation of the lamina dura has occurred. A postoperative examination shows that there has been a maintenance of the healed situation. However, it is believed that a mistake in judgment was made by not employing minor tooth movement in regard to the upper and lower anterior teeth. The patient does not believe that this was a blunder because her mouth has been returned to a state of health. (See Case 8-1 to 8-18.)



Case 8-18. Postoperative roentgenograms.

Case 9

Vital statistics

Female, a housewife, 34 years of age.

Medical history

The patient was in fairly good health. The physician's report called attention to some apparent sensitivity to vitamin C. It was thought a possible endocrine disturbance could be responsible for loss of alveolar bone in absence of local factors. However, physical examination revealed no significant abnormalities and no evidence of endocrine disorder. A psychogenic component was present and was probably connected with the bruxing habit exhibited by the patient.

Dental history

There is a history of poor early dentistry and orthodontics. The patient has been receiving routine periodontal treatment, subgingival curettage, and occlusal equilibration for a number of years. She also has worn a modified Hawley retainer with a labial arch wire to move the upper left central and lateral incisors into correct position. She was told that her condition was hopeless because of periodontosis and dental caries and that the loss of the complete dentition was inevitable in a short period of time. It was believed that this disease is difficult, if not impossible, to control completely.

Chief complaints

The patient complained of bleeding of gums, packing of food interproximally between upper right first and second molars, sensitivity in the cervical region of many teeth, inability to chew with ease and comfort, poor anterior esthetics, and protrusion and rotation of upper left lateral incisor. However, the psychologic impact of the impending loss of her teeth at such an early age was creating an anxiety that could trigger off a more serious condition.

Clinical findings

The patients oral hygiene habits were reasonably good, but excessive and constant smoking created a problem. The patient was very nervous, and a severe tenseness made registration of correct interocclusal relations almost impossible. It was apparent that there were mixed emotions coming into play—a fear of losing her teeth and a fear of dental manipulations. The outcome was very much in the hands of the dentist in this particular case. Could he control the situation by establishing the proper rapport, by being firm but still kind and understanding?

Gingival tissues were injected, and restorations probably had been executed as well as could be expected under the circumstances. A lack of coincidence of centric occlusion and centric relation was very obvious, and anterior esthetics needed attention. The buccal mucosa, floor of the mouth, lips, tongue, and throat appeared normal. Recession of labial gingiva over the left maxillary lateral incisor with extensive pocket depth, markedly rotated with open contact on the distal surface, was present.

Photographs and roentgenograms were taken. Impressions for study casts, hinge-bow transfer, and centric relation records for mounting casts on an adjustable articulator (by split-cast method) were taken. Pulp vitality tests and pocket depth determination also were done.

Diagnosis

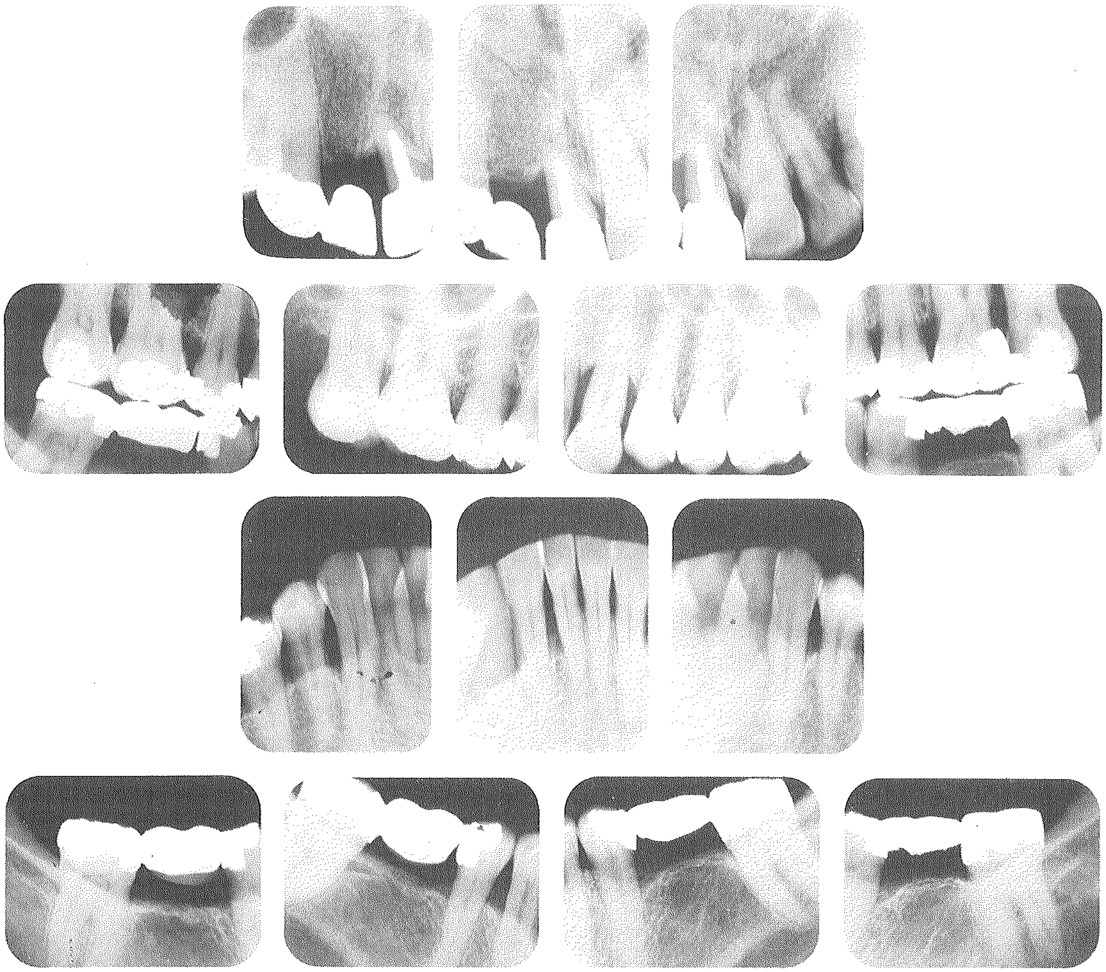
Roentgenographic, clinical, and cast orientation findings were studied and correlated. Centric occlusion and centric relation were not coincident, and the posterior prematurities were the cause of the labial displacement of the upper left lateral incisor. There was marked resorption of alveolar bone surrounding the left maxillary lateral incisor and definite resorption of alveolar bone around the right and left maxillary molars and canines and the lower incisor region. We were confronted with an inflammatory condition of the gingivae, coupled with a secondary occlusal traumatism.

This was a case of occlusal periodontitis.

Treatment plan

After initial periodontal treatment and minor orthodontic tooth movement, the teeth were to be prepared and temporarily splinted before periodontal surgery. Removal of the upper left lateral incisor was to be seriously considered.

After healing and keratinization of tissues, delineation of gingival margins of all prepared teeth was to be completed. Impressions, hinge-bow transfer, and centric relation records for the correct mounting of the working casts for development of the articulation, first in wax and



Case 9-1. Preoperative roentgenograms showing extent of periodontal disease.

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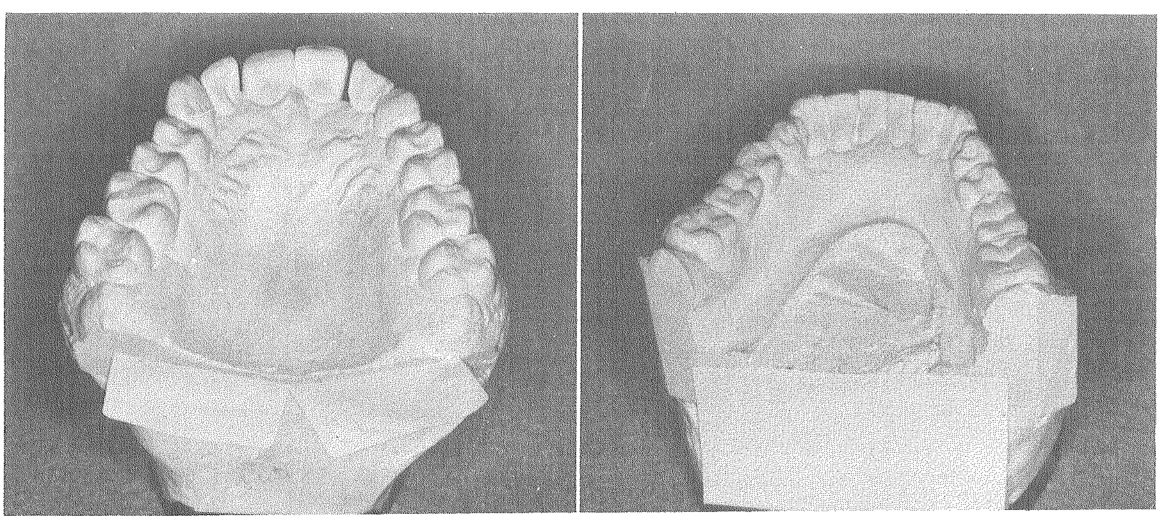

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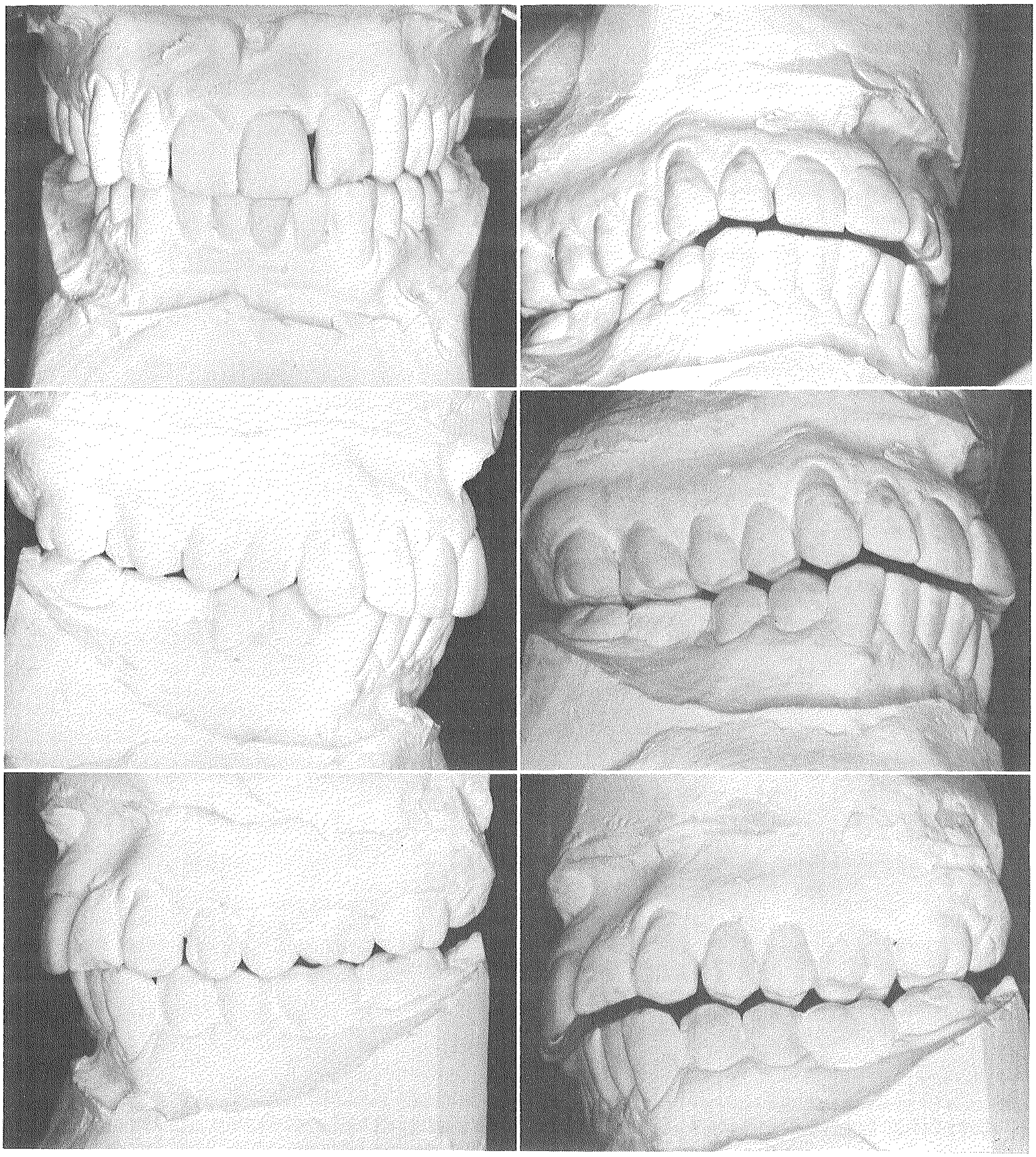
Case 9-2 and 9-3. Casts of upper and lower teeth (preoperative).



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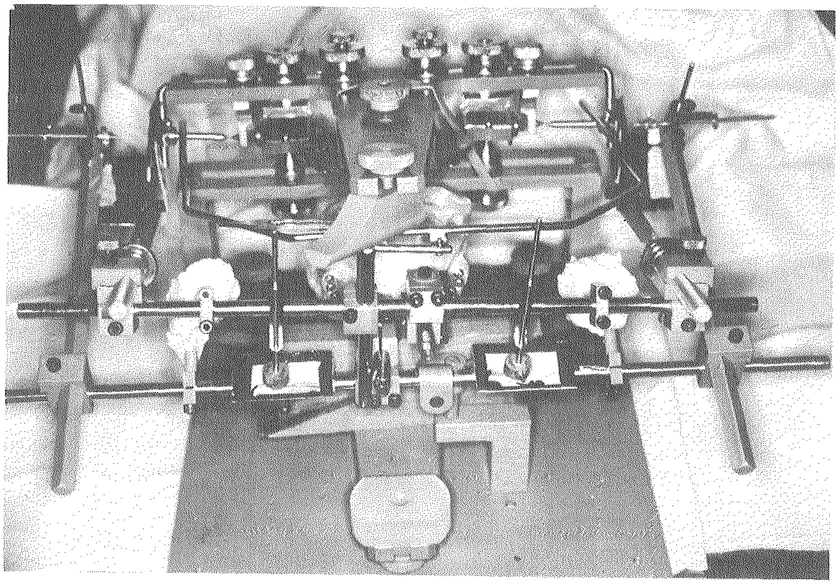
Case 9-4 to 9-9. Correctly oriented casts on an adjustable articulator showing anterior, right side, and left side views of casts in acquired centric (**4**, **6**, and **8**) and correct centric relation (**5**, **7**, and **9**).



Case 9-10. Pantograph being mounted on Stuart articulator.

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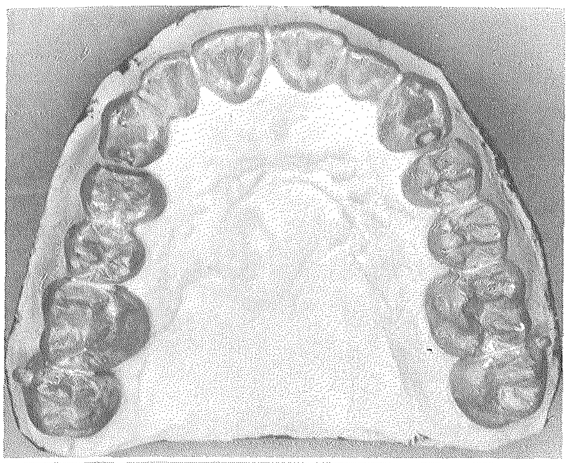

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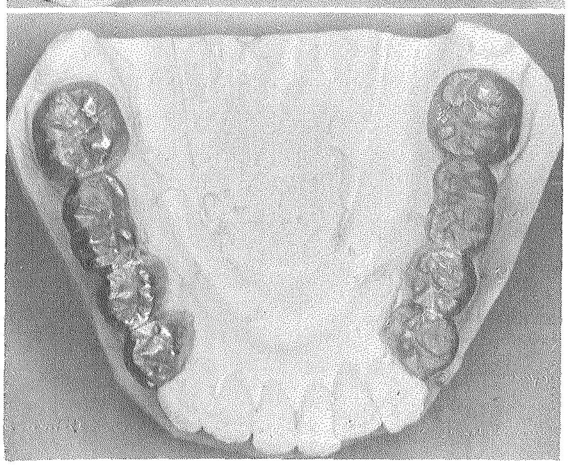

Case 9-11 and 9-12. Upper and lower remount casts. Note areas in cuspid region (upper) where key and keyway attachments will be placed for sectional splinting.

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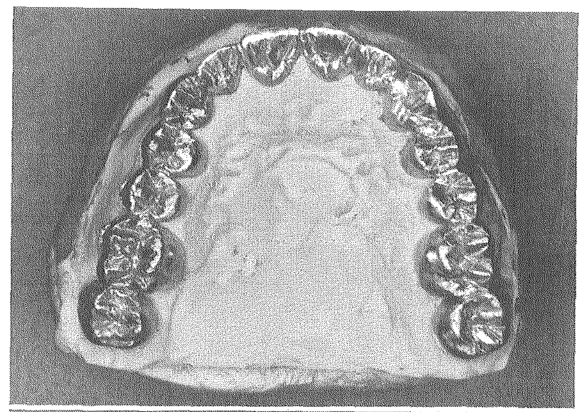

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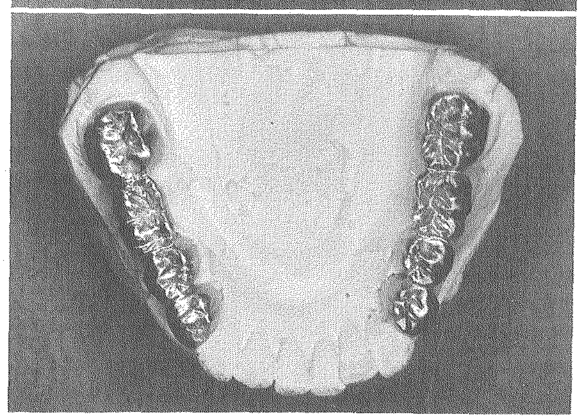

Case 9-13 and 9-14. Showing upper and lower remount casts after completion of placement of key and keyway attachments (upper) for effective bilateral splinting, and also note refinement of articulation.

Case 9-15 to 9-29. Series of illustrations showing restorations in various test glides (protrusive and lateral) and centric position, on adjusted articulator and in mouth. It shows this case on adjusted articulator in various positions before and after processing of veneers, as well as completed case in mouth in centric position, protrusive, and right and left lateral test glides.

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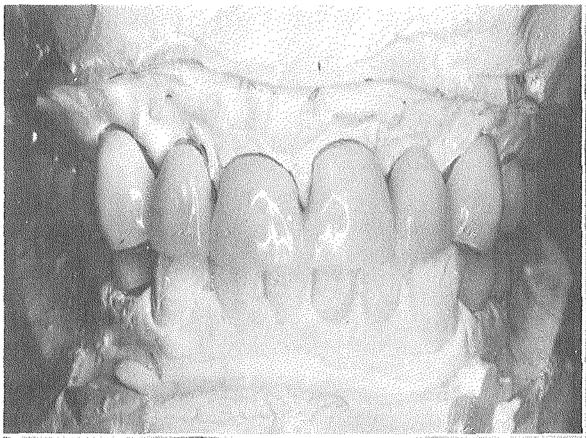
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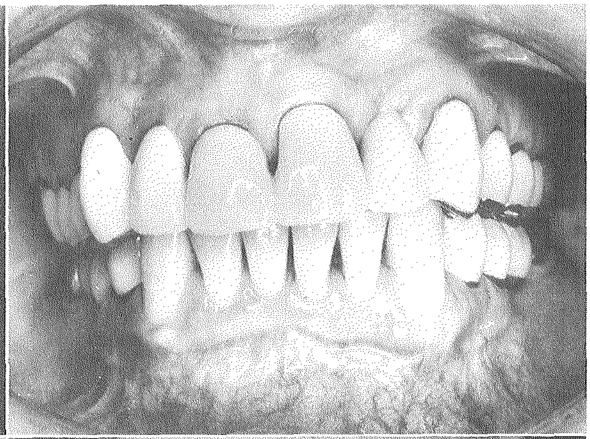

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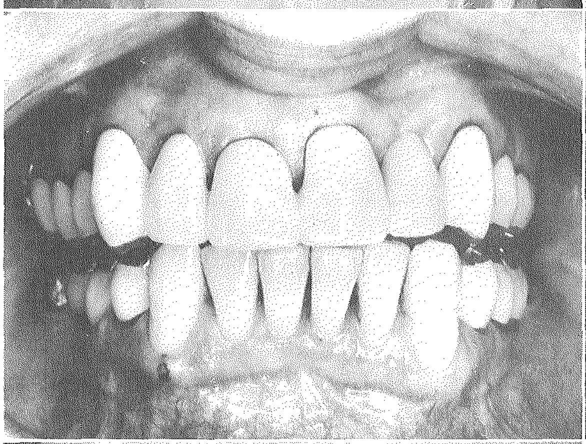
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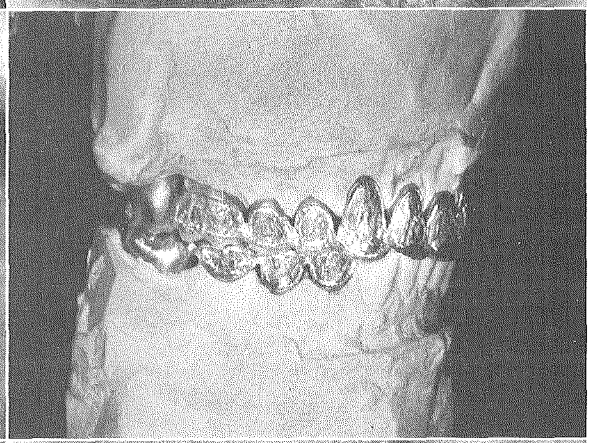

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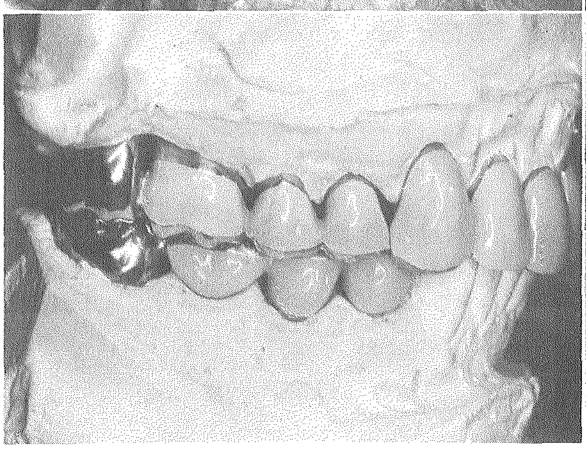
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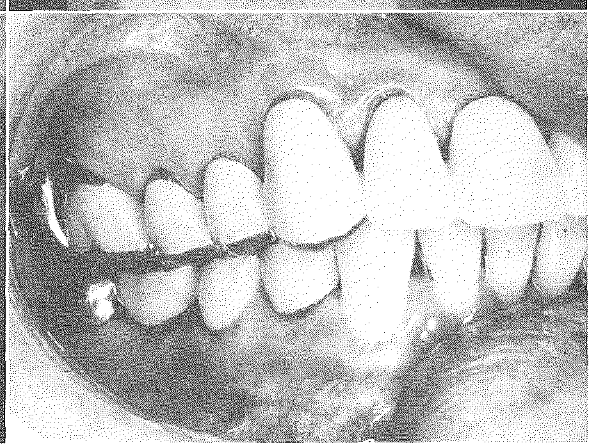

Case 9-15 and 9-16. Centric position on articulator and in mouth. A correct centric relation creates "a peaceful household."
Case 9-17. Protrusive position in mouth.
Case 9-18 to 9-20. Centric position (before and after processing veneers) on articulator, and completed case in mouth (right side).

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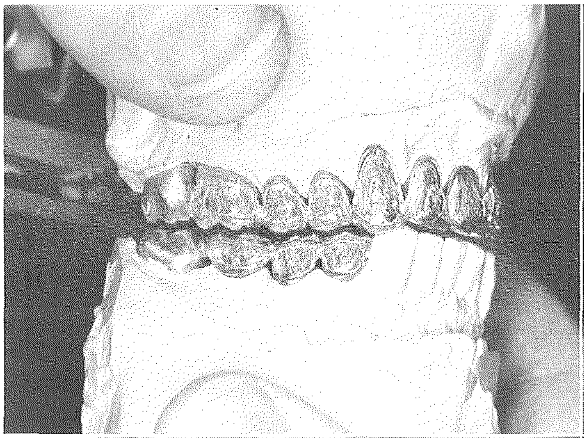

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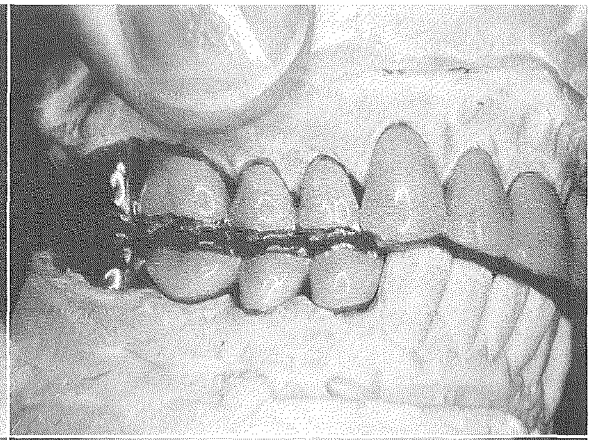

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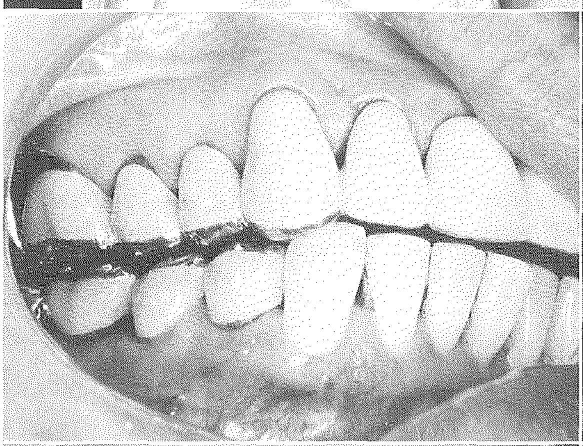

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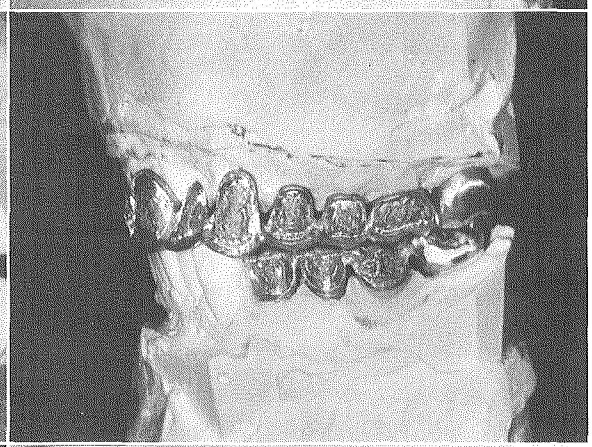

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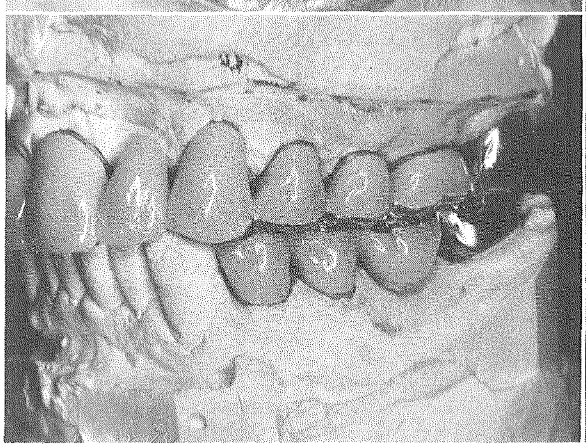

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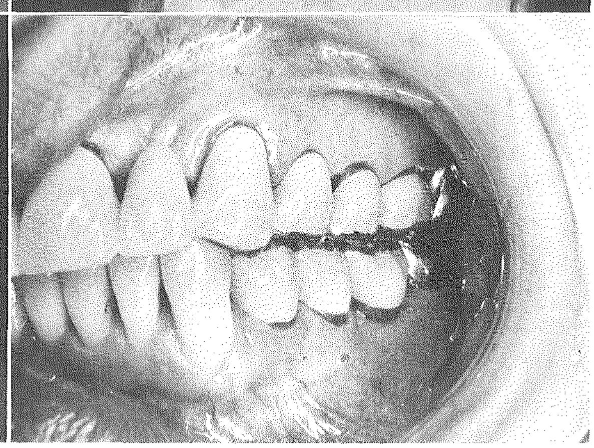
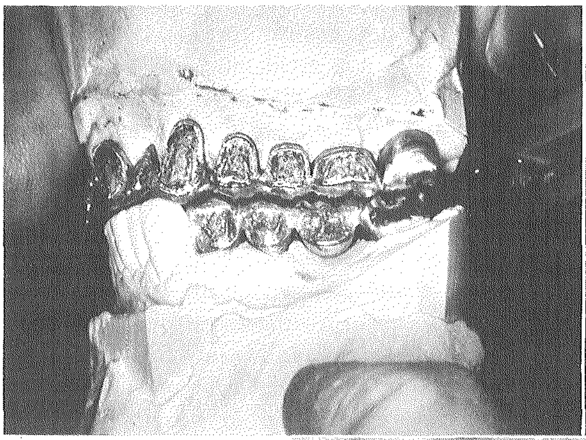
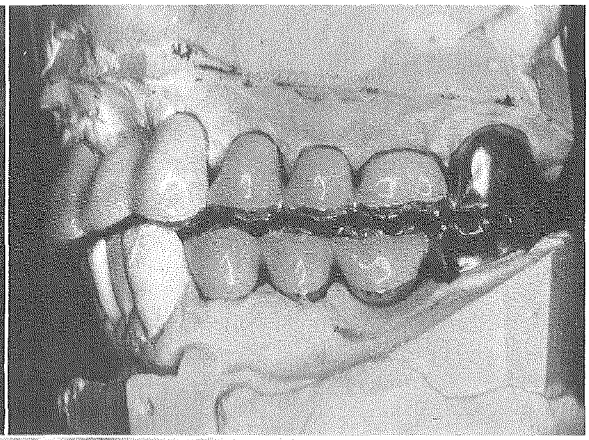
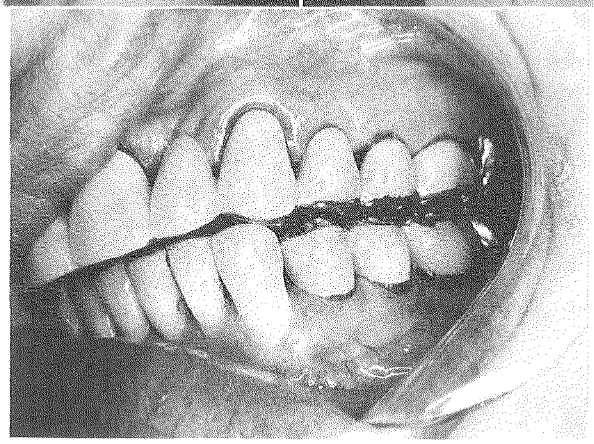
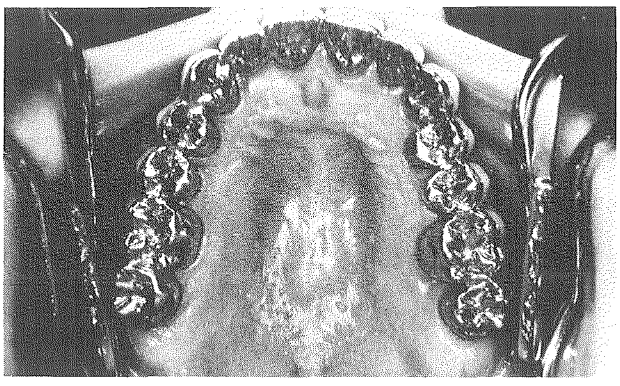
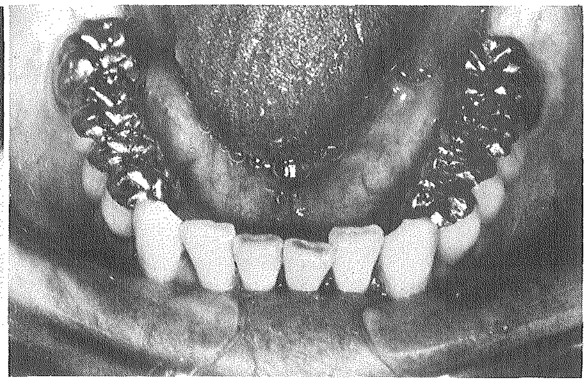


Case 9-21 to 9-23. Right lateral test glide (before and after processing) on articulator, and completed case in mouth. "Misses" are quite immediate.
Case 9-24 to 9-26. Centric position (before and after processing veneers) on articulator, and completed case in mouth (left side).

27   28

 29

Case 9-27 to 9-29. Left lateral test glide (before and after processing veneers) on articulator, and completed case in mouth.

30   31

Case 9-30 and 9-31. Upper and lower occlusal views of completed case. A coincidence of centric occlusion and centric relation was established. This case, seven years postoperatively, demonstrates response to therapy—good tissue tone and texture, embrasure form, and coronal contours. Mobility pattern is almost nil, and esthetic pattern is good. Absence of wear is evident. Creation of a good periodontal climate allowed for placement of restorations with good form and function.

then in gold, would be the next procedural steps. Bilateral splinting was to be used in the upper arch and unilateral splinting in the lower arch. This was to be followed by remount procedures and refinement of the articulation before temporarily cementing the case for a period of time, after which hard cementation will be done. A night guard is to be constructed.

Results

Establishment of correct masticatory relations were very difficult but were attained. Gingival tissue tone, color, and texture are good, mobility pattern is almost nil, a reformation of lamina dura has taken place, and a thinning of the periodontal ligament space has occurred. The coronal and embrasure form, despite extensive splinting, appears good, and no "crowding out" of the interdental papillae is present. A good esthetic pattern has been established. Home care habits have improved, and the wearing of the night guard has been of great assistance in this particular case. The patient has a negative occlusal perception.

Good teamwork among the periodontist, orthodontist, and prosthodontist created a good periodontal climate, allowing for placement of restorations with good form and function. The psychiatrist's help was of inestimable value. (See Case 9-1 to 9-32.)

Case 9-32. Roentgenograms taken seven years postoperatively. Upper right first and second molars have been questionable in my mind all this time, but no exacerbations have occurred to warrant removal of these teeth.

Case 10

Vital statistics

Female, a housewife, 42 years of age.

Medical history

In good general health, and the patient had no unusual past medical history. Recent laboratory tests (on request of the periodontist)—complete blood count, urinalysis, blood calcium, blood phosphorus, alkaline phosphatase, and sugar tolerance test—were within the range of norm. A psychogenic component probably was responsible for the bruxism during sleeping hours and for the tongue thrusting, causing excessive pressure against the anterior teeth.

Dental history

The patient visited the dentist regularly every six months for prophylaxis, roentgenograms, and any necessary restorations. She lost several molars as time went on, but no effort was made to replace these teeth. Because of recurrent periodontal infections, the patient was referred to a periodontist. Periodontal surgery and occlusal equilibration were executed, but nothing was suggested or done about the restorative phase. From time to time in the next two years certain areas around the mouth were surgerized again because of recurrent infections.

Chief complaints

Development of diastemas between upper and lower central and lateral incisors, sensitive recession and erosion areas, mobility of teeth, food impaction, and gritting and grinding of teeth were the patient's major complaints.

Clinical examination

It was apparent that the patient was making an effort to perform home care instructions, but an incorrect Stillman method of toothbrushing was being used. Restorations had been done without any conception of what constitutes proper form and function. The majority of the teeth exhibited a severe mobility pattern, and a lack of coincidence of centric occlusion and centric relation was very obvious. The lips, tongue, palate, throat, cheeks, and floor of the mouth appeared normal. Some teeth were in torsiversion and presented wear facets.

Roentgenograms, photographs, and impressions for study casts were taken. Also hinge-bow transfer and centric relation records for mounting study casts on an adjustable articulator for preliminary study, construction of aluminum clutches (for hinge axis location and jaw "writings"), and preoperative wax-up were taken. Vitality tests and pocket depth determinations were made also.

Diagnosis

Correlation of roentgenographic, clinical, and cast orientation (on the correct axis) findings showed that this was a case of advanced periodontal disease, and the prosthodontic phase would be very difficult.

Treatment plan

Centric occlusion and centric relation were not coincident, and their correction would require minor tooth movement and extensive crown and bridge procedures. Bilateral therapeutic splinting was indicated.

Upper teeth

Extraction of the upper right second molar seemed necessary, but I decided to take a chance on this tooth despite the periodontal involvement and marked mobility.

Central and lateral incisors were extracted because of much bone loss, diastemas, mobility, pockets, and poor esthetics.

All remaining upper teeth, right cuspid and bicuspids, second molar, and left cuspid and bicuspids, were to be prepared for full coverage and bilateral splinting.

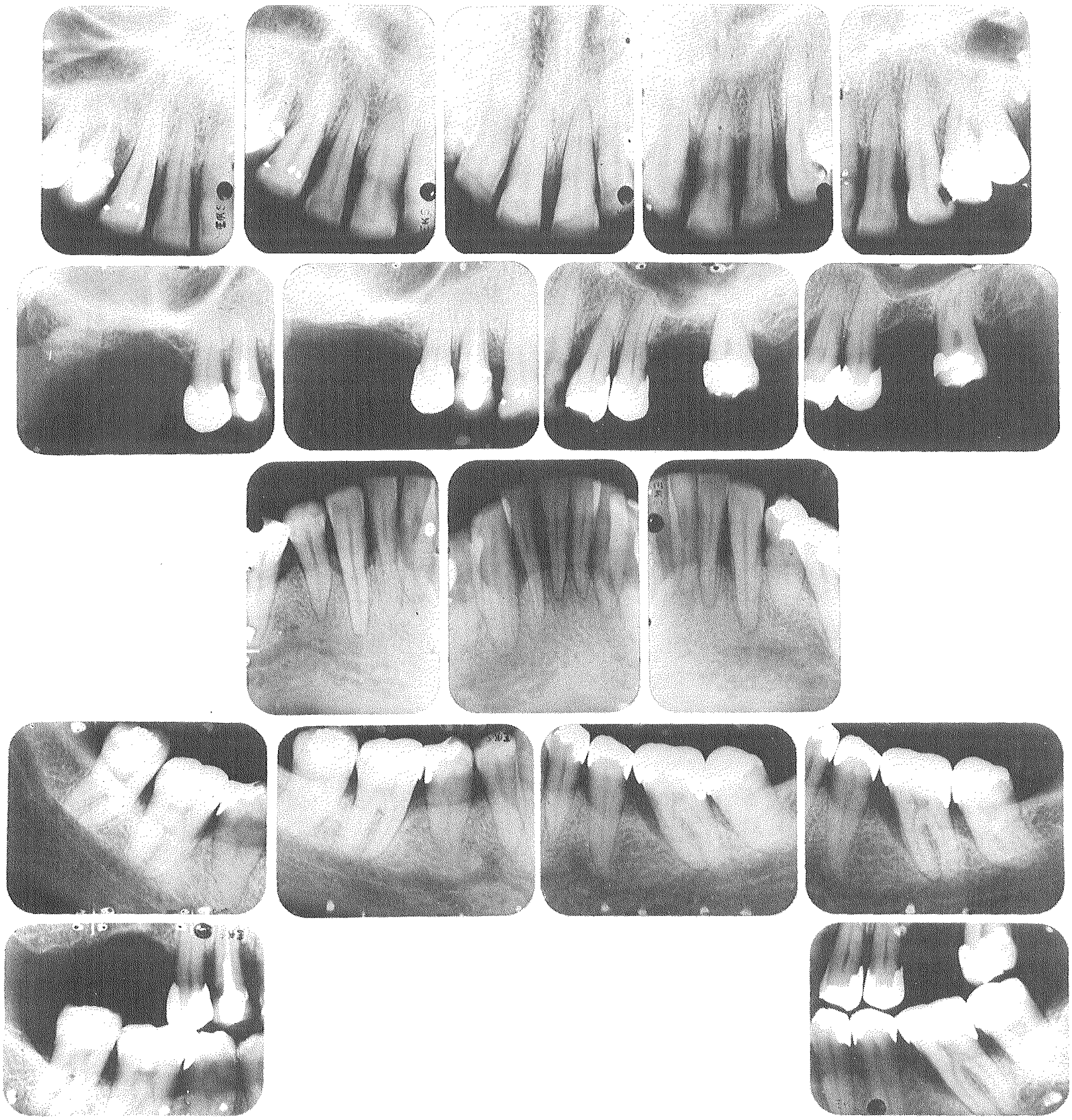
Temporary cementation was to be used.

Lower teeth

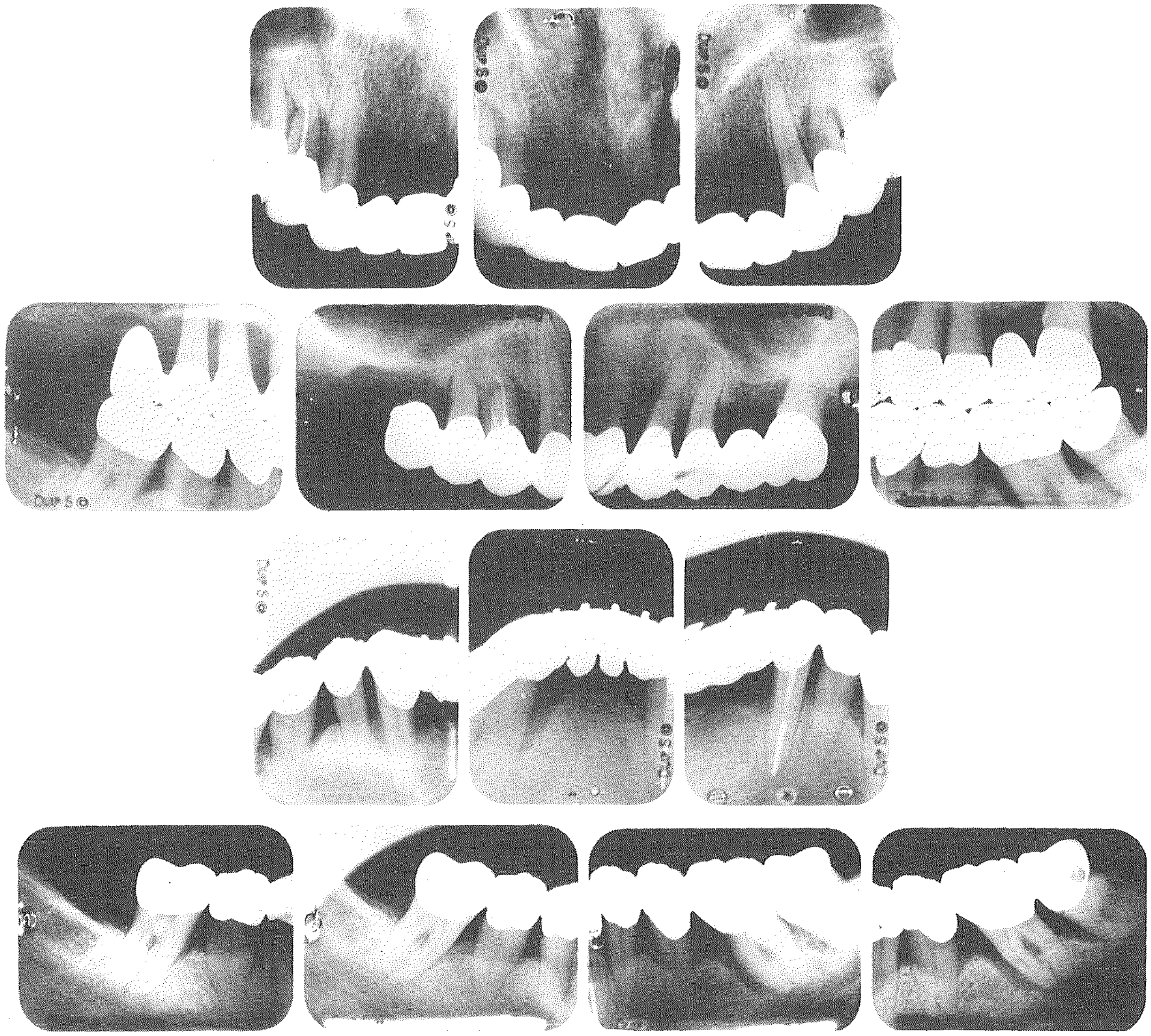
Right and left central and lateral incisors were extracted because of severe bone loss, mobility pattern, and esthetics. All remaining lower teeth were to be prepared for full coverage and bilateral splinting.

Temporary cementation was to be used.

Subgingival curettage and more osseous surgery would be required, but the patient ruled out periodontal surgery. A night guard was to be constructed.



Case 10A-1. Preoperative roentgenograms showing extent of periodontal disease.



Case 10A-2. Roentgenograms taken after case was provisionally splinted. A period of eighteen months had elapsed since roentgenograms shown in Case 10A-1 were taken. A periodontist was of opinion that occlusal equilibration and good home care would stop bruxing habit and probably arrest periodontal destruction. Condition became worse in several areas.

Prognosis

The patient was not promised anything—it had to be a pure gamble. This case had to be designated as "terminal." However, it was believed that a few years of service with comfort could be expected and was worth the extreme effort, especially for this particular patient.

Results

Correct masticatory relations were established and proved satisfactory, and this, in conjunction with bilateral splinting, reduced the mobility pattern markedly. Gingival tissue color, tone, and texture were improved, and if the patient had allowed the periodontist to do more periodontal surgery, an even more satisfactory result would have been achieved. The bruxing and tongue-thrusts habits seemed to be diminished, but not entirely eliminated. With instruction and close observation home care regimen became most satisfactory. The esthetic pattern was improved greatly, adding impetus to the patient's desire to retain her remaining teeth. Reformation of the lamina dura and thinning of the periodontal ligament space were not as good as desired, but the patient had a negative occlusal perception and was functioning rather comfortably. (See Case 10A-1 to 10A-14.)

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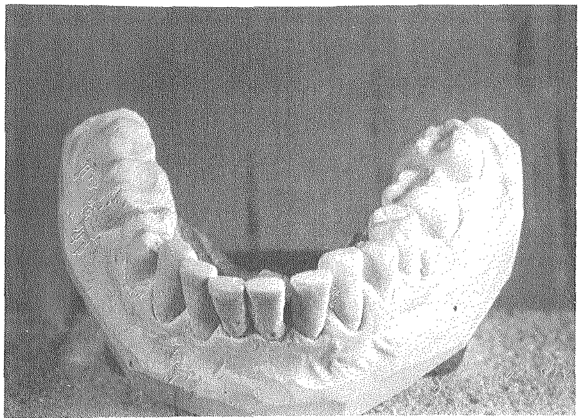

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Case 10*A*-3 and 10*A*-4. Casts of lower and upper teeth (preoperative).

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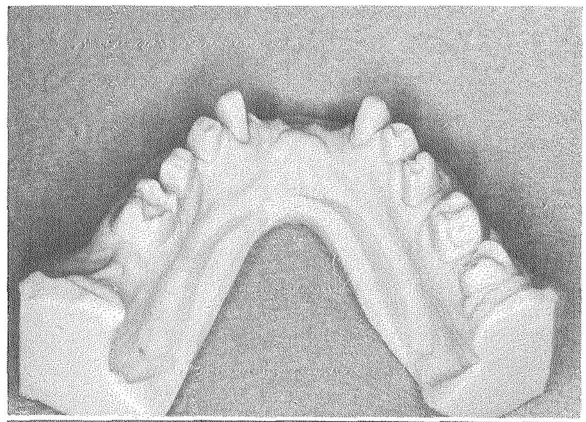

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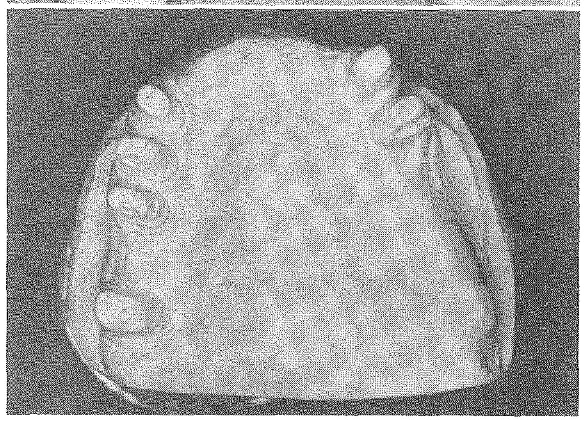

Case 10*A*-5 and 10*A*-6. Lower and upper working casts.

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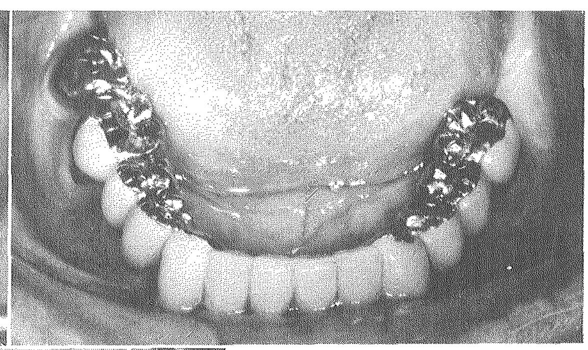

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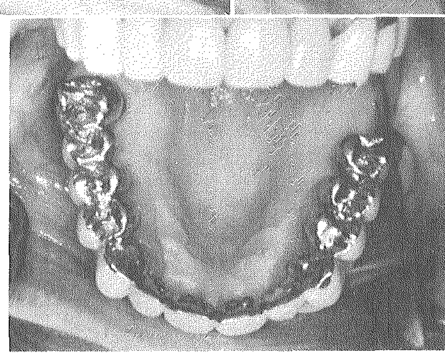
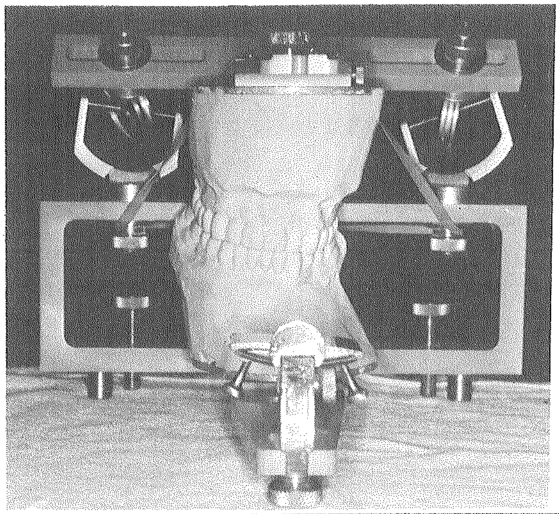


Case 10*A*-7 to 10*A*-9. Photographs of completed case (bilateral splinting) taken nine years postoperatively.



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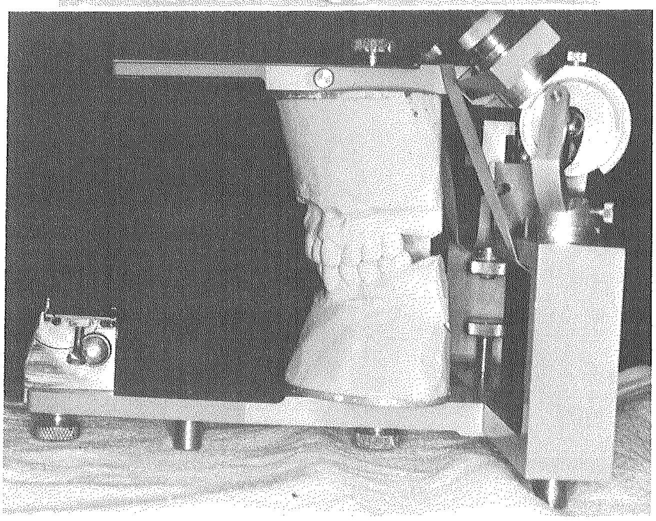

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Case 10*A*-10 and 10*A*-11. Postoperative casts correctly oriented on adjusted McCollum articulator.

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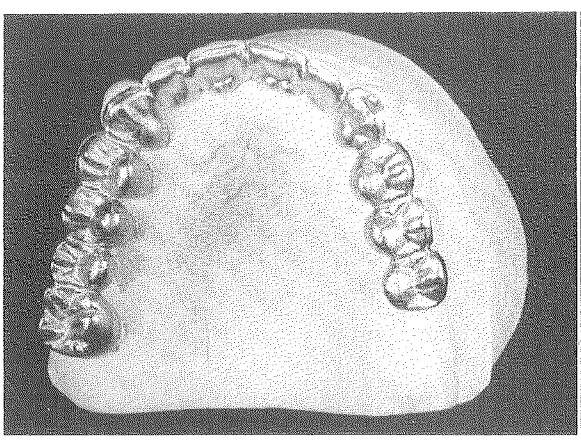

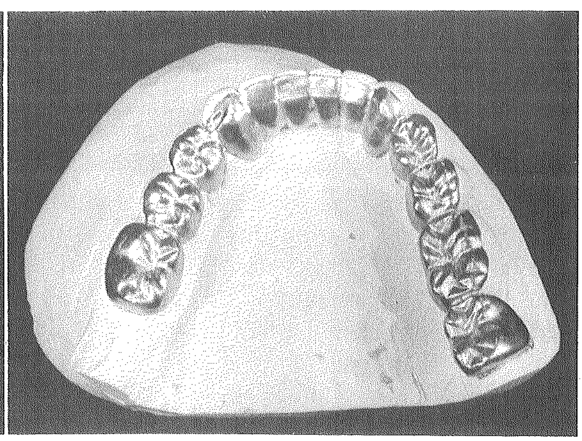

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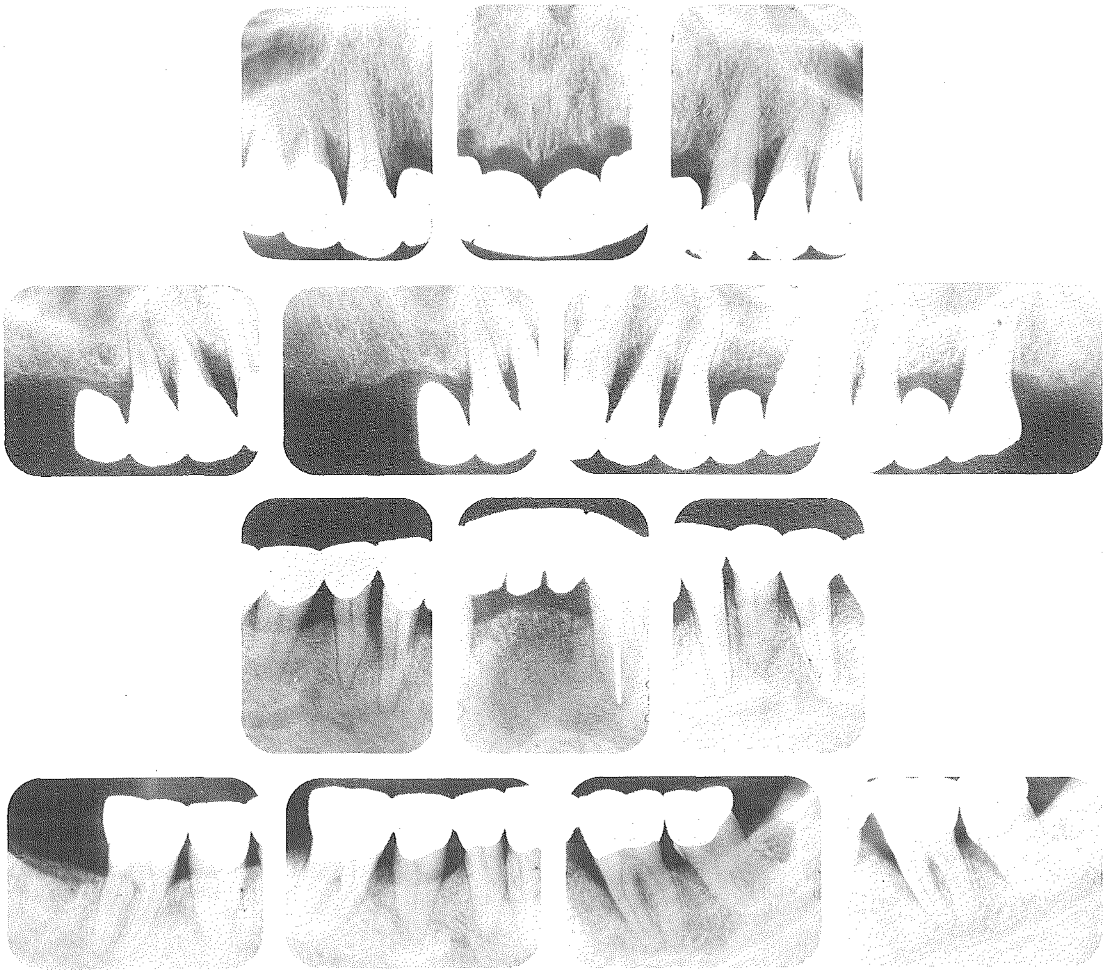
Case 10*A*-12 and 10*A*-13. Upper and lower casts of completed case.



Case 10A-14. Roentgenograms of completed case taken nine years postoperatively. Patient refused to undergo periodontal surgery for third time even though she was urged to do so at beginning of rehabilitation. I was of the opinion, at the time these roentgenograms were taken, that some healing had occurred.

All went along as just related for ten years and then, during a period of great stress and strain that caused an increase and more severe pattern of clenching and grinding, five of the remaining seven upper abutment teeth had to be extracted—all but the right and left cuspids.

The psychologic impact of wearing a full denture was of such severity that it was decided to make a fixed splint from the right cuspid to the left cuspid with cantilevered pontics to contain the female attachments of an extensive upper removable precision partial denture. It was believed that this type of arrangement would serve as a transitional stage to condition the patient for a full denture in the near future.

The upper right cuspid was devitalized, and a post anchorage cast gold core was constructed and cemented.

Precision attachments were used as the retaining devices because they fulfill more of the physiologic requirements of the teeth and their supporting structures. The stresses are directed along the long axes of the teeth, and no torquing is involved.

Proper relation of the base of the partial denture, which has to have good fit and adaptation to the tissues, to the fixed splint was of the utmost importance if we hoped to retain the two remaining cuspids for any period of time and stave off the full denture for as long as possible.

After constructing, fitting, and soldering the retainers and pontics for the fixed splint, the next step was the taking of a mucostatic impression of the areas to be covered by the base of the partial denture.

To obtain a precise fit of the saddle, it is important that a detailed mucostatic impression and an additional relational impression to join the fixed and removable parts be taken. Dykins[1] has pointed out that the mucostatic base has made it possible to arrive at a condition that he has termed the "tissue base constant," which is "that intimate mucosa-base relationship on which stability is based."

The impression must be a microscopically accurate reproduction of the denture area. It must reproduce the tissues in their perfectly passive form because lasting stability demands an impression and denture base that are absolutely accurate negatives of ridge tissues in their normal passive form. The tissue is composed of solids and liquids. For all practical purposes tissues are incompressible and can be displaced but not stretched. Properly utilized surface tension (interfacial surface tension) produces much better denture retention than even a perfect vacuum. The power of surface tension is dependent upon the thinness of the intervening moisture film.

The impression tray (made on the working cast from which the fixed splint was made), an individually cast aluminum tray that is light in weight, was made narrower than the area to be covered by the impression, and handles were placed in areas that cannot interfere with the lips, cheeks, or tongue. It was necessary to have enough space between it and the tissues so that it could not come through the impression material and by contact cause any displacement of tissue. A single layer of Tenax baseplate wax was adapted to the cast over the area to be covered with the base for the partial denture (two layers for full dentures). In the case under consideration one layer of wax provided ample space because the anterior teeth were the guide in the correct seating of the tray. A sheet of 1/1000-inch tin foil was burnished over the wax spacer, which was lubricated with petroleum jelly, and a tray formed with Tenax wax, small handles being placed in the proper positions. This provided a spacer-relieved tray that covered the desired areas. Invest wax tray in casting investment, burn out, and cast in aluminum. The finished tray is the vehicle to carry impression material to place in the mouth.

The patient was told of the importance of being relaxed during impression taking and coached to relax cheeks and tongue. The saliva tube was placed in the mouth, petroleum jelly was applied to the lips to prevent sticking, gauze was packed around the buccal surface of the upper ridge, and the palate was wiped with a piece of gauze.

The impression material must not offer greater resistance to flow than the softest tissue with which it will come in contact. To have enough body to carry it into the mouth and still flow without pressure, it must have a very low surface tension. In other words, it must be an impression material that does not demand force to flow and copy. Once in the mouth it must become hard enough so that it can be removed without distortion, replaced and still be as rigid as the base so that it can be tested for stability. Zinc oxide-eugenol impression material* is my choice for this procedure. This type of material absorbs a slight amount of moisture from the tissues, thus affording the thinnest possible space between the impression and tissue and therefore a better interfacial surface tension. It also eliminates the need of a separating medium.

The mixing technique must be mastered, and this takes practice. A smooth creamy mix must be the end result. A large, wax-free, paper mixing pad and a large, relatively stiff spatula is used. Experience will teach one the correct quantities of powder and liquid needed (if more liquid or powder is needed, they can be added). The powder is placed in the center of the pad, a crater made in the middle of the pad, and the liquid poured into the crater. The powder and liquid are stirred together until they begin to wet down; then the spatulation is commenced with long, sweeping strokes, spreading it well over the whole pad. More powder should be added at this point, if needed. The mix should be spatulated until the proper consistency has been reached—until it is smooth and not too thin so that it runs freely all over the tray. Then the tray is loaded and more material piled in the center of the vault (since this is an upper impression). The loaded tray should be handled

*Ackerman Dental Co., Santa Monica, Calif.

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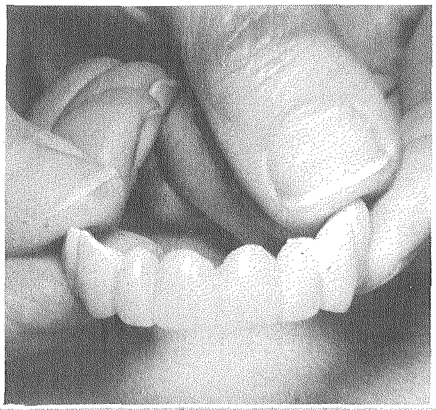

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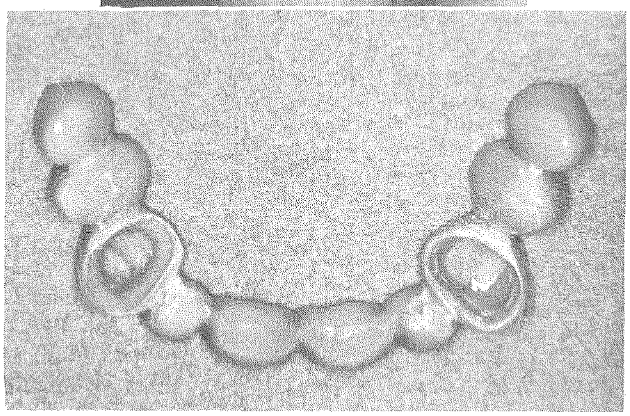

Case 10*B*-1 and 10*B*-2. Two views of temporary acrylic resin splint used in Case 10*B*.

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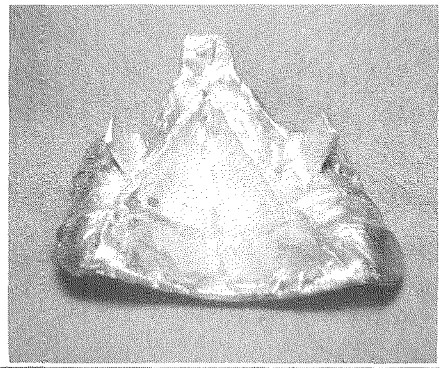

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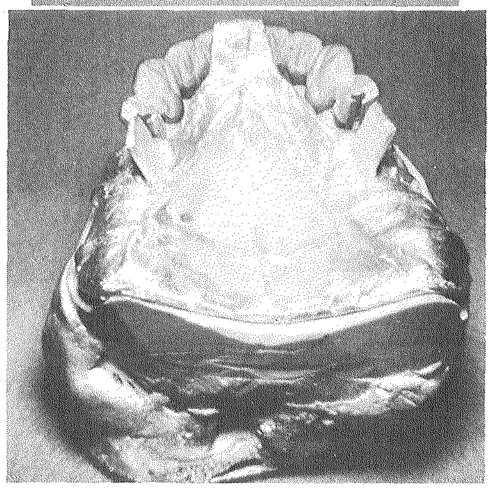
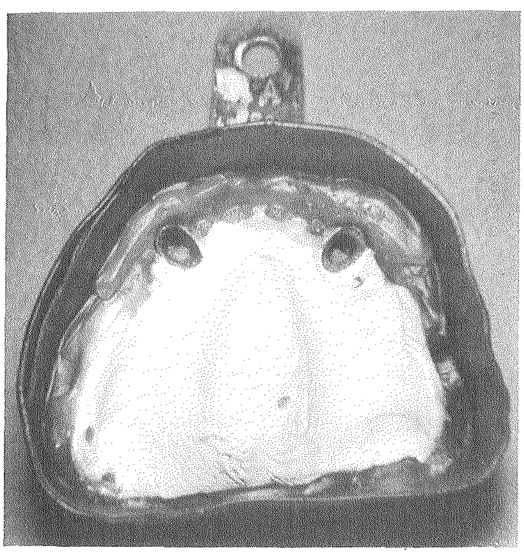
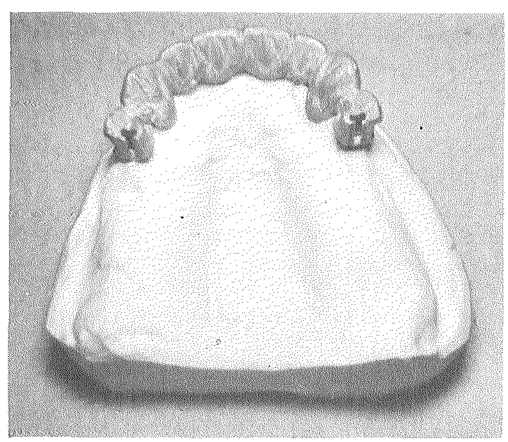


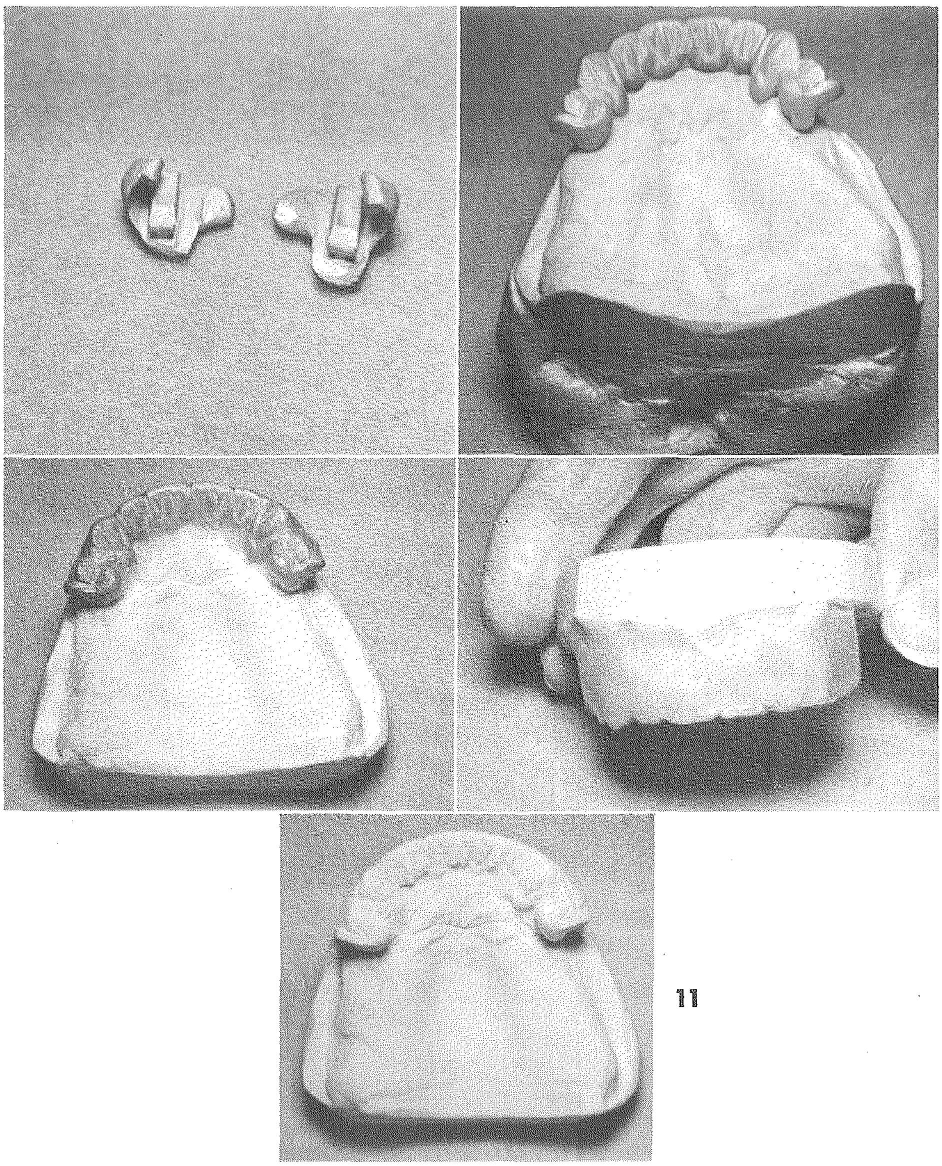
Case 10*B*-3 and 10*B*-4. After construction, fitting, and soldering of retainers and pontics for the fixed splint, an individualized cast aluminum tray was made on working cast, from which fixed splint was made.



Case 10*B*-5. Relational impression (an overall plaster impression taken to relate fixed splint with mucostatic impression) is rimmed with a soft wax and boxed in preparation of pouring stone to form cast.



Case 10*B*-6. Master cast for construction of precision removable partial denture, with G/L females soldered into retainer "cutouts."



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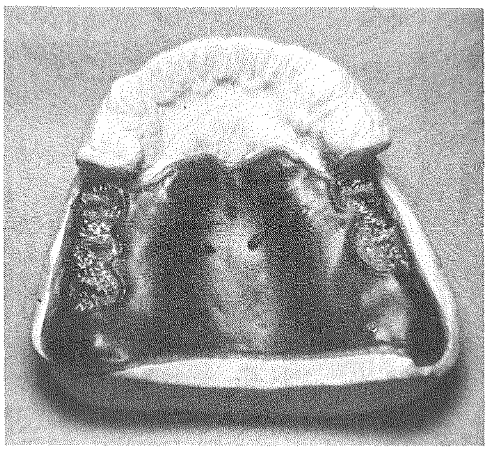
Case 10*B*-7 to 10*B*-11. Stern G/L male attachments with finger removal spurs seated into females in preparation for duplication to construct casting model (11).

with care to keep the material exactly as it was placed.

The saliva ejector and gauze are removed and, if possible, a small amount of the impression material is wiped on the center of the vault and in the regions of the hamular notch. The tray is positioned in the mouth, teasing it into place with a slight vibratory motion. The impression is not forcefully pushed into place. Be sure that the cheeks are not trapped between the tray and the ridge area. Material is allowed to slowly and gently settle into place over the semidried tissues. The tray is gently supported until the initial set has taken place.

After the material has set completely the impression is removed and read to see if it is a good one or not. Then any excess material is carefully cut away. The perimeter of the impression should encompass the maximum bone-supported mucosa, with the necessary mutations for muscle attachments, etc. Reliefs are contraindicated since they reduce the usable contacting base area in which there is the least possibility of soft tissue displacement.



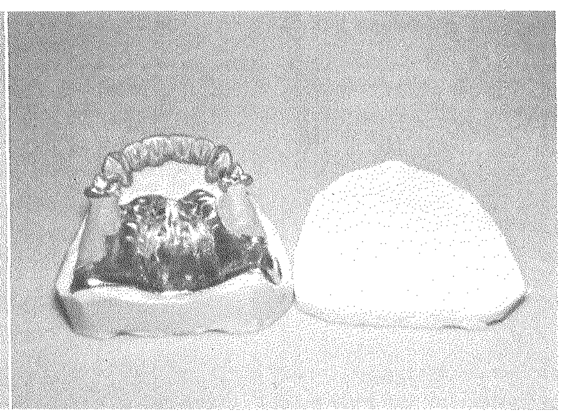
Case 10B-12. Wax-up of denture base.

The impression is then returned to the mouth to test it for stability by applying finger pressure from area to area to make sure that there is no "give" in any area. If the impression responds properly to tests for stability, then it is certain that the base will have retention when in use. At this point an overall plaster impression is taken to relate the fixed splint with the mucostatic impression.

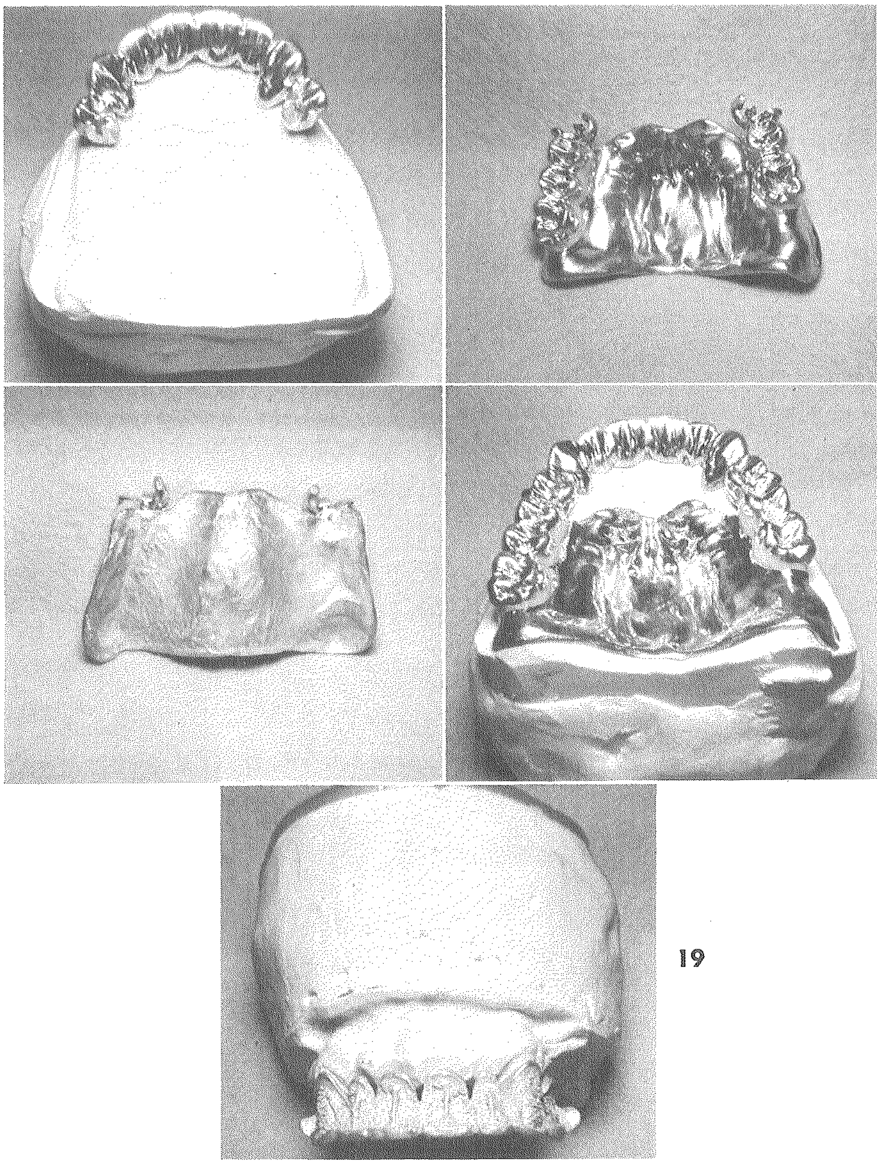
The cast should be poured immediately, if possible.

The denture base must be a perfect replica of the impression. It is best to use a metal base, and the design of the denture base must provide for skirting of the gingival and proximal tissues. When the base is completed, it will rest in perfect contact with tissue that has not been displaced and therefore will not spring out of place. Since the tissue is not compressible, the base resting upon it is solid and unyielding. "Briefly, it can be said that the tissue base constant originates in the impression, is delivered by the base, and is perpetuated by the articulation."*

*From Dykins, William R.: Requirements of partial denture prosthesis, J.A.D.A. 57:232-236, 1958.

13   14

Case 10B-13 and 10B-14. Completed upper precision removable partial denture being readied for registering centric relation by split-cast method. "Cold-cure" acrylic on saddle areas.



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Case 10B-15 to 10B-19. Illustrations showing fixed splint, precision removable partial denture made from a mucostatic impression, with gold occlusals, and finger spurs for ease of removal without twisting or torquing. Note surfaces of partial denture that are to contact tissues are not polished (17).

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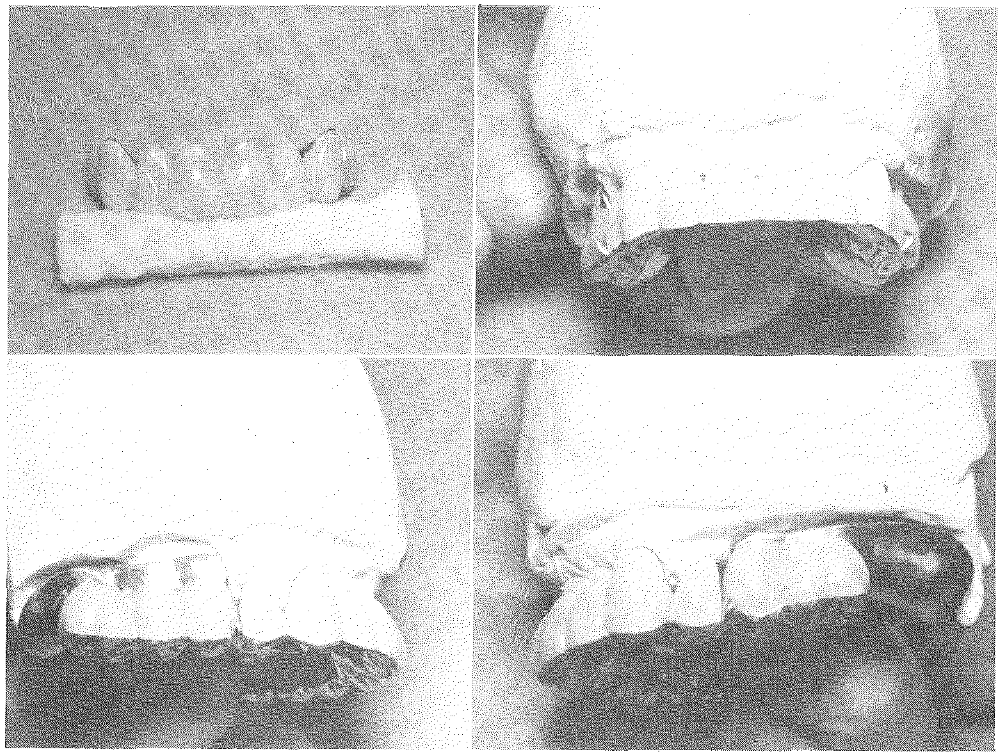
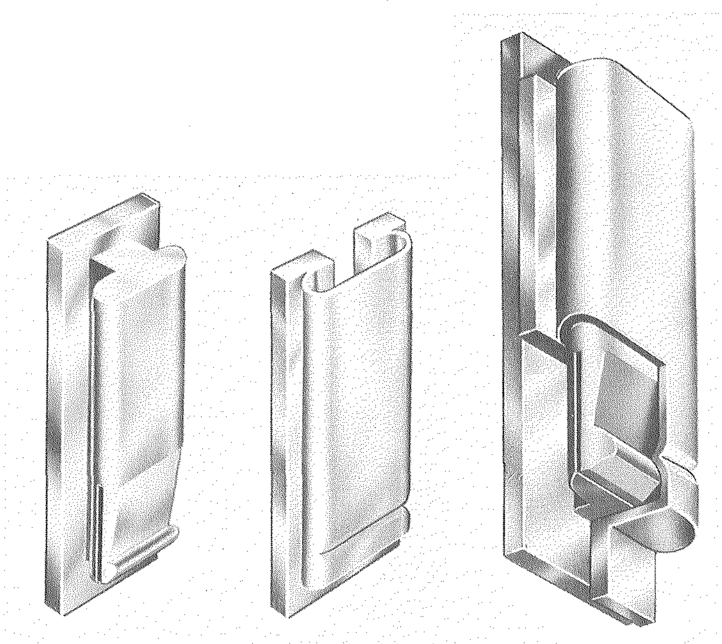
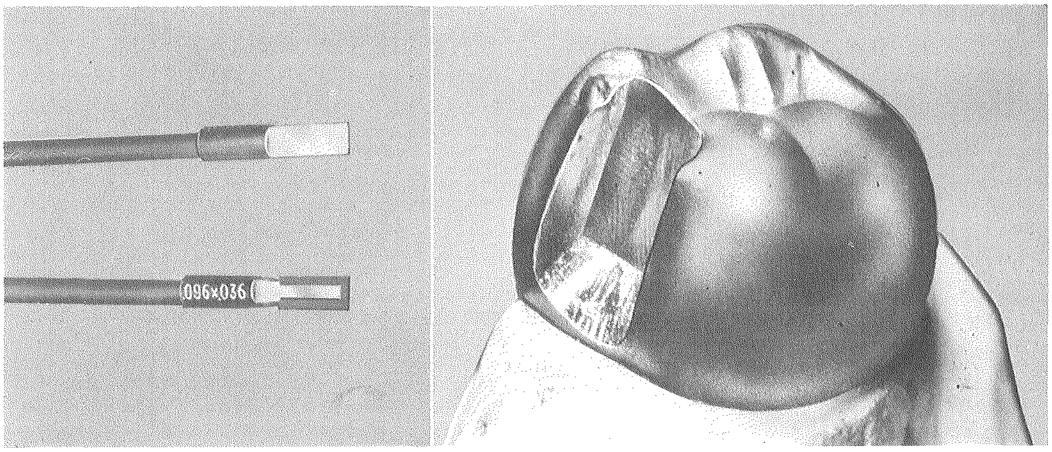


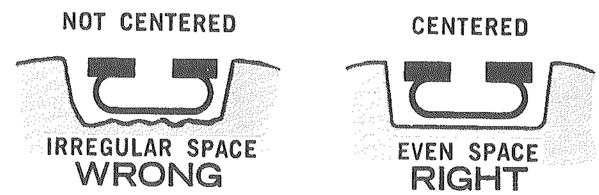
Case 10B-20 to 10B-23. Fixed splint and removable partial denture after processing of veneers.

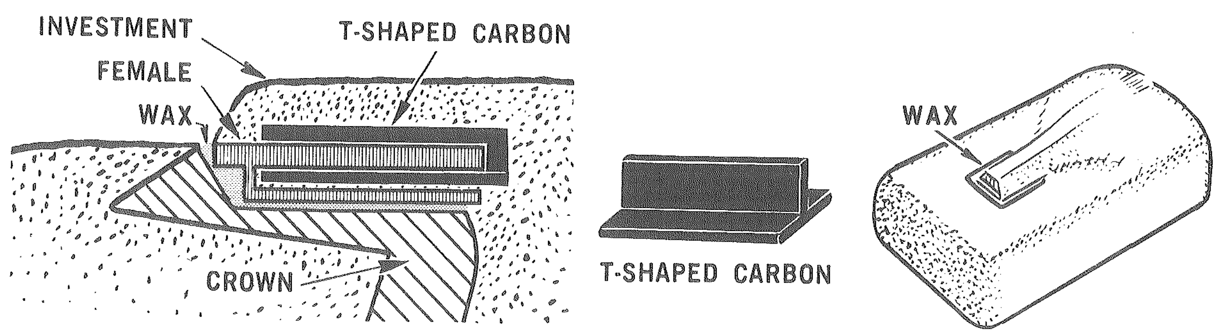


Case 10B-24. Stern G/L attachment with unique gingival latch. This was type of attachment used in this case. (Courtesy Stern Dental Co., Inc., Mt. Vernon, N. Y.)

25  26

Case 10B-25 and 10B-26. Each female must be placed on a suitable mandrel, warmed gently over a flame, and inserted to position in "cutout" of retainer, which contains a little plastic sticky wax. (Courtesy Stern Dental Co., Inc., Mt. Vernon, N. Y.)

27 

28 

Case 10B-27 and 10B-28. Female attachments must be centered correctly in retainers before investing for soldering. With a sharp knife, shave a carbon until it is about half the thickness of female. Antiflux margins of abutment and female reinforcement plate. Fill female with a creamy mix of soldering investment, using a thin wire or pin. Gently insert carbon as far as possible into female; do not use a pumping motion as this will displace investment and leave an air pocket. Embed retainer in a pat of the same mix, covering abutment retainer, carbon, and reinforcing plate; when investment has set, trim to expose the waxed joint only. (Courtesy Stern Dental Co., Inc., Mt. Vernon, N. Y.)

Although a denture base with stability and retention is of great importance, physiologic articulation must not be overlooked. When the base has been made from a mucostatic impression, articulation is an absolute "must." A floating base takes up the shock of malocclusion, but the solid base made from a mucostatic impression transmits it instantly and harshly to the underlying mucosa, causing pain and soreness and finally shrinkage of the ridge. Teeth on the partial denture base must be related correctly to the residual ridges.

The denture-bearing mucosa and periodontal support were properly related in function in this case (Case 10*B*-1 to 10*B*-36). This case, with the fixed splint and partial denture, now has been in service for two years.

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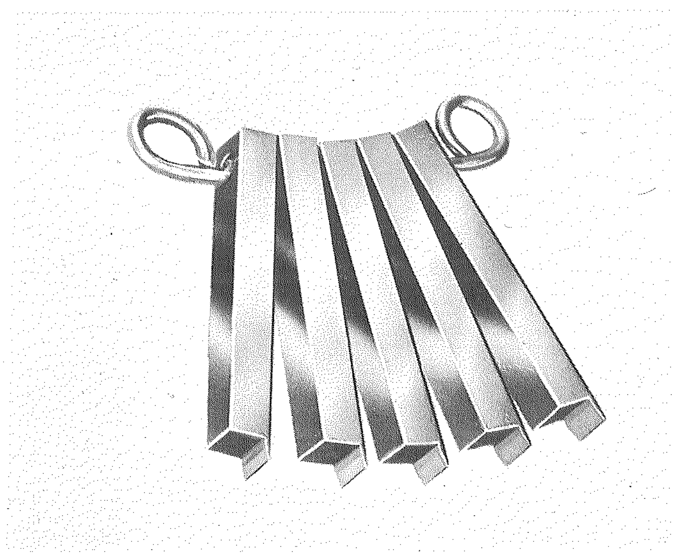

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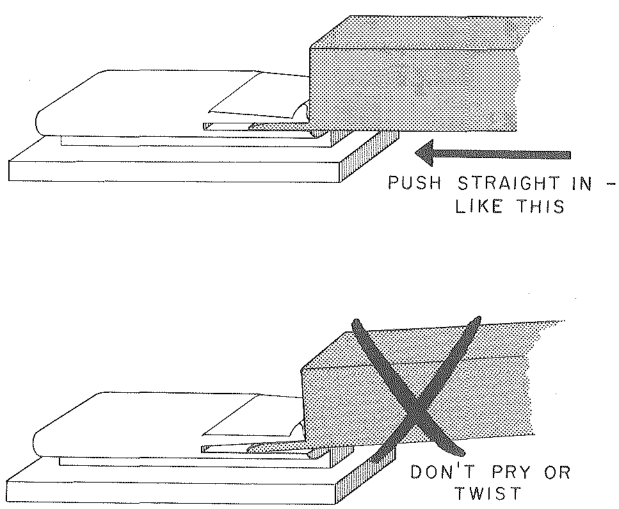
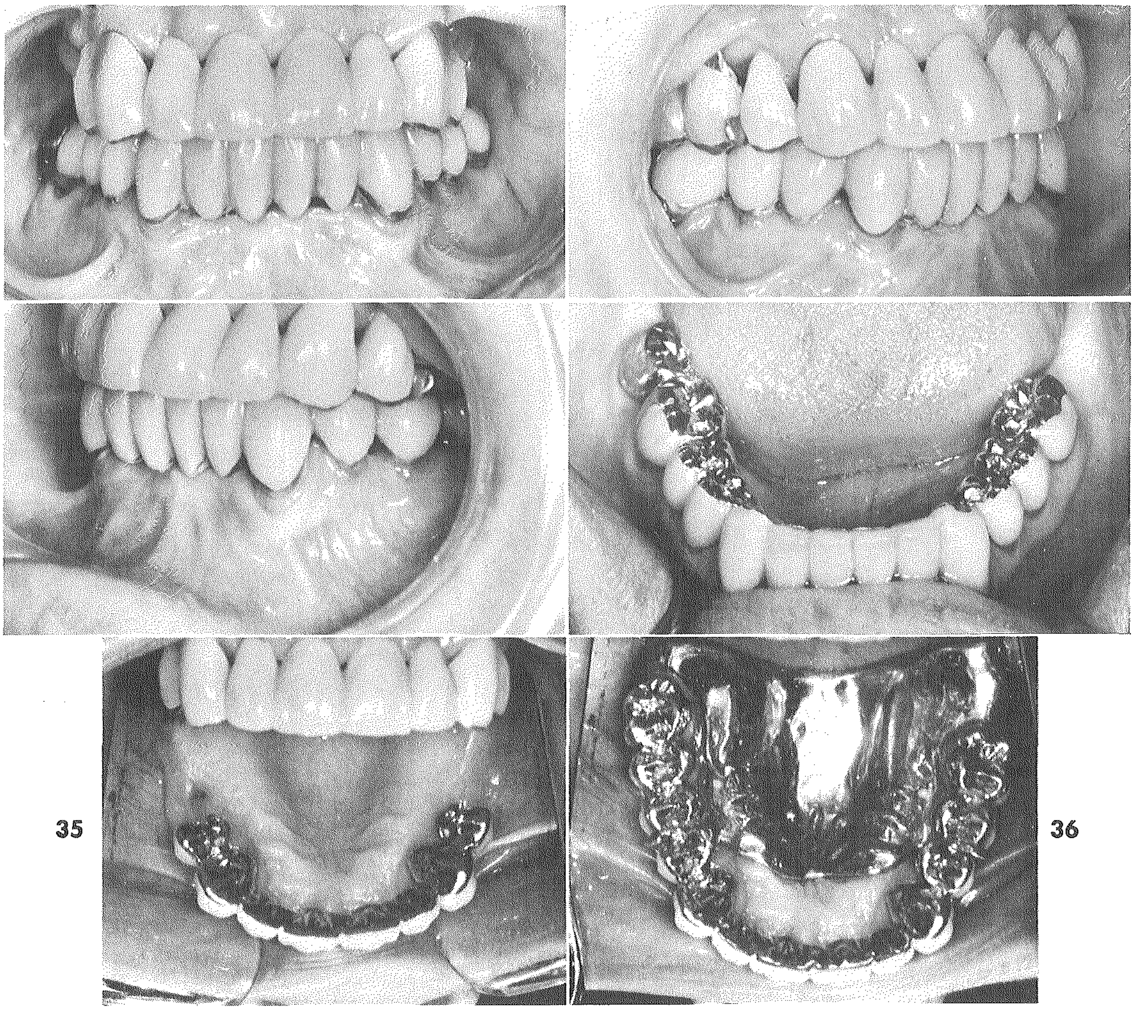


Case 10*B*-29 and 10*B*-30. Stern adjustment tool to activate a G/L attachment, and correct method to adjust this type of attachment. (Courtesy Stern Dental Co., Inc., Mt. Vernon, N. Y.)



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Case 10B-31 to 10B-36. Clinical photographs of completed upper restoration related to previously made (ten years ago) lower restoration (note gingival recession of lower cuspids). Note that use was made of an external lingual arm in the removable partial denture to furnish some external frictional grip. A recessed area in lingual portion of crown receives lingual arm, allowing for good coronal form and tongue comfort.

I also have used the telescopic crown retainer very successfully in a number of lower removable partial dentures (Case 11). Other types of attachments also have been used (Case 12). A few interesting cases are illustrated in Cases 13 to 20. See also Plates I and II at end of chapter.

Joy of Perfection

A great deal of the joy of life consists of doing perfectly, or at least to the best of one's ability, everything which he attempts to do. There is a sense of satisfaction, a pride in surveying such a work—a work which is rounded, full, exact, complete in all its parts—which the superficial man, who leaves his work in a slovenly, slipshod, half-finished condition, can never know.

It is this conscientious completeness which turns work into art. The smallest thing, well done, becomes artistic.

William Matthews

REFERENCE

1. Dykins, William R.: Requirements of partial denture prosthesis, J.A.D.A. **57**:232-236, 1958.

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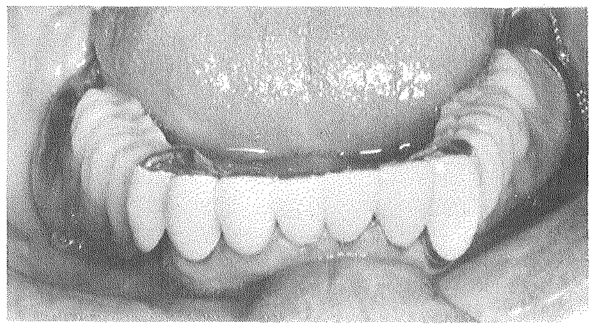

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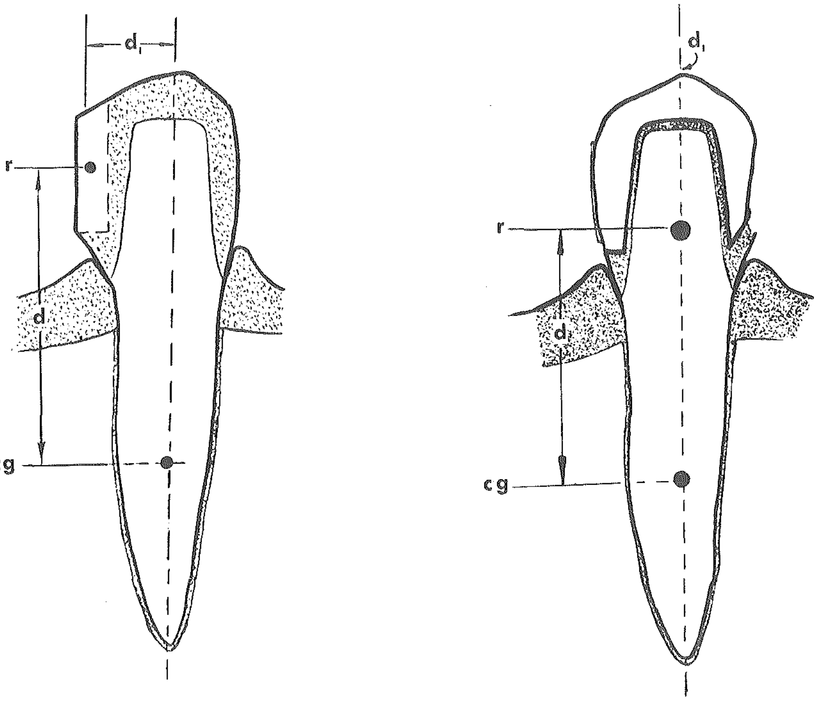
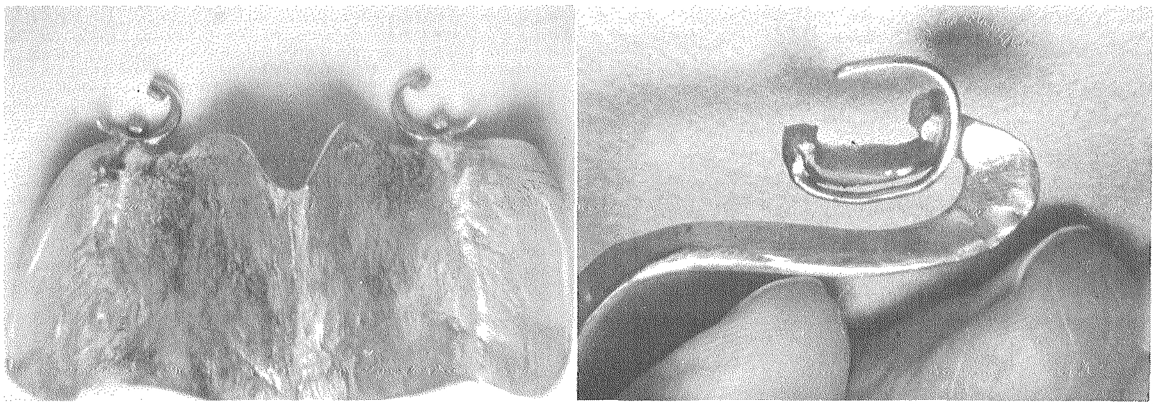
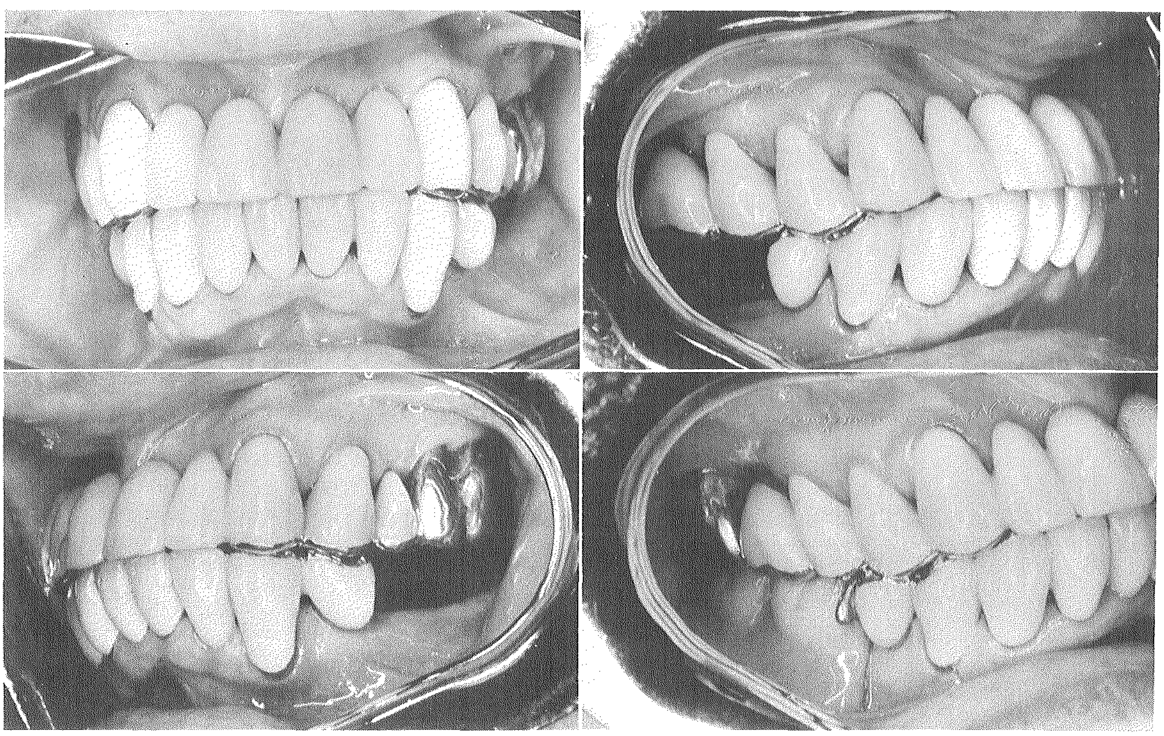


C

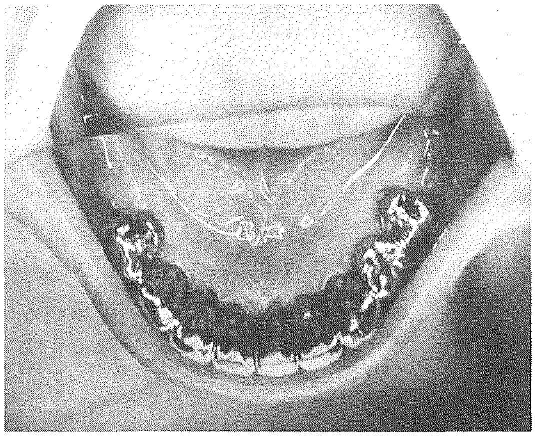
Case 11. A, Telescopic crown retainer was used in this lower removable partial denture. **B,** Location of stress-receiving area in abutment tooth for removable partial denture prosthesis, utilizing key and keyway prefabricated precision attachment. *cg,* Center of gravity or fulcrum point of the root support—hypothetical ideal location for resistance to force by root housing; *r,* point of force transmission by denture retainer; d_1, distance from axial center of root to retainer; *d,* distance from retainer transmitting site to center of gravity of root support. **C,** Location of stress-receiving area in abutment tooth for removable partial denture prosthesis, utilizing telescopic crown retainer. Note reduction in dimension of d_1 and *d* as compared to **B.** *cg,* Center of gravity or fulcrum point of root support—hypothetical ideal location for resistance to force by root housing; *r,* point of force transmission by denture retainer; d_1, distance from axial center of root to retainer; *d,* distance from retainer-transmitting site to center of gravity of root support. (From Abrams, Leonard, and Feder, Morris: Alpha Omegan **55:**123-136, 1962.)

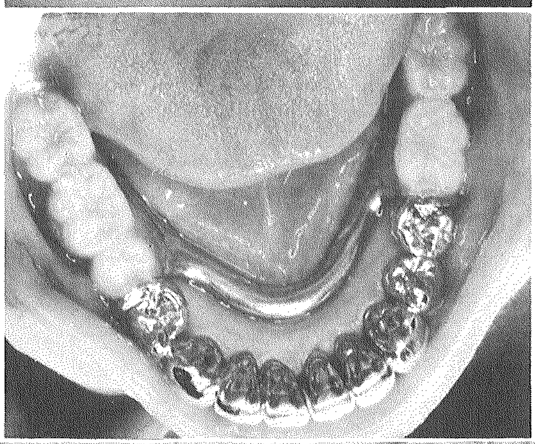


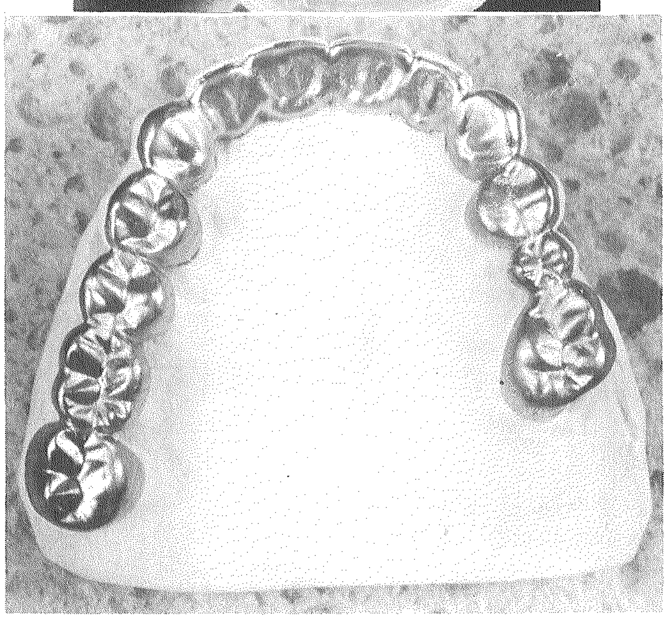
Case 12. Other types of clasp retention that can be used in restorative dentistry.



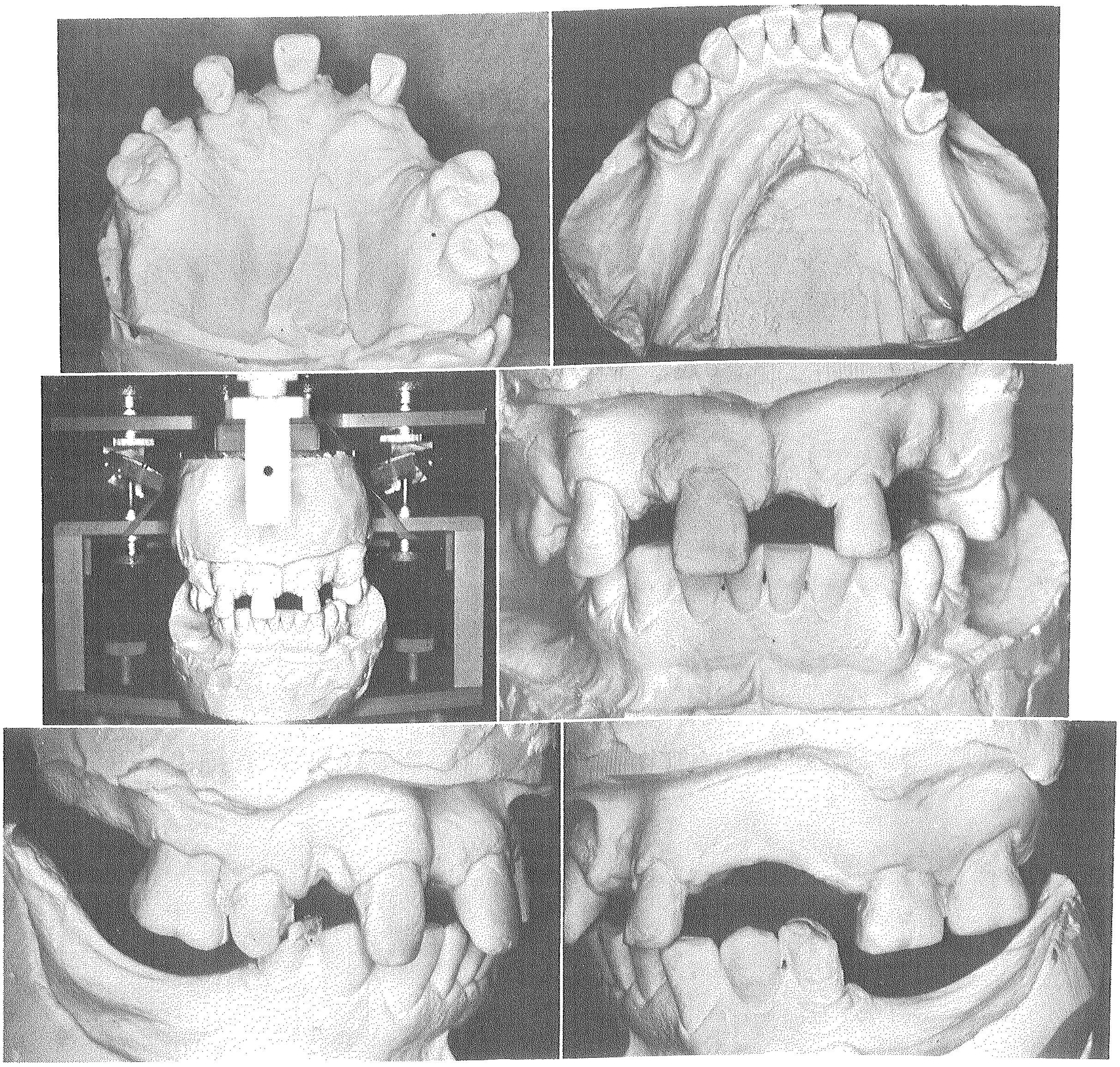
Case 13. Periodontally and endodontically involved case requiring bilateral splinting of upper teeth and splinting of remaining lower teeth in conjunction with a precision removable partial denture. A very difficult case.



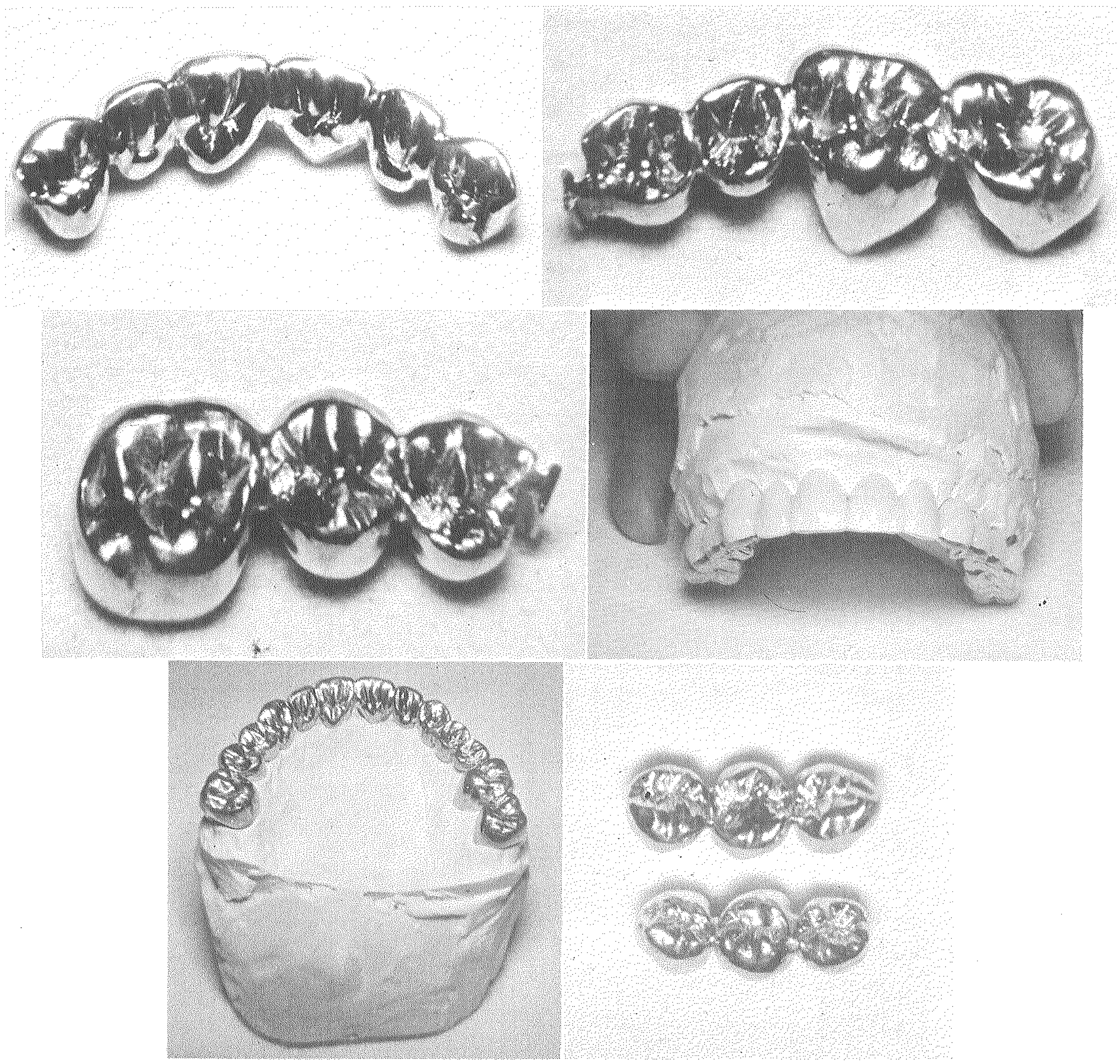




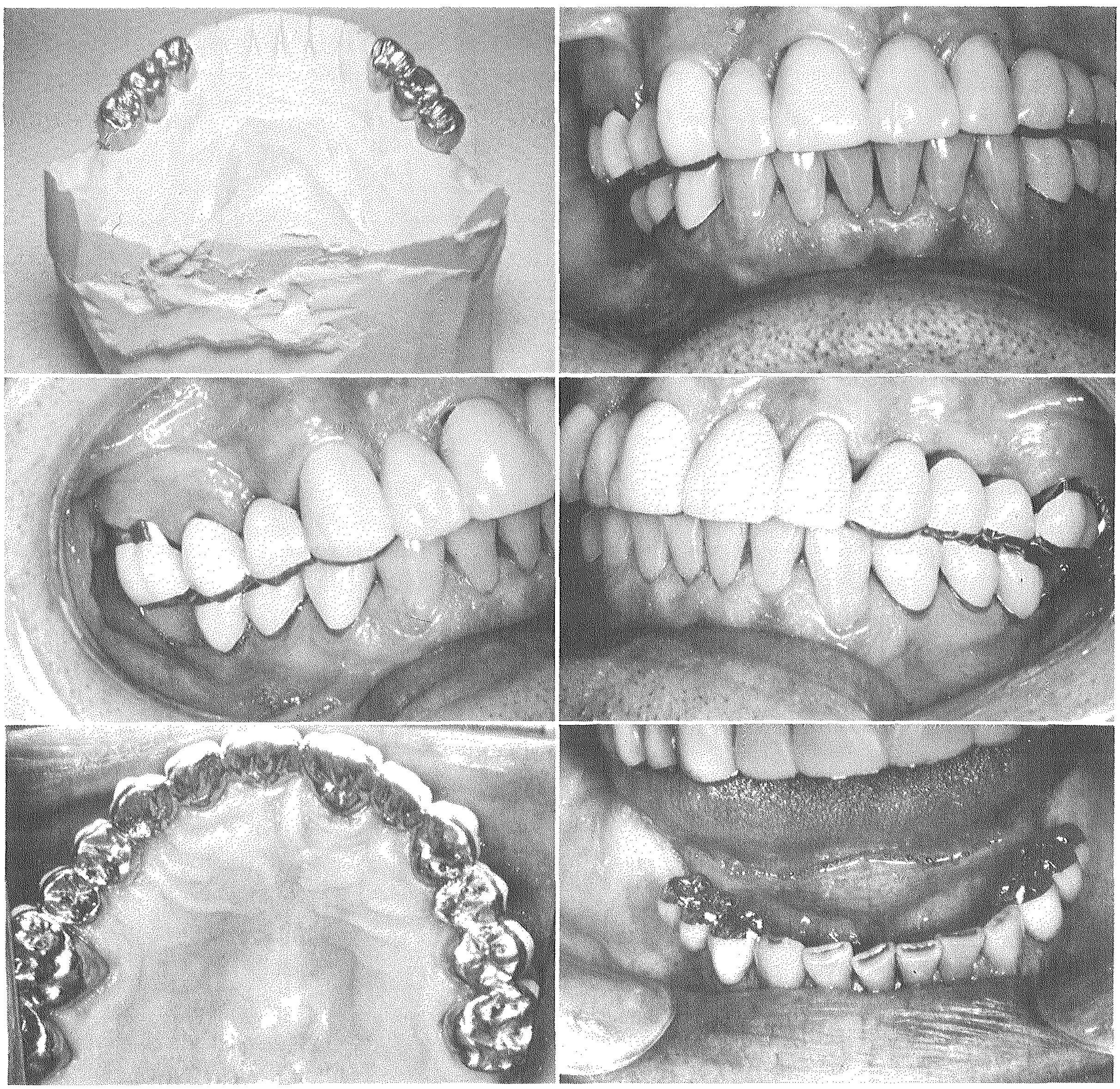
Case 13, cont'd. Photograph of upper cast postoperatively.



Case 14. Periodontally involved mouth with posterior bite collapse. Study casts mounted on correct axis on adjusted articulator showing anterior and right and left side views of relationships of teeth.

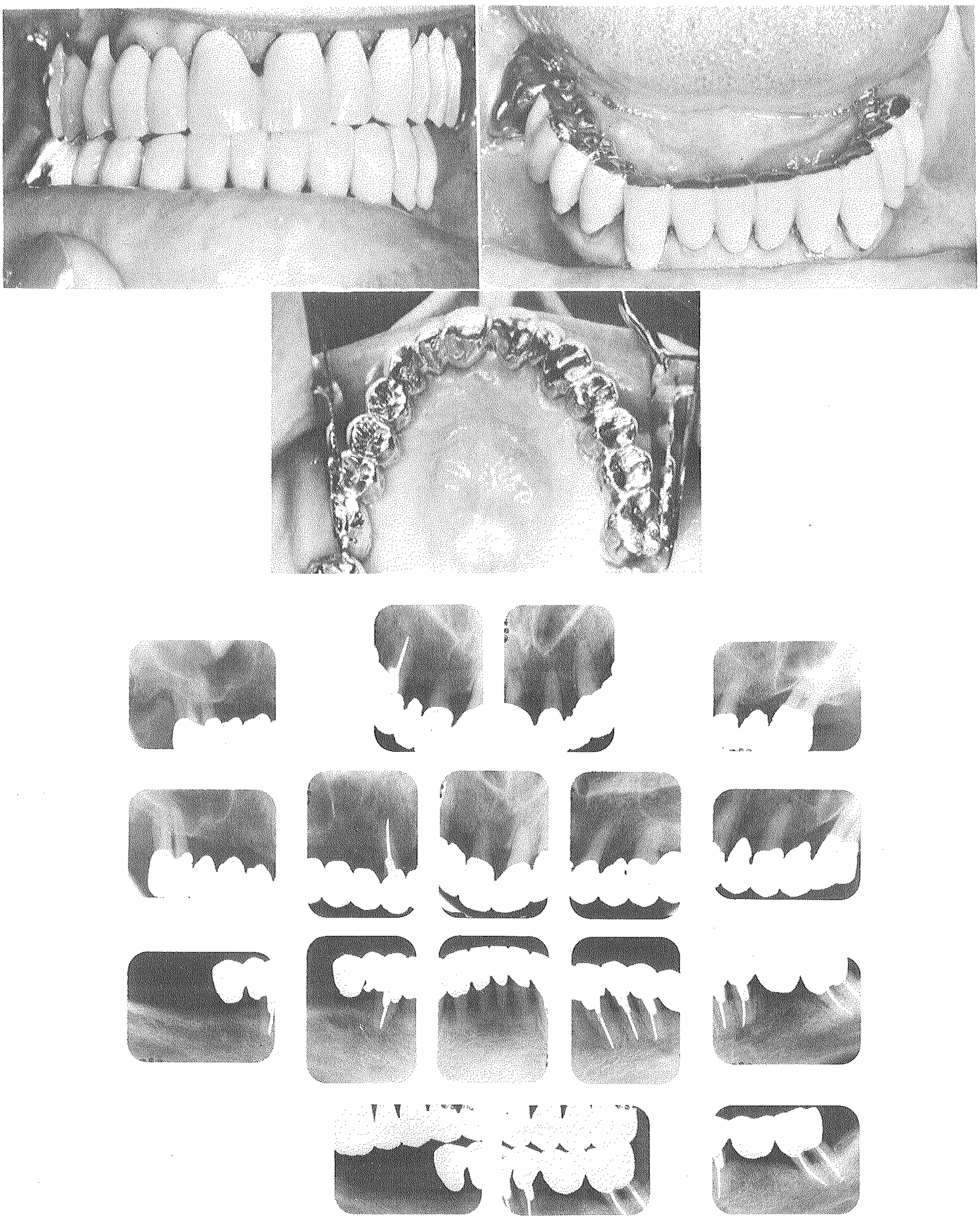


Case 14, cont'd. Sectional splinting (with precision attachments) was used in upper arch and unilateral splinting with cantilevered pontics in lower arch. Case on casts after refinement of articulation, processing of veneers, and polishing.

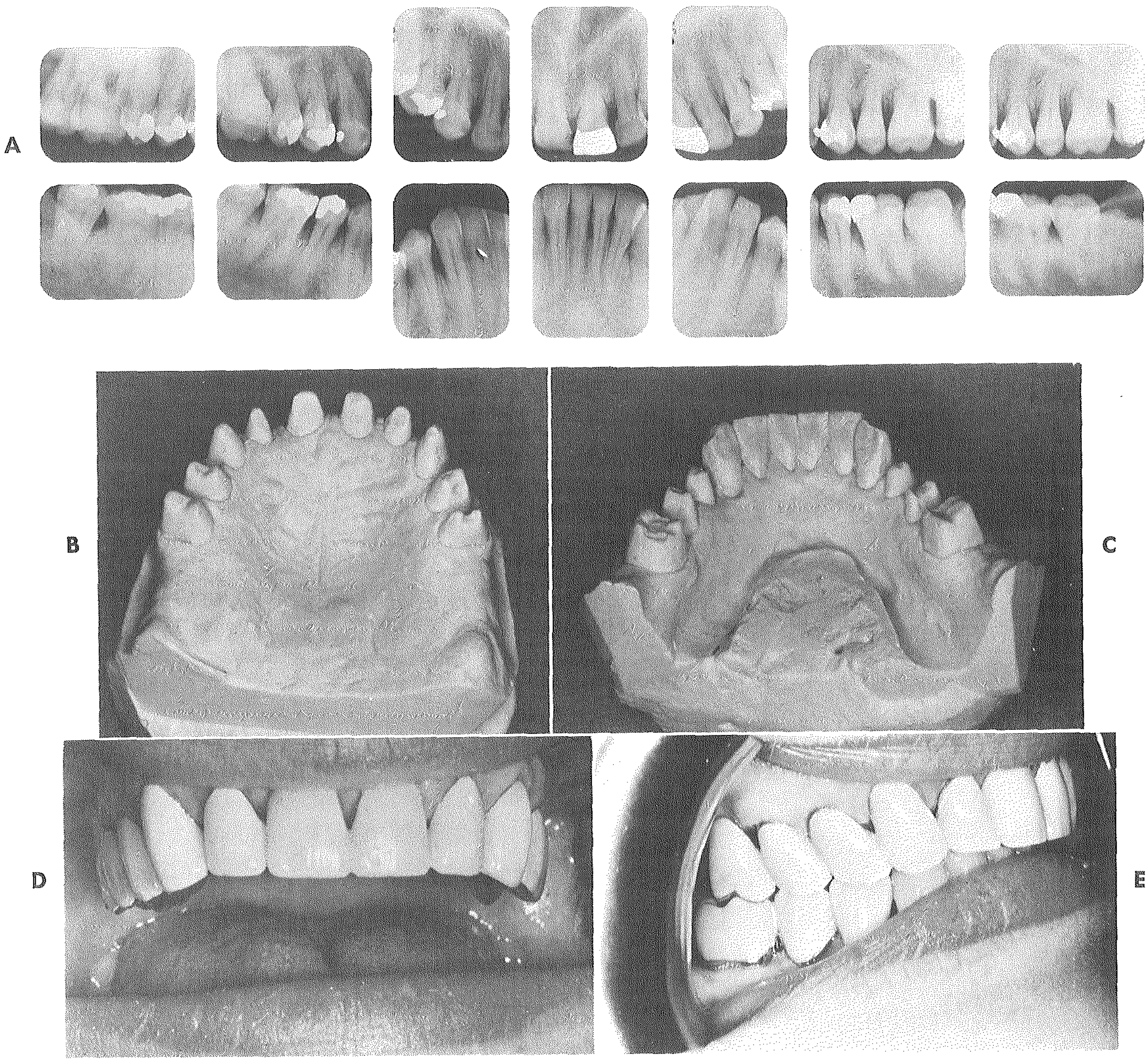


Case 14, cont'd. Views of completed case in mouth.

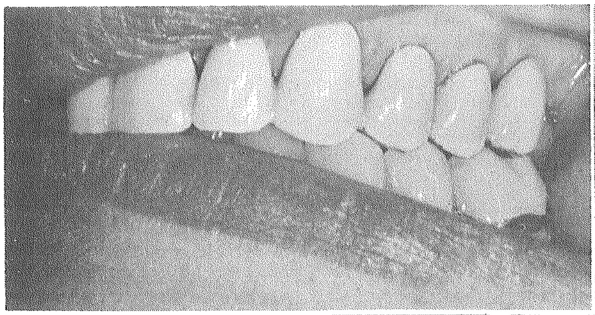
Case 15. Preoperative roentgenograms show extent of periodontal disease. Prognosis was negative. Roentgenograms taken (nine years postoperatively) show condition of case at present time. Periodontal surgery was performed and bilateral splinting with full coverage. Photographs shown are of recent date.

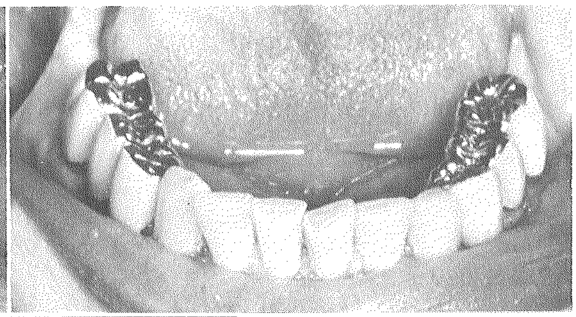


Case 15, cont'd. For legend see opposite page.

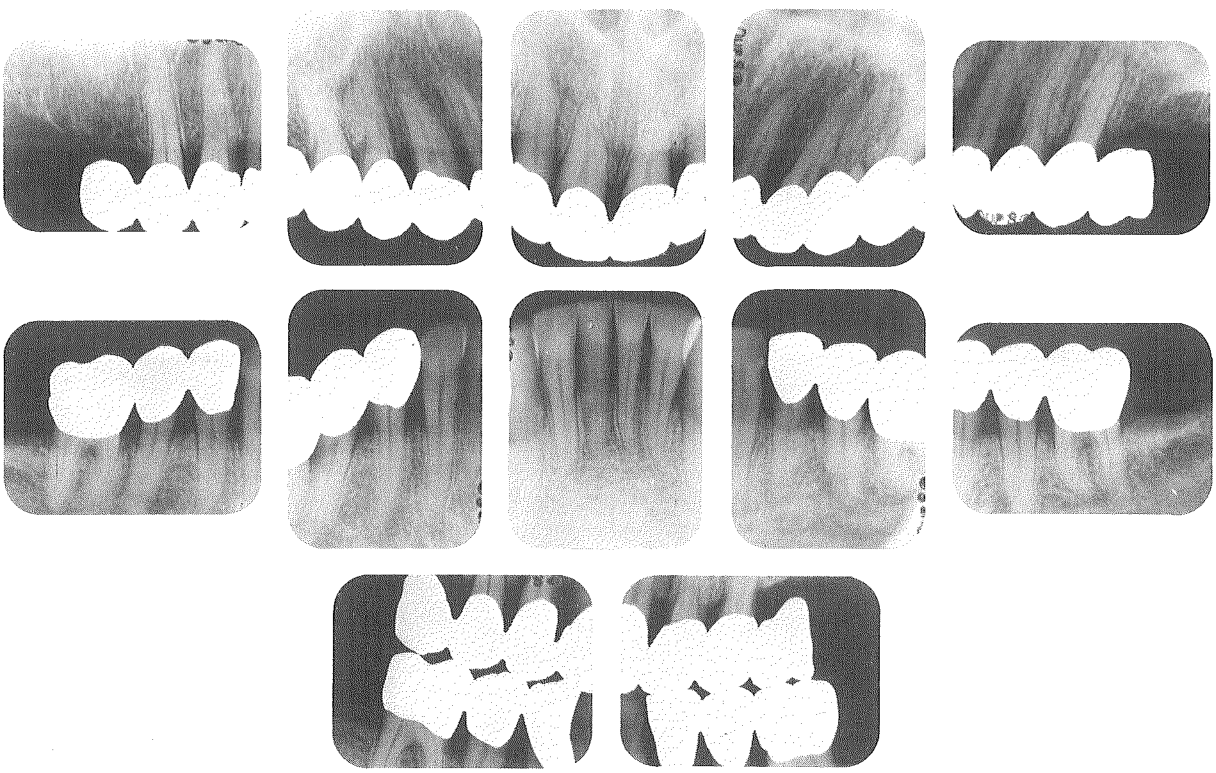


Case 16. A, Preoperative roentgenograms show extent of periodontal disease. All upper molars and lower second molars were removed. Periodontal surgery and prosthodontic procedures were carried out. **B** and **C,** Upper and lower casts showing type of preparations used in this case. **D** to **H,** Postoperative clinical photographs taken ten years postoperatively showing (1) proper coronal contour and embrasure form, (2) fulfillment of therapeutic occlusal objectives, and (3) occlusal views of character of anatomy used in case. Note tissue tone and form and amount of attached gingiva. Bilateral splinting was used in the upper arch, with cantilevered pontics replacing first molars, thereby preventing opposing teeth from erupting because of splint action. Unilateral splinting was used in lower arch. **I,** Roentgenograms taken ten years postoperatively. Teeth are functioning in health, and healed situation has been maintained.

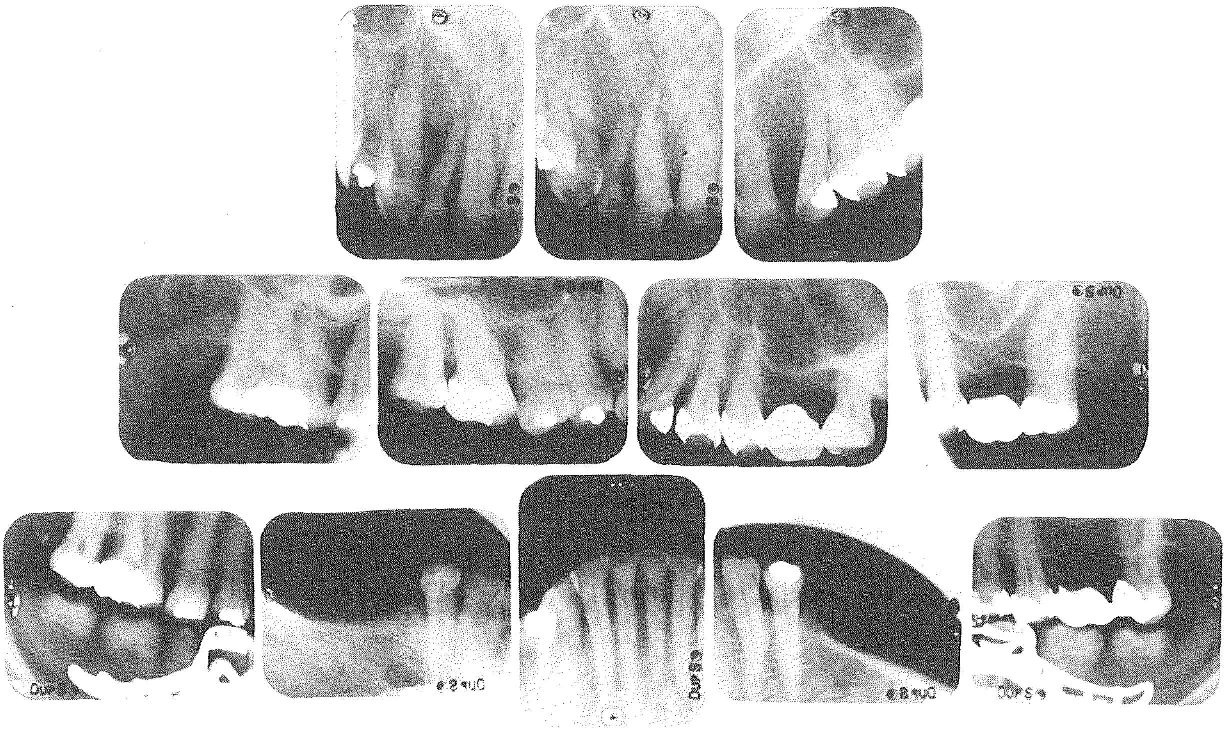

F


G


H

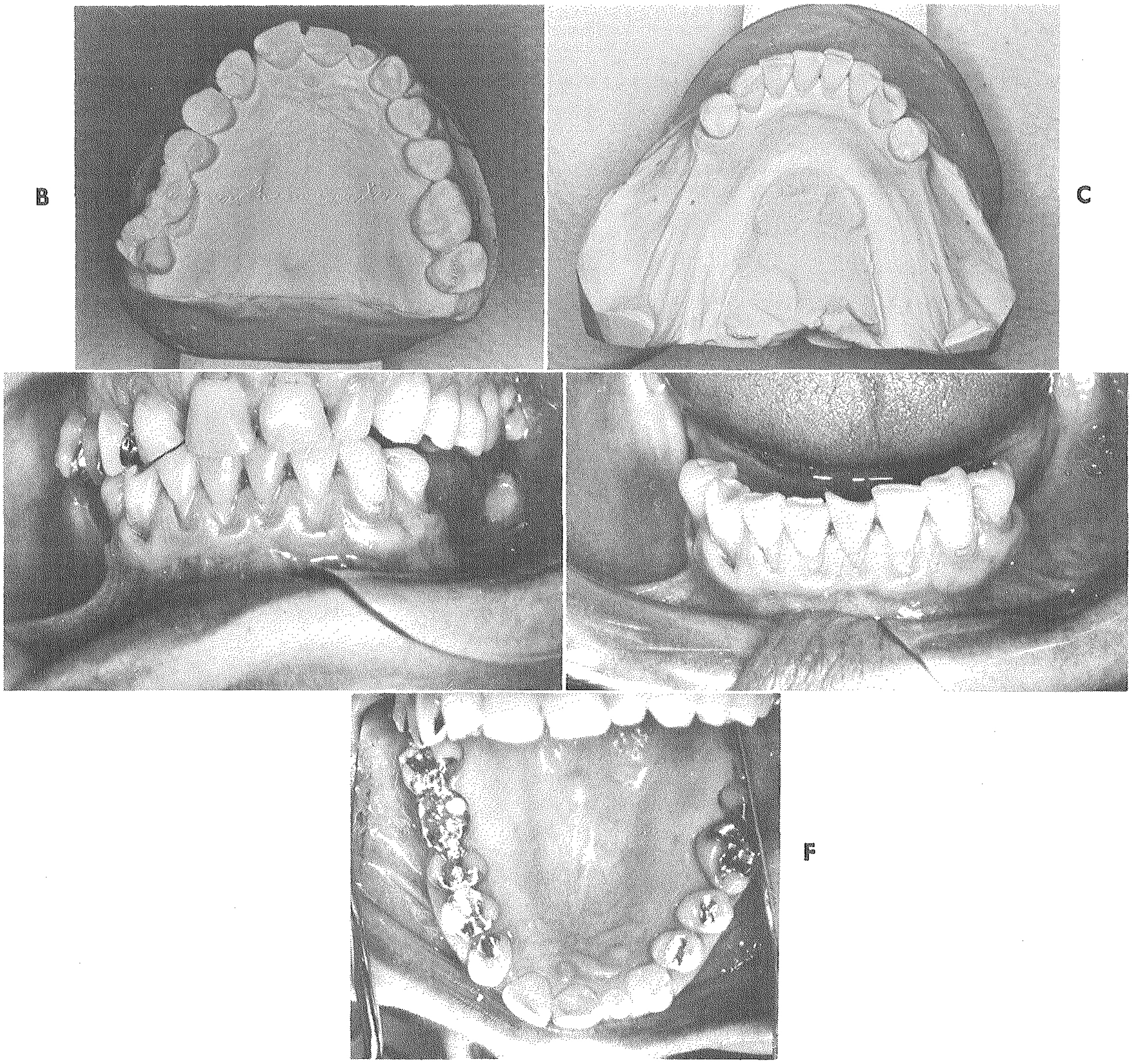

I

Case 16, cont'd. For legend see opposite page.

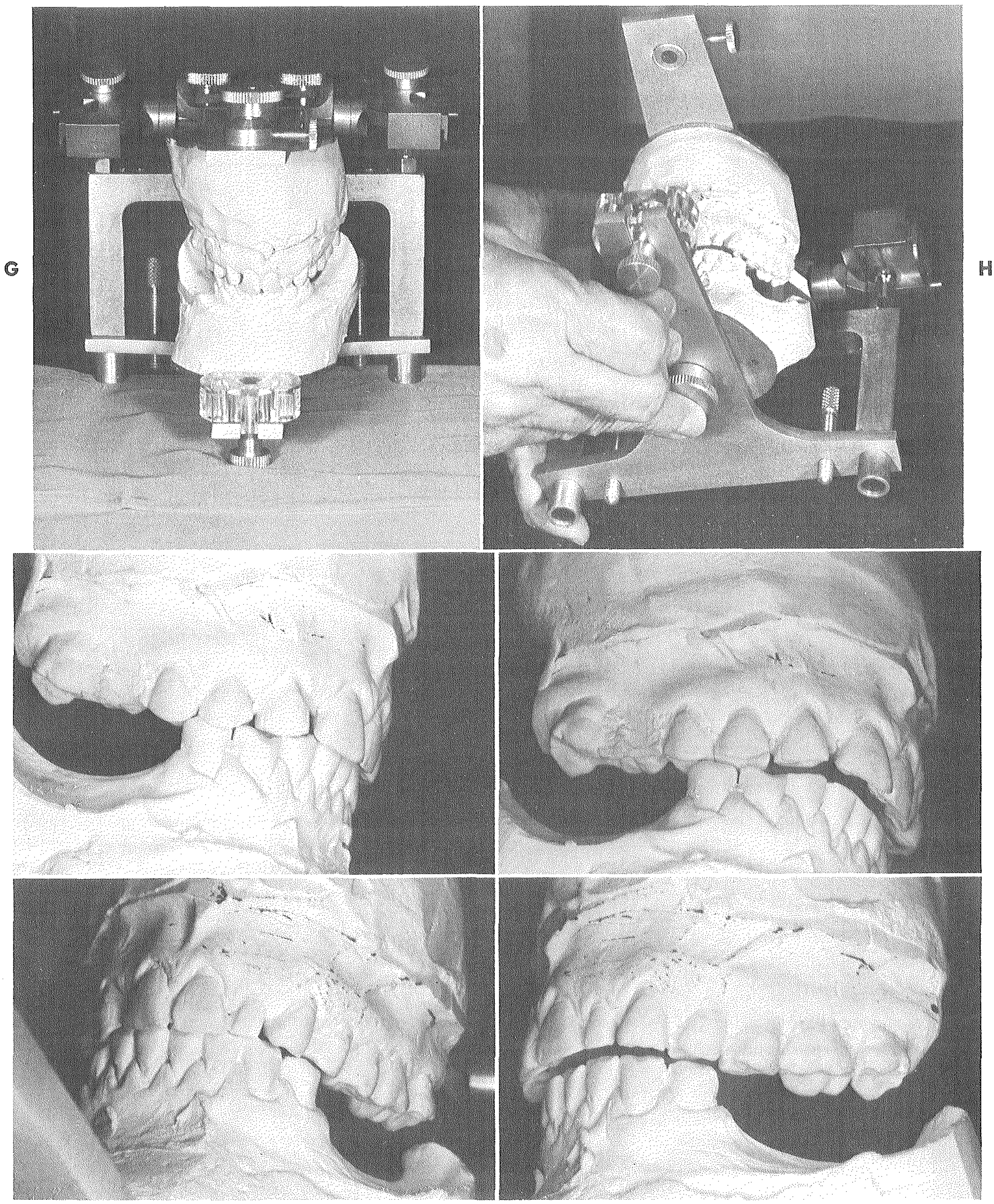


A

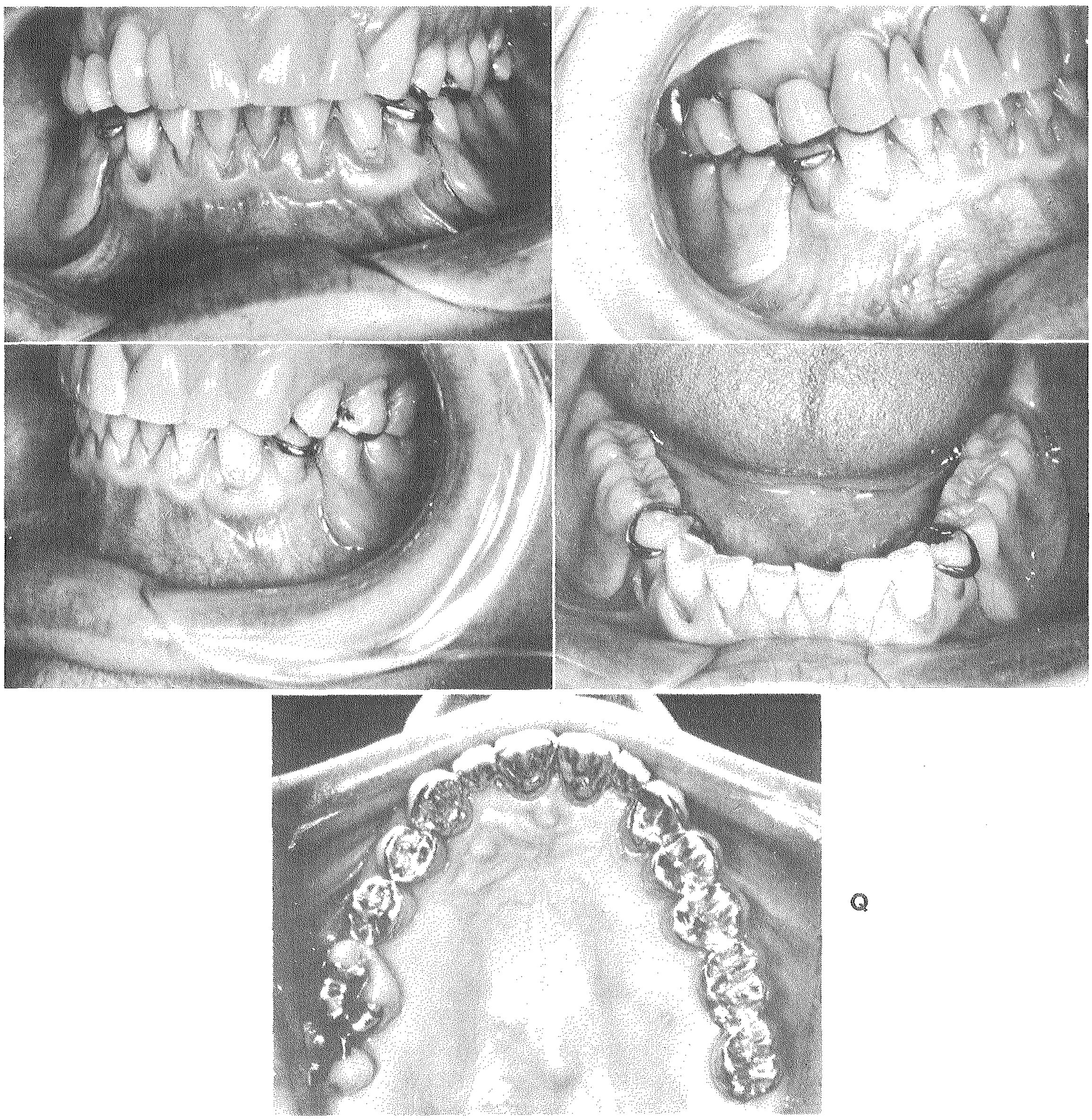
Case 17. **A,** Preoperative roentgenograms. A lack of coincidence of centric occlusion and centric relation created a considerable amount of wear on the teeth, a joint involvement, some mobility, and enough periodontal involvement around upper right cuspid area to necessitate surgical interference. Because of a number of circumstances, a compromise treatment plan was instituted. Good masticatory relationships were established, allowing patient to function reasonably well and be rid of joint pain. Tissue tone and form show improvement. A thinning of periodontal ligament space and reformation of lamina dura are evident. Casts of teeth, preoperative clinical photographs, acquired and correct centric positions on properly oriented casts, postoperative clinical photographs, and roentgenograms are shown.



Case 17, cont'd. **B** and **C**, Upper and lower casts (preoperative). Note amount of attritional wear. **D** to **F**, Clinical photographs (preoperative) of relationship of teeth (anterior view) and occlusal views of lower and upper teeth.

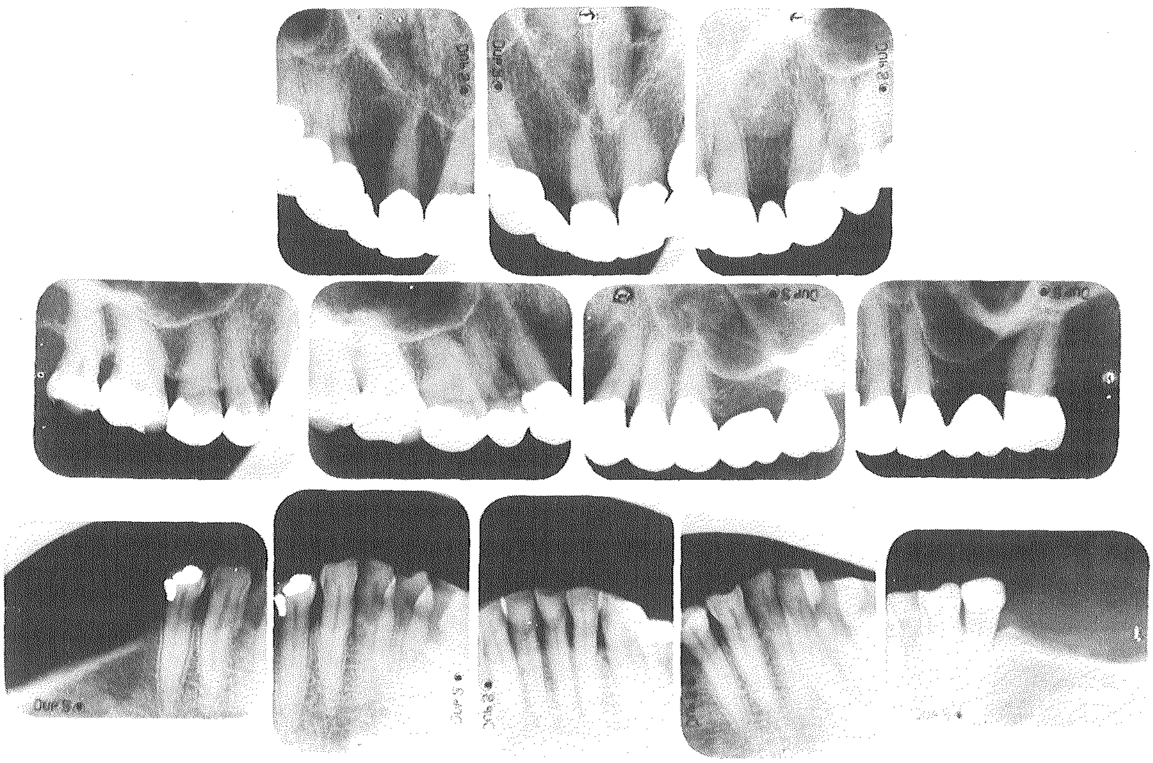


Case 17, cont'd. **G** to **L,** Acquired and correct centric positions shown on properly oriented study casts.



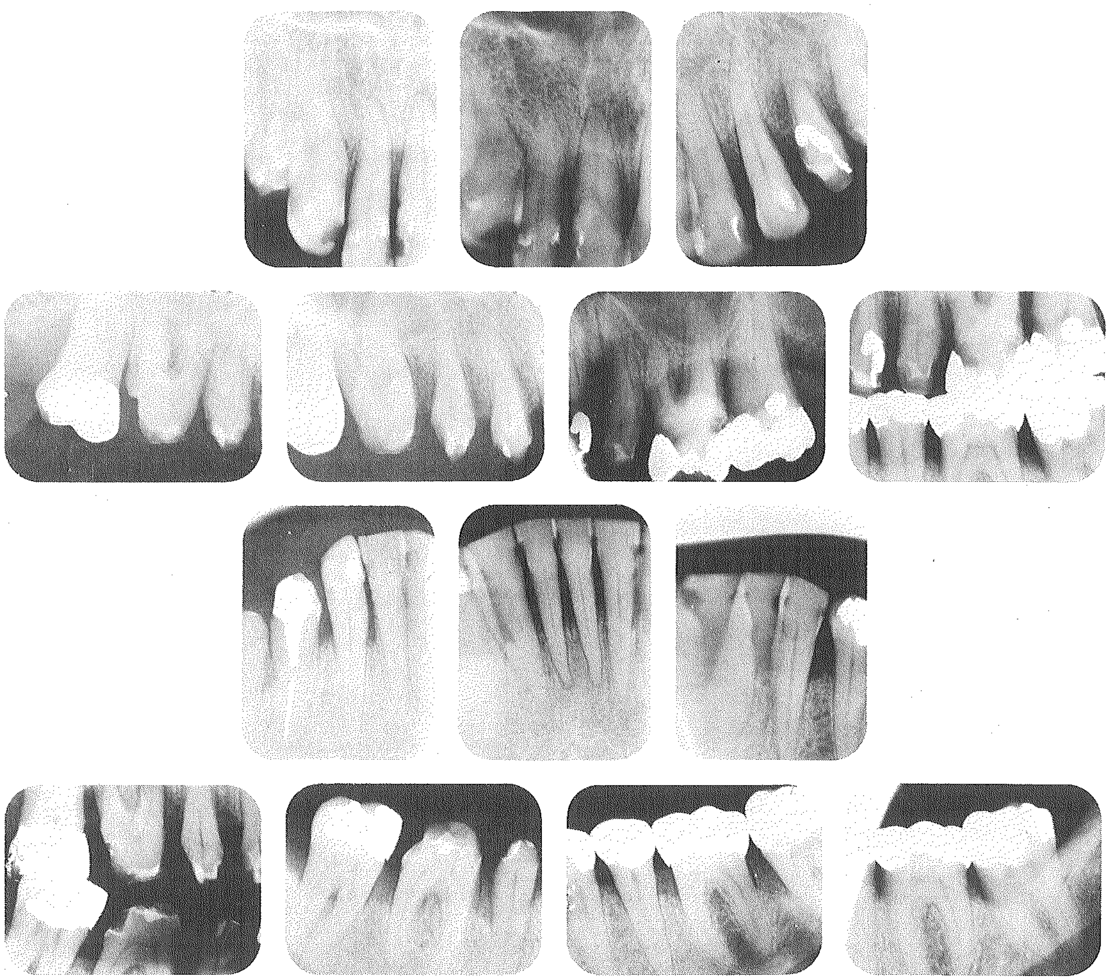
M N O P Q

Case 17, cont'd. M to **Q,** Clinical photographs (postoperative) showing relationships of teeth (centric position) and occlusal views of lower and upper restorations. Previously made inlays (upper left first and second molars) were equilibrated, and a lower clasped removable partial denture was used. Tooth relationships are not ideal, but it is best relationship possible under compromised conditions.



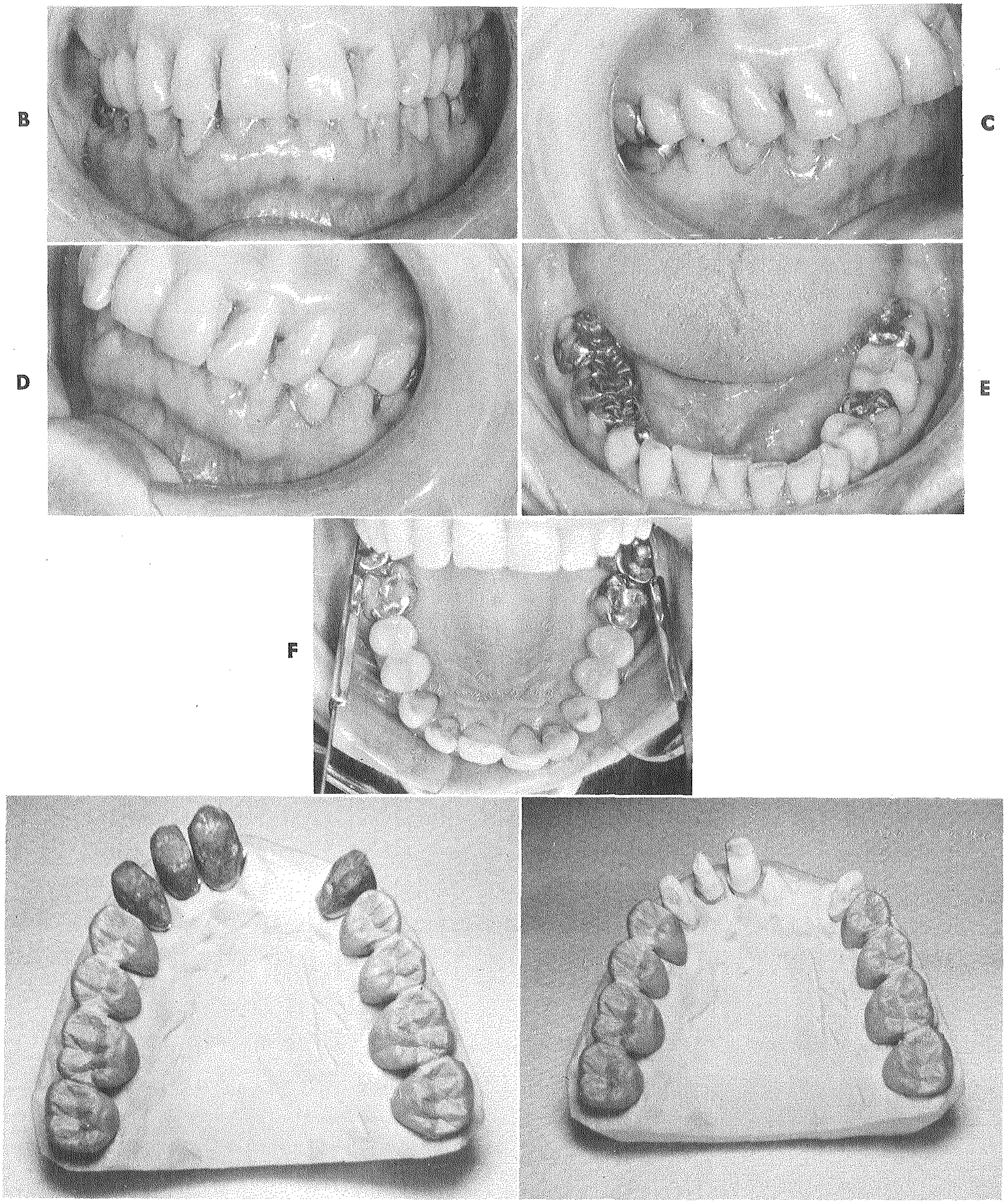
R

Case 17, cont'd. R, Roentgenograms taken two years postoperatively.



A

Case 18. A, Preoperative roentgenograms show extent of periodontal disease. A case with a negative prognosis. Several periodontists believed that periodontal surgery was contraindicated. On patient's insistence treatment was undertaken nearly ten years ago. Correct masticatory relationships were established, subgingival curettage was carried out in a careful and thorough manner, bilateral splinting in sections was used in upper arch, unilateral splinting in lower left posterior region, and individualized restorations with correctly placed contact areas on right side. Lower anterior teeth were not to be restored (except fillings) in overall plan. (Lower anterior teeth are now in need of some restorative work.) What appeared to be a case with short-lived possibilities has maintained itself for a number of years. Photographs show case preoperatively, method used in splinting upper teeth, completed case on remount casts, and postoperative views of completed case.



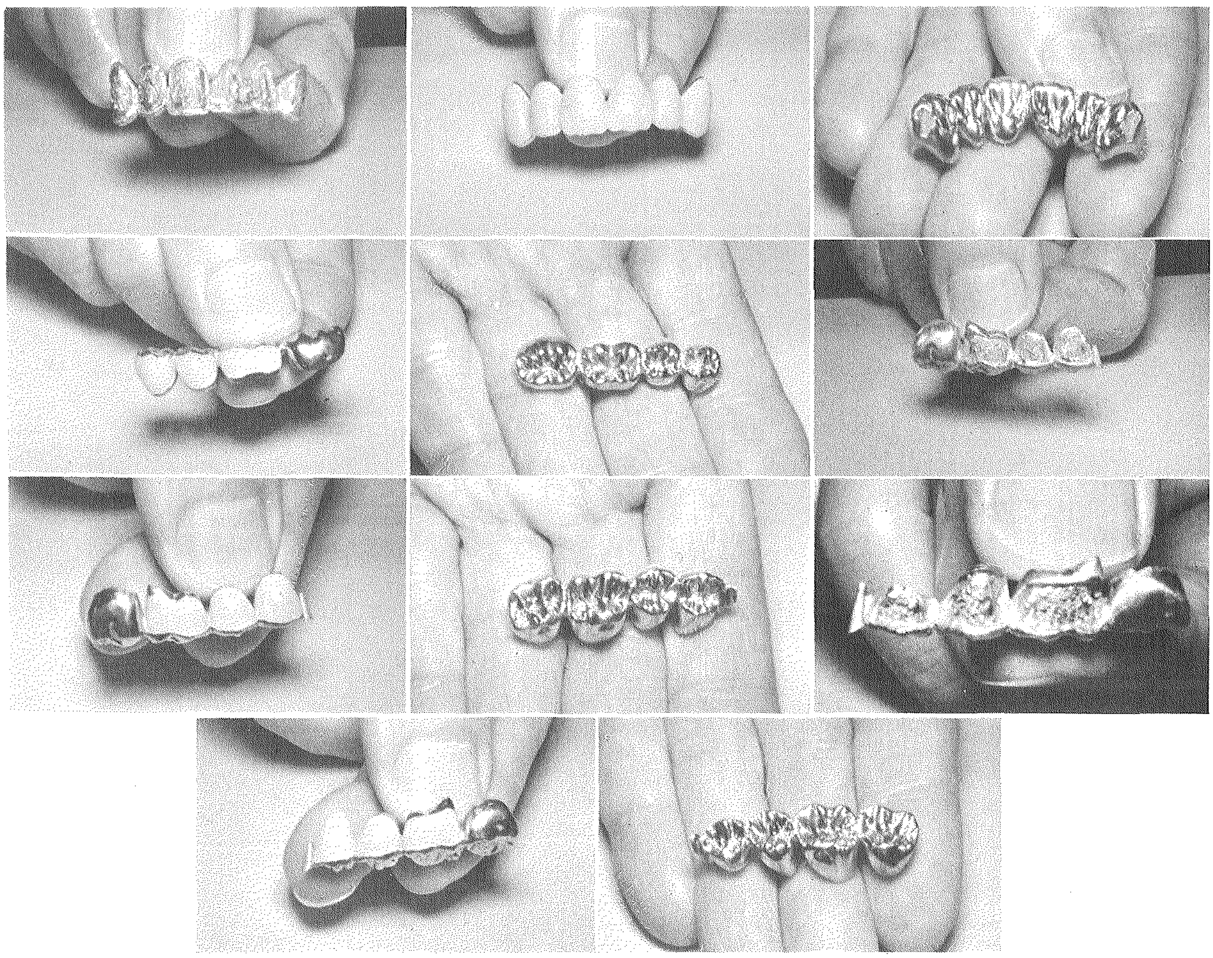
Case 18, cont'd. B to **F,** Clinical photographs (preoperative) showing (1) relationships of teeth in acquired centric position (note overbite), (2) occlusal views of lower and upper teeth. **G** and **H,** Remount casts showing castings and DuraLay copings positioned on anterior dies and copings removed. DuraLay copings are placed on prepared teeth before impression is taken, allowing for correct positioning of dies. An accident caused loss of two anterior teeth.

I J K

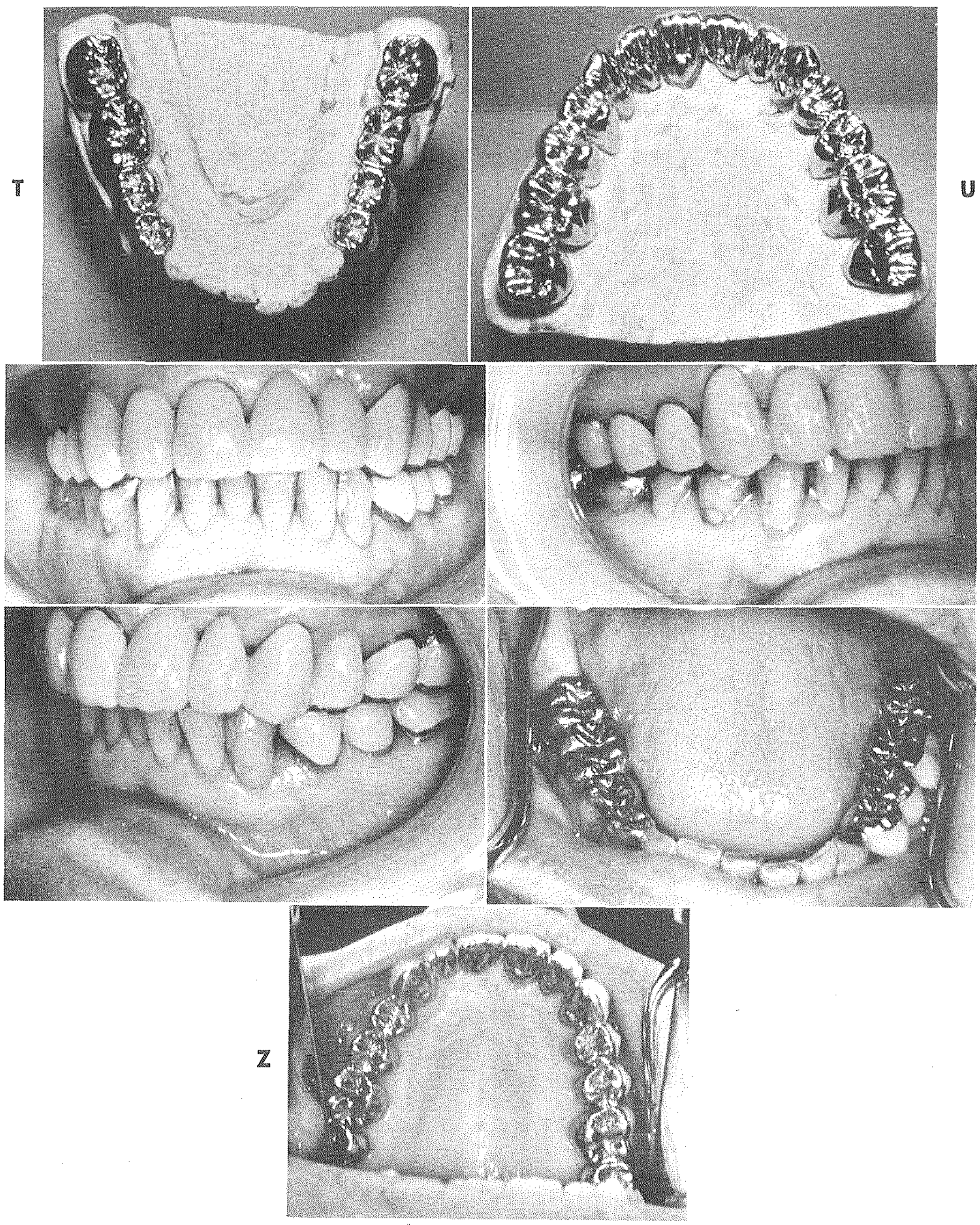
L M N

O P Q

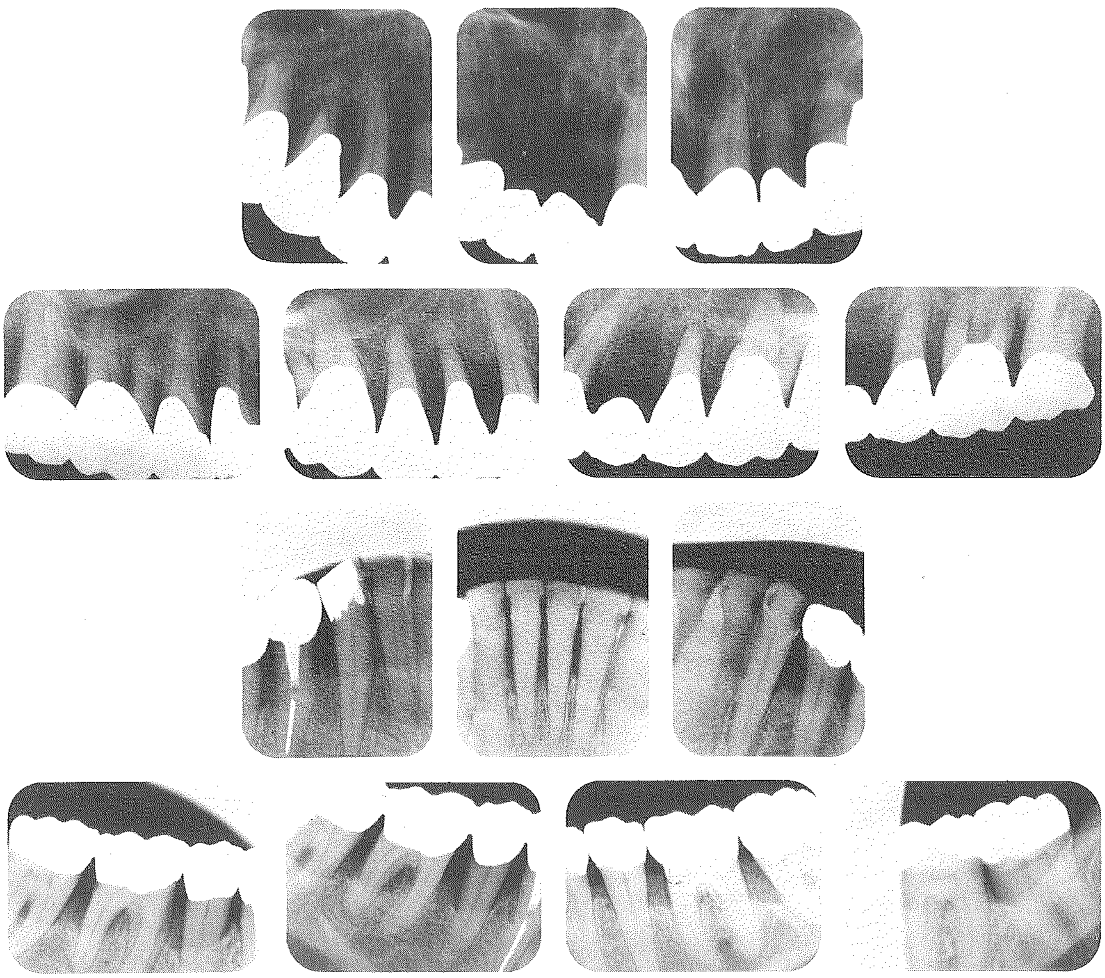
R S



Case 18, cont'd. I to S, Views of four sections of the reconstruction. Method used for bilateral splinting of upper arch is shown.



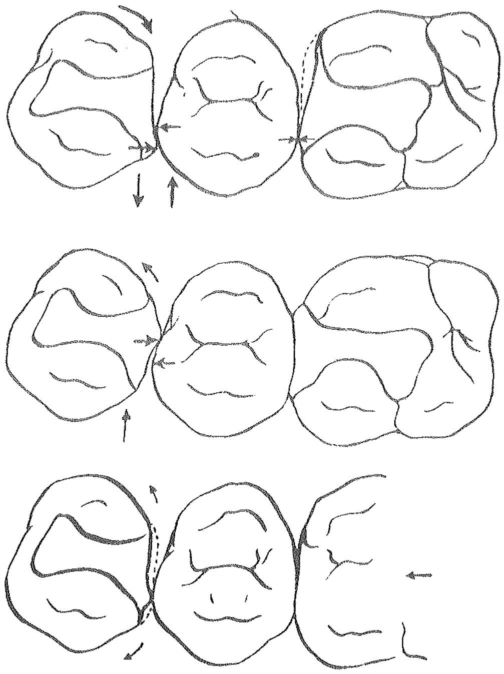
Case 18, cont'd. T and **U,** Completed case on remount casts. **V** to **X,** Clinical photographs (postoperative) show relationship of teeth in centric position. Note coronal and embrasure form. Excellent oral physiotherapy has helped to maintain this case. **Y** and **Z,** Occlusal views of lower and upper restorations. Note type of occlusal anatomy used in this periodontally involved case to fulfill therapeutic occlusal objectives. Slopes of lingual surfaces of upper anterior teeth must be in harmony with condylar surfaces.

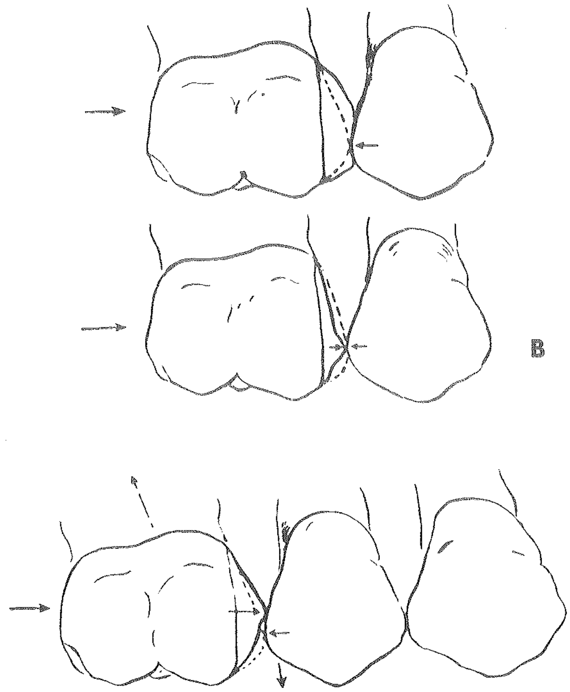


Z′

Case 18, cont'd. Z′, Roentgenograms taken nine years postoperatively. Periodontal surgery was contraindicated. Fillings in lower anterior teeth have been replaced since these roentgenograms were taken.

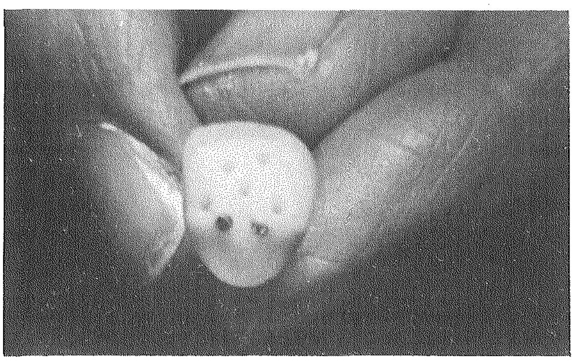
A





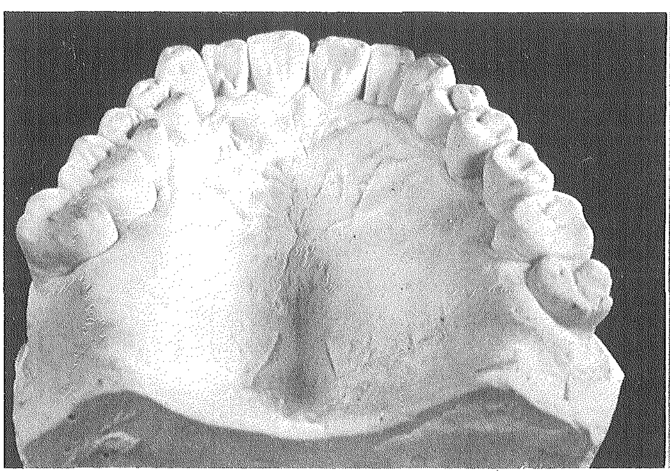
B

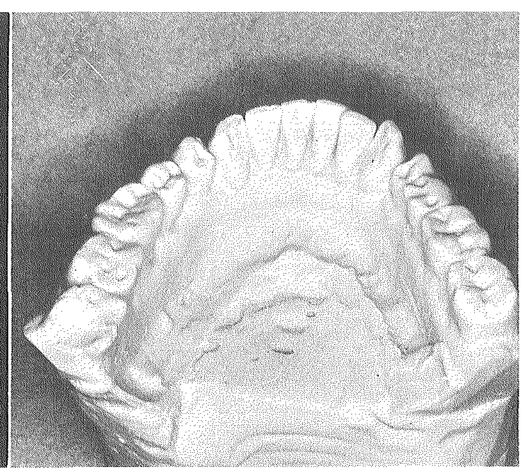
C



Case 19. **A** and **B**, illustrations showing ill effects of improperly made and placed contact points—tipping, rotation, axial distortion, impingement, etc. **C**, Reverse pin facing (for veneering of crowns and pontics), utilizing plate teeth that allow for a much better selection of shades, is used in many cases of mouth rehabilitation.

A

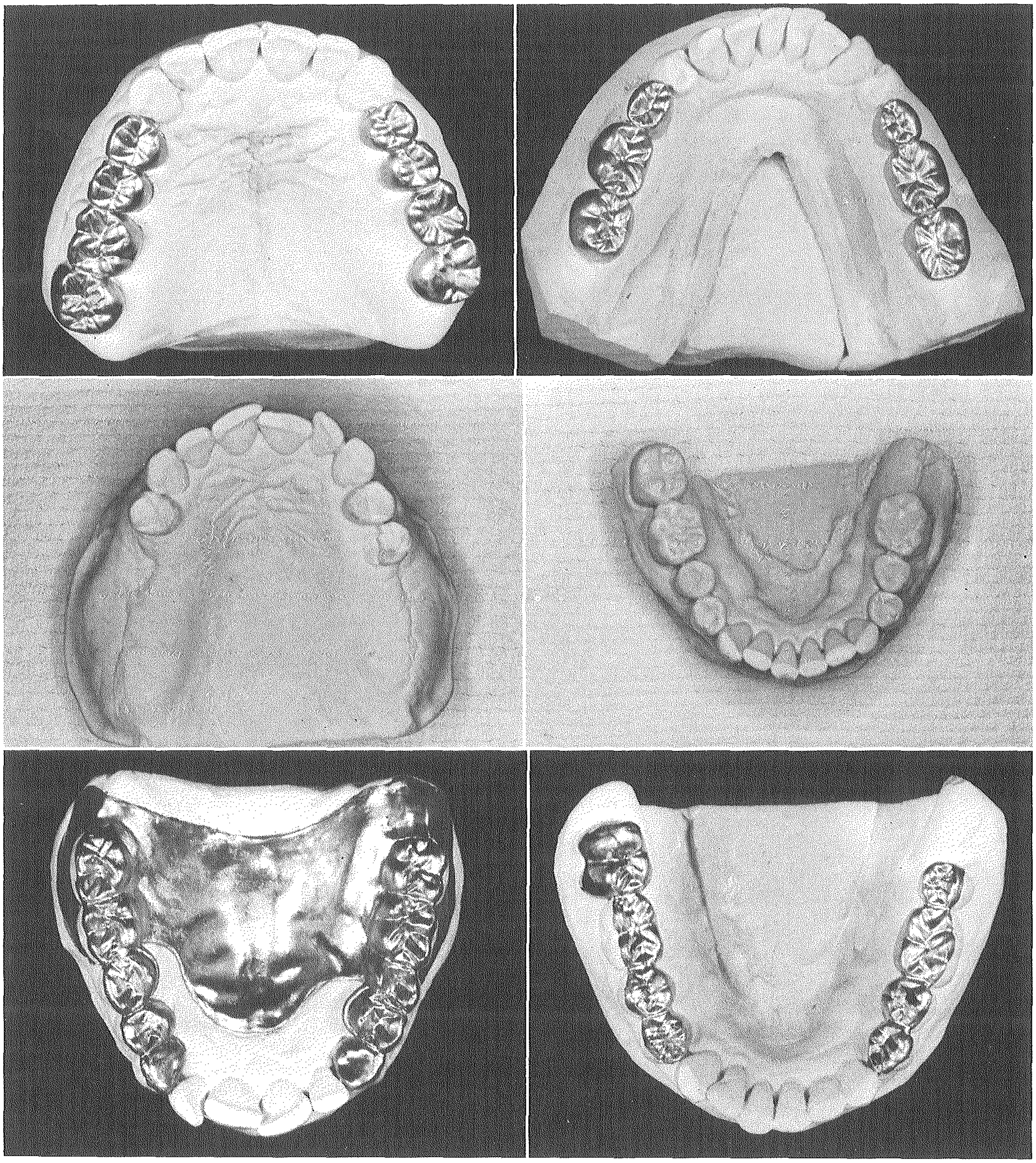




B

Case 20. For legend see opposite page. (This case had a cross-bite on the left side.)

A′



B′

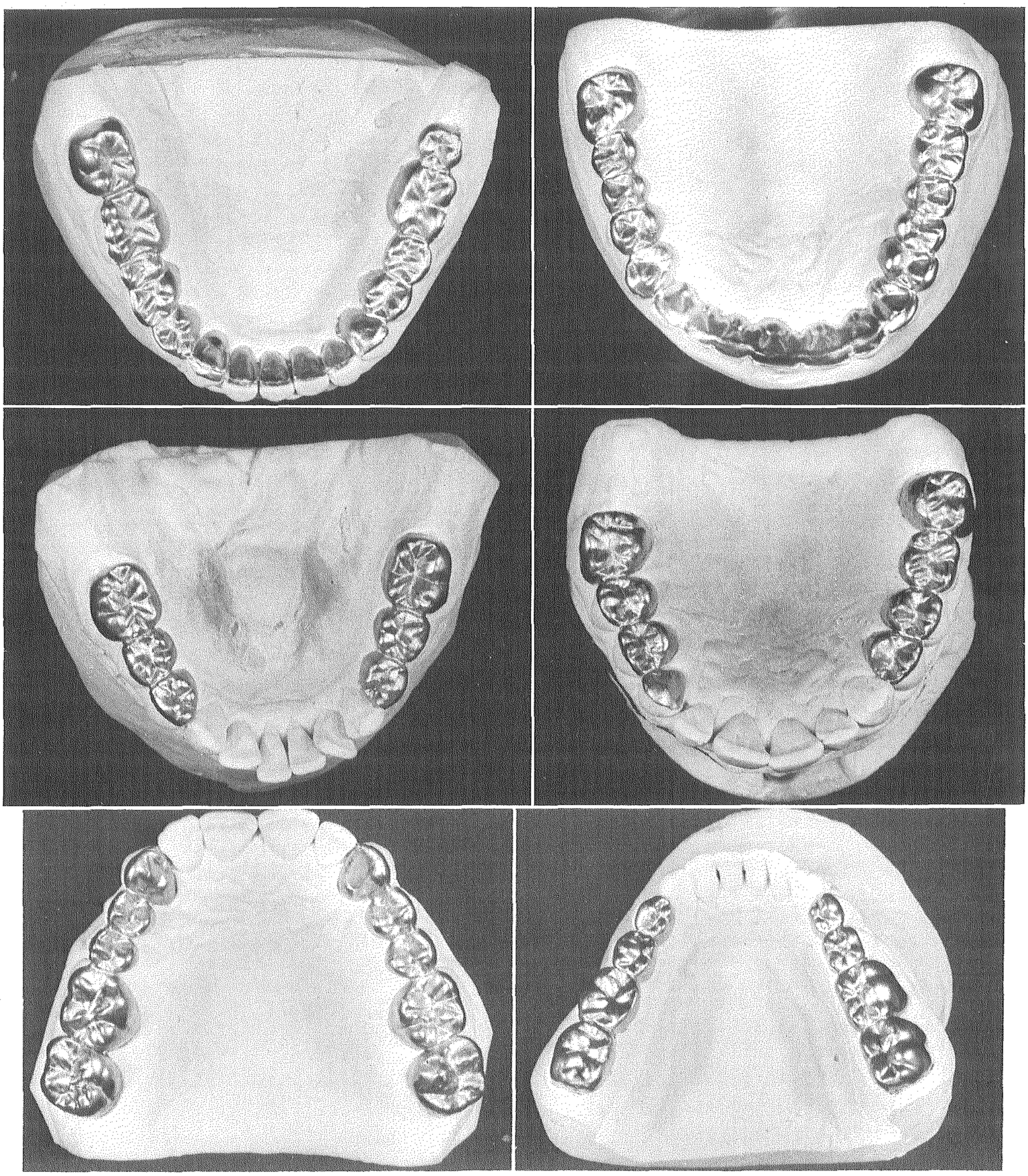
C

D

C′

D′

Case 20. Preoperative and postoperative casts of some cases completed in my office in last eight years. The "mutual protective" concept of occlusion was used in most of these cases. It was used in **A-A′**, **B-B′**, **G-H**, and **I-J**. In **C-C′**, **D-D′**, and **E-F** working side contacts were used with elimination of balancing side contacts.



E F G H I J

Case 20, cont'd. For legend see preceding page.

A B
C D
E F
G H

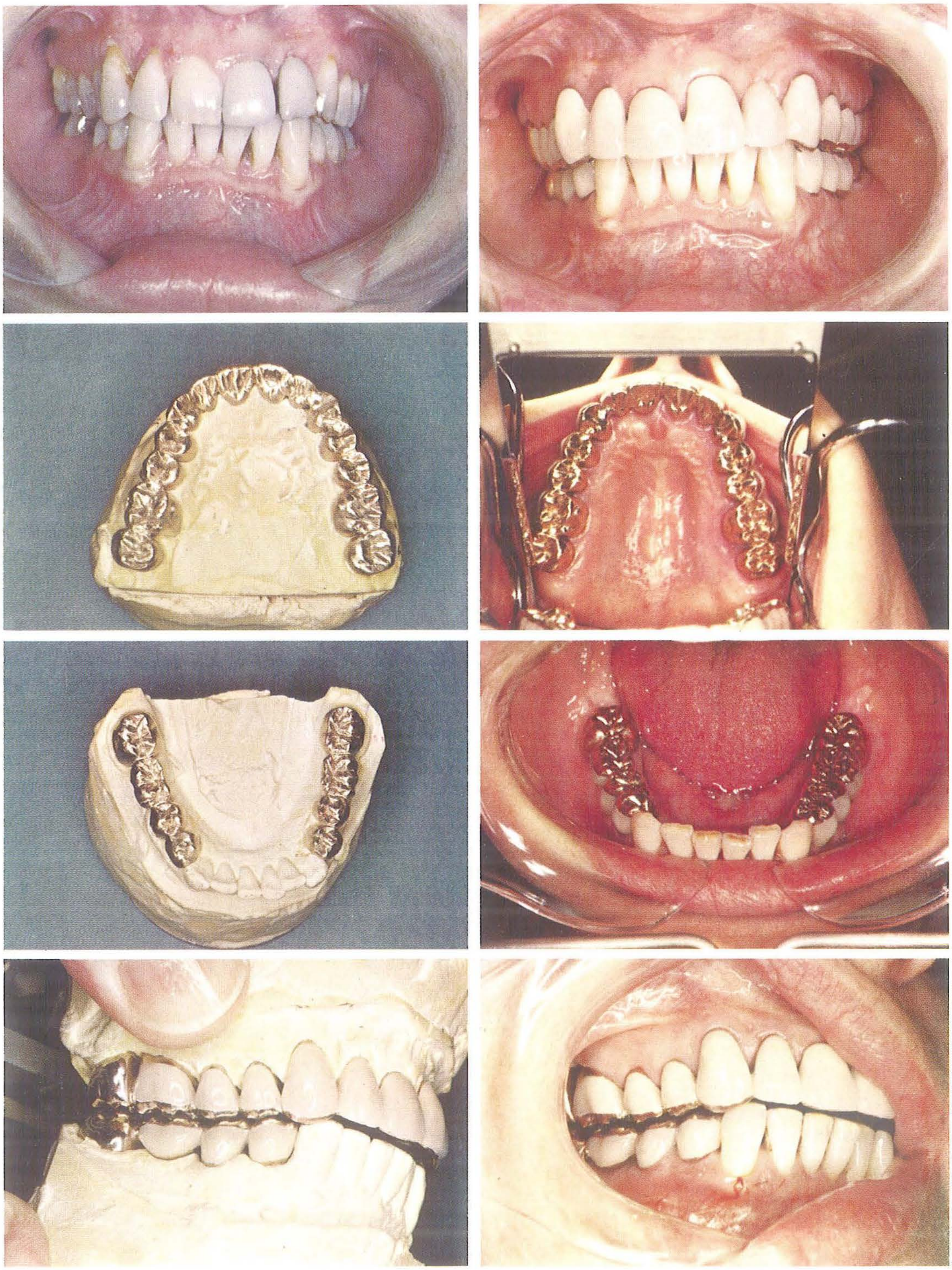
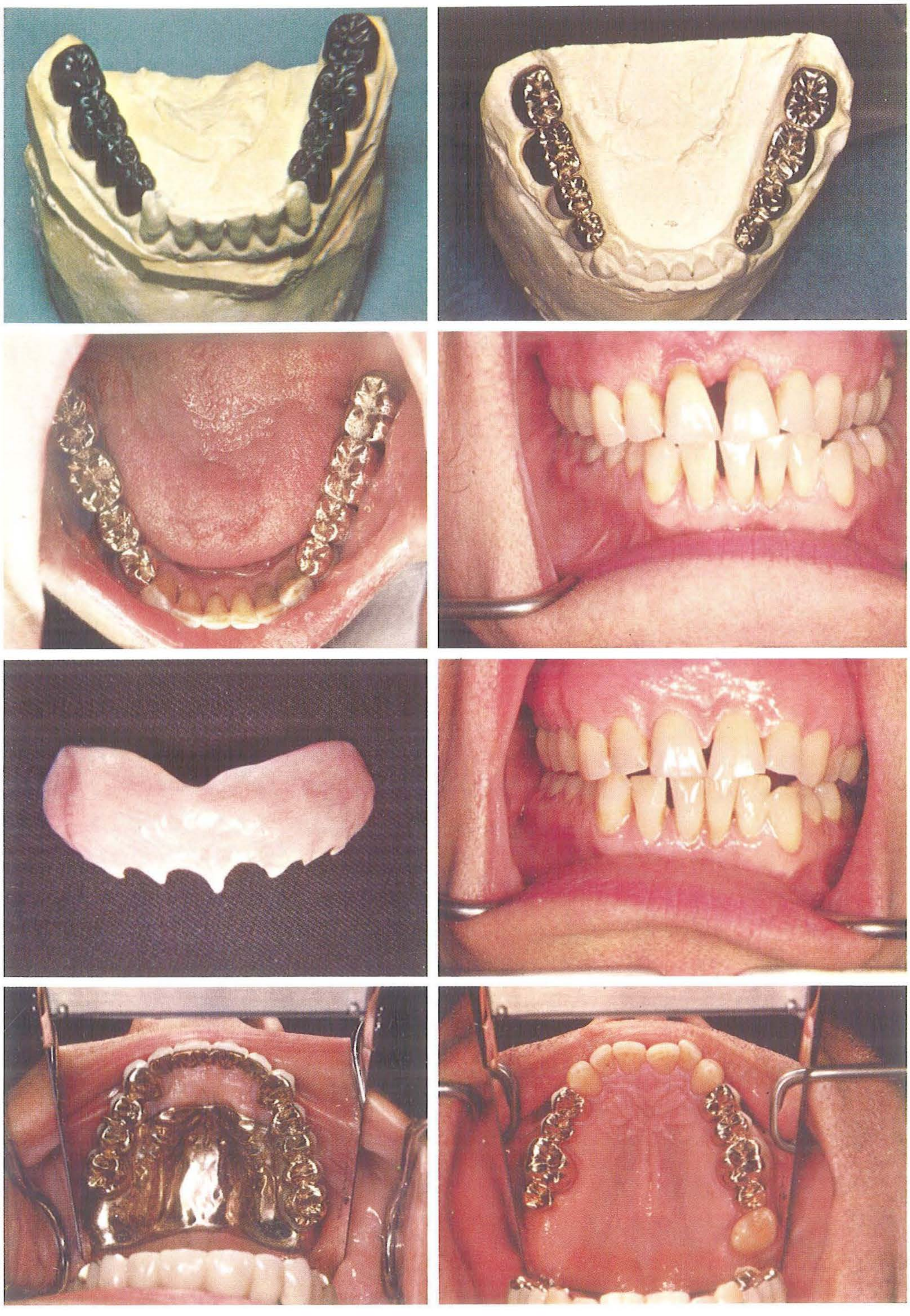


Plate I. Several views of case treated by means of "mutual-protective" concept of occlusion. **A,** Relation of teeth—anterior view (preoperative). **B,** Relation of teeth—anterior view (postoperative). **C,** Remount cast of upper restorations. **D,** Completed upper restorations in patient's mouth. **E,** Remount cast of lower restorations. **F,** Completed lower restorations in patient's mouth. **G,** View of case on articulator in lateral test glide. **H,** View of case in patient's mouth in a lateral test glide. (In lateral position cuspids protect incisors and cusps of premolars and molars.)



I J

K L

M N

O P

Plate II. **I,** Wax-up of lower restorations of case restored by means of "mutual-protective" concept of occlusion. **J,** Remount cast of case that was shown in wax-up stage (**I**). **K,** Completed lower restorations in patient's mouth. **L,** Preoperative view of case requiring an acrylic resin mask. **M,** Completed acrylic resin mask. Note interproximal projections for retention. **N,** View of acrylic resin mask in patient's mouth. **O,** Postoperative view of a restored upper arch. Use was made of a fixed splint and a precision removable partial denture employing gold occlusals. **P,** Fixed bridge splints showing cantilevered pontics.

Chapter 15

Emotional aspects of extended restorative procedures

Dentistry is demanding in both physical and mental effort. It requires not only stamina and technical skills, but also a psychologic insight to be able to cope with the anxiety and tension that accompany the performing of professional duties.

The emotional strains and upheavals of a busy dental practice affect the dentist not only in relation to the patient, but also in relation to his own personality makeup. Let us first take under consideration *the patient.*

Generally, man's behavior is guided more by his feelings than by his rational thinking. Joy comes out of our feelings, our emotional responsiveness.

As we grow we develop an ego ideal, which has to do with what we would like to be or what our parents or teachers would like us to be. We also develop a superego, which acts as a very strict policeman, calling us to account if we do not work toward or achieve our ego ideal.

We have the problem of learning how to cope with the various aspects of our environment. If our parents or other figures of authority give us the opportunity to develop the abilities to make decisions smoothly and easily without procrastination and to stick by them, to take on responsibilities, to be productive socially, to act on our own, to be able to love other persons besides ourselves and to adjust to their needs, and to make mistakes without fear of punishment or ridicule, then we can achieve a psychologic equilibrium that is so necessary in the attainment of good mental health.

To avoid dependency we must learn to be in charge of ourselves. We must learn to work hard, to use our aggressiveness productively rather than turning it against ourselves or others, to be flexible enough to adjust to new situations without difficulty, to have humility, to be patient, conscientious, understanding, and sincere. We must be self-sufficient, feel worthy, recognize and accept our assets and limitations, have sources of gratification, and never be disrespectful of our fellowman.

The art of communication is essential in a doctor–patient relationship. Learning more about better and more effective communication is a matter of survival. So many persons use words without a thought as to their meanings, and then they are disappointed with the results in communication.

The dentist must be able to separate his own feelings and reactions from those of his patients to be able to work realistically and comfortably and perform his services to the greatest advantage of all concerned. He also must remember that the increased tempo of living may be expected to increase the number of stress patients in his practice, and he must learn to become perceptive in recognizing verbal and nonverbal clues to be able to understand the feelings and behavior of his patients. Not only should interest be manifested in what the patient says, but also in why he says it.

When we are convinced in some instances that our dental replacements meet all biomechanical requirements and still are not satisfactory to the patient, it becomes necessary to ask ourselves "why". What possible advantages can this type of attitude offer the patient? What unresolved personality conflicts are at work in this situation? Have we failed to give this type of personality constant reassurance, which may be a basic need of this individual? If we do just that, will he become a claim on the dentist? The dentist should always remember that, if this claim is frustrated, the patient may react aggressively and with anger and rage. The more secure the patient is in his self-evaluation, the more successful the dental treatment will be.

Patients come to the dentist with full recognition that he is fortified with his scientific knowledge, surrounded with the culturally accepted concept of an authority and the aura of a healer, and will take care of all the pain and suffering whether it be of physical or psychologic origin. It makes little difference to this type of individual that the origin of the dental suffering may be related to some emotional conflict. They still expect the dentist to take care of them.[1]

Whenever two people interact, part of each person's attitudes, feelings, and behavior is motivated by forces of which he is unaware. This interaction, when related to an authoritarian figure such as a doctor, becomes even more complex because of the influence of unconscious determinants developed in early childhood.

In interpersonal relations of this type the psychologic phenomenon of "transference" takes place. This means that the patient may transfer to the dentist the perceived attributes of a person or persons significant in his previous experiences; for example, a father figure to be adored or deplored, as his own case may be. A parent–child relationship may develop. I am sure that many of my readers have been told by a patient that they remind him of his father. By this same mechanism the dentist may feel toward a patient the way he felt toward someone the patient even vaguely resembles or acts like. These transference attitudes may distort the patient's or dentist's ability to see each other realistically. Childhood attitudes of dependency, rebelliousness, and affection among others may be reenacted during the course of treatment. Some people unconsciously fear authoritarian figures, whereas others suspect authority. There lives on in most adults, to some degree, a troubled, anxious child.

These unconscious determinants also cause the dentist to be confronted many times with unrealistic attitudes and expectations from the patient, such as hostility, aggressiveness, suspiciousness, complaints, challenges, questions upon questions, passive dependence and compliance, and other unreasonable demands. A psychologically oriented dentist, one having an understanding of dynamic psychiatry, will see the problem for what it is. He will make an effort to provide a nonthreatening supportive relationship to mitigate the patient's anxieties and tensions. He must have an increased awareness of the dynamics of human behavior in dental situations. Although he is not in a position to bring these unrealistic anxieties to a conscious level, despite the fact that his dental treatment contains a psychotherapeutic component, he is quick to recognize when a patient is in need of psychotherapy and promptly refers him to a well-trained psychiatrist.

As dentists we must be aware of the intense psychologic significance of the mouth—it is one of the most sensitive areas of the body. It is highly charged emotionally.

A significant group of patients react to dental manipulation as an oral threat to the mouth, teeth, or gums with either overt or repressed anxiety, the latter evidenced by hostility, avoidance, restlessness, gagging, and exaggerated reaction to pain. Unconsciously some adults may fear work in the mouth as a danger to, or an interference with, breathing or probably with life itself. I have observed this reaction a number of times.

"The teeth have symbolic meaning arising from experiences in early years, and their damage or loss is over-reacted to by most people. Some patients show this symbolism in phantasy and dreams when the dentist may appear as a mutilator and an aggressor. To other patients the dentist is a powerful father figure, who can relieve pain, restore dentofacial function and magically bring about cherished hopes of success in business and marriage, or even the restoration of youth."*

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*From Kaplan, Alex H.: Psychological factors in the practice of dentistry, J.A.D.A. **57**:835-843, 1958.

Patients with temporomandibular joint dysfunction are appearing with greater frequency in the dental offices, and with this problem is contained a large psychologic component. Psychic stress can manifest itself in increased muscle tension, which in turn can cause temporomandibular joint dysfunction and also facial pain.

A relationship can be established between exacerbation of symptoms and difficulties in personal or social adjustment, indicating conflict and anxiety. In my experience, many patients complaining of this type of disturbance seem to have a rigid personality, exhibit overt dependency, and are of a suspicious nature.

Kaplan[1] has said that nearly all dental patients may not have obvious emotional disorders, but they all have differing personality traits or psychologic defenses, which make them react in specific ways to dental manipulation; some patients react without anxiety and others with varying degrees of anxiety. Dentists do not treat an isolated mouth, the dentist treats the whole person with a dental problem.

The dentist must try to understand how the patient views the situation and feels about the situation and why he reacts as he does to the situation. He must recognize the function of stress and personality makeup in causing or aggravating discomfort, and he must remember that the attitudes he encounters in patients, realistic or not, are usually not entirely personal attitudes toward him.

The neurotic disturbances influencing oral health may be of two types: (1) those producing neglect and (2) those utilizing the oral tissues, teeth, tongue, and gums in a symbolic fashion.

Possibly the outstanding manifestation of emotional difficulty from the viewpoint of the dentist is *bruxism.* These type of patients have the habit of intense and prolonged clenching or gnashing of the teeth. It is an attempt to alleviate psychic tension through the infantile reaction of oral expression. The patient directs his aggression toward himself to prevent expressing his hostility toward the outside world.

Bruxism then is an attempt to overcontrol anger and occurs in those persons who do not know how to express rage or who suffer from disproportionate anger. It can be produced by frustration, anxiety, tension, or repressed hostility. Fear of expressing anger is often a result of dependency upon some figure of authority whose reaction is feared. Over 50% of patients complaining of temporomandibular joint pain studied by psychiatrist Ruth Moulton were not aware of their defensive bruxism.[5]

Clenching of the jaw may frequently begin as a conscious controlling device, but it becomes self-perpetuating, leading to muscle spasm and resulting pain.

Other parafunctions such as tongue thrust and lip, tongue, and cheek biting are usually of psychogenic origin.

Tongue thrusting is the child's way of using the tongue as a nipple and sucking on the tongue, leading to the development of incorrect or abnormal swallowing habits.

Lip, cheek, and *tongue biting* are inverted oral aggressions that can arise from feelings of guilt and are used as a form of self-punishment.

Gagging in many instances is an attention-getting device that gives the patient a kind of perverted type of pleasure, or it may be demonstrating the choking reaction induced by anxiety.

The tense patient reacts more strenuously to pain. This indicates that the patient, when he reacts to dental manipulation with excessive pain, is trying to communicate to the dentist that he needs help because of excessive emotional reactions to operative procedures.

Picking at the teeth may be a means of relieving anxiety just as biting of the nails and sucking of the thumb serve to protect the child against tension.

To those patients who overclean and overbrush their teeth dirt has a symbolic meaning and is a threat to their integrity. Their underlying aggression is defended by conformity and compulsive cleanliness.

"All of this behavior protects the individual against anxiety, but the other aspect of this activity is the self-destruction or self-injury which is true of all psychologic symptoms. Some patients use dental manipulative procedures to bring on self injury and punishment for masochistic needs and relief of tension. They can and do submit to the most painful dental procedures even without the desire for novocaine or sedation of any kind. They even seek to have their teeth extracted even before the dentist suggests it. To such patients the removal of the teeth may symbolize a return to an infantile state which is at the same time both desired and disdained. It can be said at this point that the more their total human problem is understood, the less they need the pain as a way to get some attention and help from the outside. A measure of mental health is the degree to which behavior is logical, purposeful, and free of anxiety."*

Now let us consider the emotional strains and upheavals of the dentist. The personality of the dentist may influence his technical procedures, the care and time he takes in treatment, and the satisfaction he gets from his work. A positive or negative rapport depends on how the dentist's own personality harmonizes or clashes with those of his patients.

Most dentists develop defense mechanisms to cushion failures and to alleviate the feelings of guilt mobilized by them. The purpose of these defense mechanisms is to help maintain the feelings of personal worth and adequacy. They protect us from intolerable anxiety aroused by a threat to our self-evaluation. All of us use one or more of these defense mechanisms if the threat is great enough. We even sometimes resort to defense mechanisms that might result in distortion of reality and in self-deception. We might ignore or deny criticism since we often ignore things that are not compatible with our desires and wishes. We sometimes transfer the blame for our shortcomings to someone else or to some thing. All this is done to protect ourselves from traumatic stresses that might be aroused by certain conditions.

"Hereditary factors, the emotional climate in which the dentist lived or now lives, the degree of emotional maturity, and the social and financial security he has attained or not attained, all play a role in his desire for emotional equilibrium. Dentists have been so interested in allaying the anxiety of their patients that they have paid too little attention to the fears and anxieties in themselves.

"This anxiety may be overt or concealed, but is most commonly present in those who fear that they do not know enough about handling the anxiety of their patients, and are perhaps aware that they are not applying all available evidence concerning this subject either in theory or in practice. Because of this they tend to become insecure and to develop professional phobias. They always appear to apply the same concepts and therapeutic measures. Any attempt to change their attitude towards dental procedures acts as a threat to their organized defense mechanisms. They really do not learn in this field. They pay a high price for this method of defense, both physically and emotionally. In order to handle the patient's fears and anxieties, one must have one's own fears resolved."*

Herein may lie one of the factors responsible for the difference in attitudes among various dentists toward their patients and toward their profession. According to Raginsky[2] it also may account for the fact that insecure dentists tend to have their patients heavily premedicated before manipulative work. Since this type of patient presents less threat to the emotionally insecure operator than does the more wide-awake one.

It is not the external pressures that cause the dentist most of his difficulties, but rather his internal turmoil, which most likely was present before he started the study of dentistry. The emotionally mature and secure personality is able, to a great extent, to direct the events in his professional life and guide it to his will. The emotionally insecure person is pushed around by the events surrounding him. Also it should be remembered that these difficulties are not necessarily caused by a lack of intelligence or brilliance; many successful men are neither intelligent nor brilliant.

A dentist may save himself considerable wear and tear both in the physical and nervous systems if he can develop empathy as well as sympathy for his patients. The dentist should observe the patient's manner, mood, and anxiety. The patient should be listened to because by so doing the dentist hears what the patient is saying and can feel empathy with him. We begin to deal with the whole patient. "This is an example of the model of mutual participation and patient education stimulated by an insightful, empathic dentist with skill in the art of interpersonal relations as well as excellent technical competence."† Insight, sympathy, and empathy are of utmost importance. Try to replace the image of the man with the drill to one who listens and helps.

Sympathy is feeling for another person. In

*From Kaplan, Alex H.: Psychological factors in the practice of dentistry, J.A.D.A. **57**:835-843, 1958.

*From Raginsky, Bernard B.: The dentist as a person, J. Canad. Dent. Ass. **20**:72-79, 1954.

†From Schour, Esther: Interpersonal relationships in dental practice, Alpha Omegan **58**:123-128, 1965.

many instances it is a feeling closely allied with pity. Having some of the same feelings as the patient allows for understanding and sympathizing with him. However, a behaviourism on the part of the patient that is foreign to the dentist's personal experience within himself can cause him to be unsympathetic and even ridicule or minimize the symptoms or fears. A misunderstanding and deep hurt will result many times between the concerned individuals, leading to aggression and hostility, emotions that tend to interfere with proper relationships.[2]

Because of all this, it is necessary for the dentist to develop some degree of empathy, which allows him to understand what makes his patients behave the way they do.

Empathy, which is considered one of the best bases of psychotherapy, is experiencing with another person. It breeds sincerity. One tends to deal with this person as he would want to be dealt with.

Sinick[4] emphasizes that the creation and continuation of rapport is less a verbal process than a nonverbal one. It is not so much a question of what to say or how to say it, but of what to feel and how to feel as the patient does. Your actions speak louder than your words. Empathy will eliminate both the simulated smile and the aggressive grin.

Much unnecessary friction, resentment, frustration, and hostility toward the patient's attitudes toward pain, handling of appointments, payment of accounts, and possessiveness of the dentist's attention and time will result if empathy is not applied in these situations.[2]

Indeed it is fortunate for both the patient and the dentist when the dentist has not only sympathy but empathy as well.

"Personality structure in the dentist's makeup plays a very important part in his behavior toward his work and his patients. An individual with compulsive or obsessive trends tends to wear out because he is distracted by all kinds of unimportant details and is unable to concentrate on the main issues of life. This type of dentist generally is intolerant of human foibles and does not get the most cooperation from his patients. He tends to be inordinately tired and often suffers from gastrointestinal disturbances. His compulsions and obsessions cover some type of basic anxiety, which must be cleared away before he is able to enjoy his fellowmen and the ability to relax."*

There is also the perfectionistic type of individual. Perfectionism, as wonderful as it is, does not work too well in interpersonal relations. It is frequently an imperfection. This type of individual is constantly frustrated unless his inner conflicts have been resolved, and this frustration leads to aggressive and hostile behavior, to say nothing of his feelings of guilt and self-criticism. "He tends to put too much concern into little things, and his desire for perfection causes him to overwork. He gets tired and tense not only from the work he does, but also from the tension and concern over the work he sees waiting to be done."* He also finds others to be inadequate, and by displacement of this emotion to the patient he winds up feeling that the patient is too demanding or unappreciative of his hard efforts of rendering excellent dental services.

Another type of personality with which most of us are familiar is the martyr type. He is more than willing to have all problems dumped into his lap regardless of the amount of responsibility incurred. He never appears to be happy unless he is suffering for others. This type of individual usually has some deeply buried guilt for which he attempts to do penance by excessive consideration and help for others.[2]

Then there is the so-called big shot, the restless one who must always be right, always better than anybody, always first at all times, etc.

Raginsky[2] has pointed out that to meet the ordinary frustrations of life and dental practice with some degree of equanimity, one must be emotionally mature. This means that the personality makeup is integrated in such a way that a person is made emotionally independent from figures of authority. He is relatively free from feelings of inferiority, egotism, and over-competitiveness. His conscience is adult enough to aid rather than hinder further development.

All this means that one of the most important factors in the dentist–patient relationship is the attitude of the dentist. The unhappy, emotionally deprived, fatigued dentist finds it difficult to react to any tension in his patient without a corresponding rise of his own tension, which is translated into irritability, annoyance,

*From Raginsky, Bernard B.: The dentist as a person, J. Canad. Dent. Ass. **20**:72-79, 1954.

withdrawal, or overtreatment. The close and prolonged personal relationship so necessary in dental treatment facilitates such reactions unless the dentist has developed a matureness and personal understanding of some of his own normal emotional needs as well as those of the patient. Every dentist has personal needs, which must be gratified through beautiful and well-executed biomechanical dental restorations, adequate monetary compensation, normal healthy relationships with wife, children, and friends, or an interest in hobbies before a healthy relationship with a patient can be sustained. When a dentist is fortified with adequate gratifications, there will be no need to overreact to patients in either a positive or a negative direction. He will concern himself with the patient's reaction in a kind, accepting, and understanding manner. He will not continue to pursue the achievement of technical perfection as if, through its mastery alone, all problems in practice could be solved. Dexterity and ingenuity are basic to dental practice. The intense concentration required to do many dental procedures makes it easy to forget that the patient is alive, has feelings, and is made up of more than teeth and jaws. It is just as important for the dentist to be psychologically oriented as it is for him to be biomechanically oriented.

The use of supportive psychologic measures such as reassurance, encouragement, persuasion, warm acceptance, and explanation and clarification of procedures and techniques can alleviate much dental tension. The patient should be given information, within reasonable limits, about the services to be rendered, but the use of technical terminology should be avoided. The use of kind but firm attitudes in reaction to some patients also may be supportive.

The following salient facts, as pointed out by Ruth Moulton[5] and other psychiatrists,[6-8] should be carefully considered:

1. Emotional security decreases postoperative complications, facilitates healing, and thus greatly influences the success of therapy.
2. In general it could be said that in any person in conflict the rehabilitation may be seized upon as a tangible object on which fury and fear may be vented.
3. The important factor is that a really "neurotic fear" is not amenable to the exercise of ordinary common sense. One cannot "kid" a patient out of it. The phobic cannot be "talked out" of his fear with logic. His actual difficulty has nothing to do with the particular overt problem he presents, and nothing can make him give up the unconscious protection provided against the far more threatening inner ideas.
4. Since all neurotic reactions are based on fear of some kind, from this point of view one should never censure the patient for his peculiarity even though it makes him difficult. Punitive attitudes are inappropriate and make the patient worse.
5. Rigid ideas about the extent and tempo of therapy cause trouble. One needs to go slower and do less at a time with certain people, or to choose a simpler procedure even though it may not be scientifically the best. In other words, a compromise type treatment is needed.
6. It may become evident that the patient needs to hold onto pain as a protection against anxiety, and the alleviation of this pain is not welcome.
7. It is dangerous to make certain patients too aware of minor irregularities in their bite, which were previously causing them no difficulties.
8. Patients may often demand radical and spectacular procedures in their desperate need to find a physical answer to their problems. However, radical procedures fail to satisfy them, and they merely go from doctor to doctor looking for more spectacular methods of treatment.
9. The patient who demands to be taken care of beyond the realistic limits of dental practice is bound to be disappointed and therefore will blame the doctor no matter what the treatment is. Unreal demands cannot be satisfied and certainly should not be encouraged.
10. Only necessary dental work should be done until there is less anxiety and muscle spasm. The most recalcitrant cases are the patients who had found doctors who promised them complete cures.
11. The doctor who placates the patient, or gives in to him, to avoid disapproval often finds himself in a deteriorating patient–doctor relationship rather than a constructive one. The patient regards the doctor as weak—easily frightened and controlled—and thereby becomes increasingly anxious.
12. It always should be remembered that dental patients are not supposed to like what we

do, and, because of its very nature, dental treatment is always physiologically and psychologically traumatic.

13. Dentists must be on guard especially against the feeling of omnipotence that the excellence of our technical skills tends to foster. The doctor 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.

Some situations involve the patient, who, because of deep anxiety and rigidity, attempts to ensure the success of treatment by choosing a dentist who will serve in an omnipotent, godlike capacity. This distortion of the role of the therapist lends itself to the equally neurotic dentist who feels himself endowed with godlike abilities (in my extensive travels around these United States I have been confronted with many such type dentists). Of course, this type of interaction results in an unhealthy patient–dentist relationship.

14. In evaluating patients it is important to think not only of their emotional problems, but also of those of the dentist. It is the interaction of one upon the other that provides either a peaceful, satisfying relationship or one leading to frustration. The patient feels the need for the humanity of the healer as much as he feels the need for the dentist's knowledge and skill.

15. Soft music also has been suggested as a device for reducing fear, pain, and reflex irritability so that the patient is rendered psychologically amenable to treatment.

16. If the dentist senses something deeply abnormal and inaccessible, it is best to send the person to a psychiatrist for diagnosis and evaluation. It certainly is wise to share the responsibility with a psychiatrist and to seek suggestions from him.

17. A thoughtful, cautious, dental approach, which is based on some knowledge of the tensional factors involved, is often very useful. Sometimes it is hard for those not acquainted with dynamic psychiatry to understand that emotional disturbances may lie dormant for years and appear only when the individual is subjected to sudden stresses, which overtax his resources and call for adjustments beyond the capacity of his defense system. It is at this point that the ego struggles to maintain integrity.

When faced with a crisis or sudden change of conditions some individuals cannot meet the new demands for even a day, and yet others may struggle many years, only to break down physically with peptic ulcers, a psychotic disorder, or difficulty centered in the mouth.

Psychology would appear to have a legitimate role in both the etiologic and management aspect of dental disorders.

Dental schools certainly should pay more attention to the teaching of interpersonal relations.

Case histories

Case 1. Mrs. A., 49 years of age, presented herself with a shopping bag full of dental casts taken by a number of dentists and with the complaint that she has been unable to close her mouth correctly for several years. She informed me that she had been under treatment by many dentists during that time and has always "wound up" in a more unsatisfactory condition. She had been equilibrated, splinted, and restored at various times.

Observation of the patient's manner, mood, and anxiety during several hours of discussion and questioning convinced me that I was dealing with a very tense, nervous, and extremely dependent woman with many physical complaints, who blamed all her troubles on her teeth. She was constantly ambivalent about her emotional problems having a bearing on her dental disturbances.

A close examination of the shopping bag of casts convinced me that she originally did not have a dental problem. Only an excellent psychologically oriented dentist, in my opinion, would have failed to fall into this trap because she was a very nice, sweet, charming person who really looked like she was in need of help. She was in need of help but not dental help in the early stages.

She and her family were told that treatment without a psychiatric evaluation was out of the question. They all balked and refused this suggestion, insisting that it was a "bite" problem.

She next went to New York for consultation, and the dentist that she saw told me that I was wrong in my evaluation of this patient and asked me to do whatever I could for her. She returned to my office and on my insistence consented to have an evaluation by a psychiatrist of my choosing if conditions warranted it.

I did not have any difficulty in the removal of all restorations and the re-preparation of all her teeth. All this was performed upon her request without premedication or an anesthetic. I decided to make a very good set of temporary restorations (good form, fit, and function) because I had a very strong belief that anything that sounded like permanency was out of the question for psychologic reasons.

The "temporaries" were completed and cemented with temporary cement. According to the patient the teeth, came together much better, and she could close her mouth at times, and she was sure that the "permanents" would solve her problem completely. At this same time impressions and registrations were taken for the construction of the so-called permanent restorations.

After completion the permanent restorations, which, except for a little more attention to anatomic details, were exactly like the very good temporary restorations she had in her mouth, with which she could close her mouth most of the time, were seated on the prepared teeth, and the patient was asked to bring her teeth together. Her lower jaw started to quiver to such a degree that it was impossible to get her to even try to bring her teeth together. A colleague who was visiting with me tried to accomplish this act, but without success. He became so angry that when we went back into the laboratory he said "she must be out of her mind." I removed the permanent restorations and recemented the temporaries, being sure to show the patient the label on the cement bottles, which indicated a temporary type of cement. I called for a psychiatric evaluation because I knew now that this condition allowed her to blackmail her family for reasons unquestionably unknown to her. She balked rather vigorously, but decided to honor her commitment to me.

The psychiatrist informed me that "this patient has an extremely weak ego structure, with very rigid intolerable superego and a need for strong somatic defenses as well as a need to maintain rigid repression and regressive symptoms. She had no motivation for treatment of her emotional problems and feels very threatened at the thought of it. She will need to eventually be motivated by enough discomfort and anxiety before she would be treatable. Diagnosis—psychophysiologic reaction."

The completion of this case was an impossibility. What is the difference, as far as this type of patient is concerned, whether she complains of the mouth, the stomach, or the heart? I know that her mouth was not in bad shape when she left my office. I recognized what I was up against and made my efforts count where they did the most good—removal of decay and establishment of good fit, form, and function.

Case 2. Mrs. B., 29 years of age, was referred to me by a former student who told me that the patient had severe facial pains on the left side and that he had tried every type of treatment known to him without success. He had referred her to a psychiatrist for evaluation and treatment.

A preliminary examination revealed no dental reason for the discomfort. There is no doubt that such pain can be, and frequently is, psychogenic. Psychic stress can eventuate increased muscle tension, and this tension can cause facial pain and temporomandibular dysfunction. A more complete examination, clinical, radiographic (teeth and temporomandibular joints), and accurately oriented study casts on an adjustable articulator, did not reveal the cause of the discomfort. A few of her restorations could stand replacement for better marginal fit and physiologic form, but outside of this I did not have a dental solution. I told her that I believed that her psychiatrist would get to the root of her troubles in due time. She answered that he told her that her salvation was up to the dentist. The patient also told me that she would like for me to make whatever changes in her dental restorations I believed were necessary.

During the process of completing the dental restorations I had the opportunity to discuss many interesting national and international situations that were confronting the nation at the time. I found her extremely quick of mind, intelligent, and interested in education. A question brought out the information that she could not go to college after graduation from high school because of an economic problem but that her greatest desire was to be a school teacher. I encouraged her to enroll in college, although she had been away from school for twelve years and probably would be put on probation. She did just that and graduated four years later, earning the honorary Phi Beta Kappa key. Her facial pains only recurred during stress situations—examinations, interviews with the dean and teachers, and later with parent interviews. She would come to see me or call by telephone, and a little reassurance and understanding helped her get over the "hill." But all this is not the real solution.

I believe that I understand the situation for what it is, and I do hope that some day she will be willing to change to a well-trained psychiatrist who will bring these unrealistic anxieties to a conscious level and allow her to see them for what they are and thereby live a better and fuller life.

Case 3. Mrs. C., 35 years of age, was referred to me because of a very painful temporomandibular dysfunction. She complained of earache and generalized pain on the right side of her face as well as the rear of her head and neck, centered around the temporomandibular joint. She had consulted E.N.T. men and neurosurgeons and had worn a number of splints; the last one, a Hawley type, was exceptionally well constructed.

A very thorough examination—clinical, radiographic, and accurately oriented casts on an adjustable articulator—revealed nothing of a dental nature. I advised a psychiatric evaluation to see if possibly there might be some emotional factors in her complaints. The psychiatrist informed me that this patient has had a great deal of interest, attention, and cathexis centered around the oral cavity with the possibility of a great deal of fixation in this area. She has a domineering mother and a rather strict but demonstrative and affectionate father. She is physically oriented and does not believe that there are any psychologic factors involved in her symptoms.

When the patient demonstrated how sometimes she will respond to her children when they have done something of which she disapproved, her jaw muscles tightened up and she literally talked through her teeth. It was pointed out to her that she had a problem of allowing herself to feel aware of her anger and to feel comfortable in the handling of it. It was mentioned that her pain was probably a result of a need to avoid an awareness of a certain amount of her feelings, and that this was translated into the tension in the jaw, which then resulted in pain. Probably trying to become more aware of these feelings would be the best approach to the solution of her problem, which is the emotional tension that is being centered at the temporomandibular joint. She shows a great deal of resistance to be introspective and has a great deal of difficulty in accepting her ambivalence.

Building of a splint or many splints or even a full-mouth rehabilitation will not resolve her problem. The only solution is to enter a period of psychotherapy to work through whatever feelings are creating these tensions.

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As is evident from the cases cited, patients are often resistant to psychiatric treatment and, therefore it is necessary for the dentist to provide techniques that he can use in being of psychotherapeutic help to his patients in addition to recognizing their problems. Often supportive measures that are undertaken by the dentist or the patient's personal family physician can be of great help to those patients who are unable to accept a psychiatric referral. With some patients it is even more desirable.

Let us end this chapter by saying "know thyself." If your own inner conflicts have been reasonably resolved, you will be able to handle your patients with both sympathy and empathy and obtain the desired results within the realm of reality.

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