SELECTION OF RETAINERS IN LOWER OVERLAY DENTURE

—In relation to the abutment tooth mobility—
(A laboratory study)

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REPRINTED FROM
THE BULLETIN OF TOKYO MEDICAL AND DENTAL UNIVERSITY
Vol. 22, No. 3 pp. 207~220
September, 1975

Bull. Tokyo Med. Dent. Univ., 22: 207–220, 1975.

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ABSTRACT

This study was done to evaluate the art of retaining the lower sub-complete, overlay denture, in relation to the abutment tooth mobility while the force was applied to the denture. The lower overlay denture was placed on a simulated model which was constructed of methylmethacrylate and silicone rubber. The author developed and used the special devices for measuring the tooth mobility.

Results obtained were as follows:

1. When a force is applied directly to the abutment, the tooth mobility, i.e. the lateral excursion of the tooth, is markedly reduced according to the favorable ratio of the clinical crown to the root length. Splinting by the bar is effective to reduce the lateral excursion.
2. When a force is applied to the denture indirectly to the abutment tooth, the lateral excursion changes greatly according to the retainer selected.
3. The clasp retainer shows the greatest change in the lateral excursion against every loading on the denture.
4. All three types of bar attachment show the least value of lateral excursion.

INTRODUCTION

Where there are only few teeth remaining in the mandible, a dentist must decide whether to extract these teeth and fabricate a complete denture or to preserve these and construct a sub-complete overlay denture. It is well known that the retention and stability of a complete denture is very hard to do, especially in the mandible.

In recent years, we have made use of some therapeutic measures to replace these cases, that is the so-called "cover-denture or overlay denture" construction[1–3]. We can obtain many advantages from this type of prosthesis: easy to obtain retention and stability; mild and sustained resorption of the alveolar ridge; preservation of the periodontium, i.e. preservation of the periodontal sensitivity; fast accomodation of the patient to one's prosthesis; and psychic feature of the patient[4–6].

These new concepts have recently gained wide popularity among the practitioners[7,8].

However, there is discrepancy of displaceability between the periodontinum and the alveolar mucosa while loading, which is the main problem with the free-end saddle type of partial prosthesis[9].

In addition to this, there is a possibility that the functional need of the prosthesis

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Received for publication, May 15, 1975.

may overload the abutment. Besides, poor oral hygiene may result in periodontal inflammation, leading to the total loss of the remaining teeth[10]. This complicated problem must be solved so that a good and appraisable prognosis of the prosthesis will be obtained.

To analyze this problem, the author conducted a laboratory study where he constructs a lower overlay dentures on a simulated mandibular model of methyl-methacrylate and silicone rubber. He discusses seven types of retainers, which will affect the magnitude of the abutment tooth mobility while the prosthesis is loaded at various points.

Materials and Methods

TEST MODEL

A partially edentulous mandibular arch with only two canine teeth remaining was reproduced with silicone rubber*1 and methyl-methacrylate. The reason why two canines were selected for the experiment was as follows: in a follow-up investigation of the partial prosthesis executed by Nakazawa *et al.*[11] the canine was the last tooth to be lost.

The design and production of the simulated model were reported before[12].

Simulated mandibular canine teeth were produced, the size being based on the anatomical measurement by Fujita[13]. The prepared root surface with a dowel made it possible to replace the upper part of the crown. So the upper part can be replaced from the clinical crown to the root capping, without harming the relationship between the root and the artificial periodontinum. From the apex of the root extended a Cr-Co rod, which transmitted the excursion of the root to the displacement transducer.

*1 Dow Corning, Co., Ltd. Michigan, U.S.A.

TEST DENTURE

A test denture was made on a working cast obtained from a simulated mandibular model. It was made of methyl-methacrylate resin with sufficient strength against the bending force. It was relined directly on a simulated model with the direct relining resin material. This helped to gain accuracy of adaptation. Glycerol as an artificial saliva was applied under the plate for accuracy of adaptation. The abutment part of the test denture was hollowed to incorporate the various types of retainers. They are positioned with a self-curing resin material.

PROCEDURE

The tooth movement was measured electronically by using a strain gauge displacement transducer. This method was reported before[12]. One abutment had three transducers; two were positioned rectangularly to the rod from the apex of the root and one was positioned to the apex of the rod. Therefore the displacement of the root was measured bucco-lingually, mesiodistally and then vertically.

The test force applicator had the same structure as the tooth displacement transducer. Force was applied to the abutment directly and indirectly through a test denture, when the ratio of the crown to the root length was varied and the retainer was changed one after another. The tooth displacement was recorded by a 6L4 strain amplifier and rectigraph 8S simultaneously.*2

C-R RATIO AND SPLINTING EFFECT

First the reduction rate of the lateral force transmission and splinting effect were evaluated, when the force was directly applied to the abutment. The test force application was as follows: to the labial surface of the canine at an angle of 45 degrees

*2 San-ei Sokki Co. Tokyo, Japan

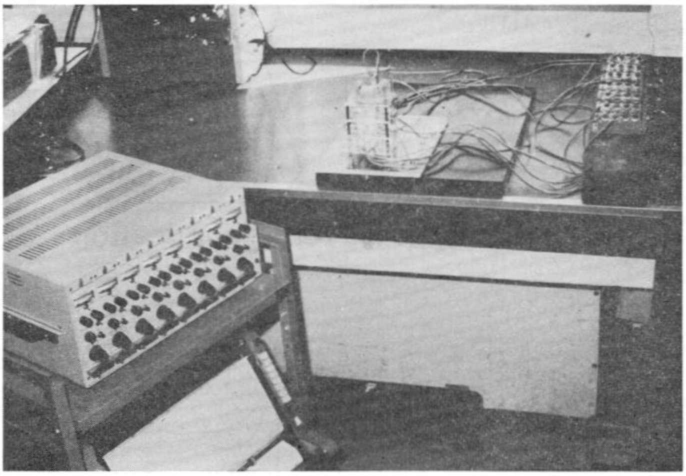

Fig. 1. Simulated mandibular model and its recording systems.

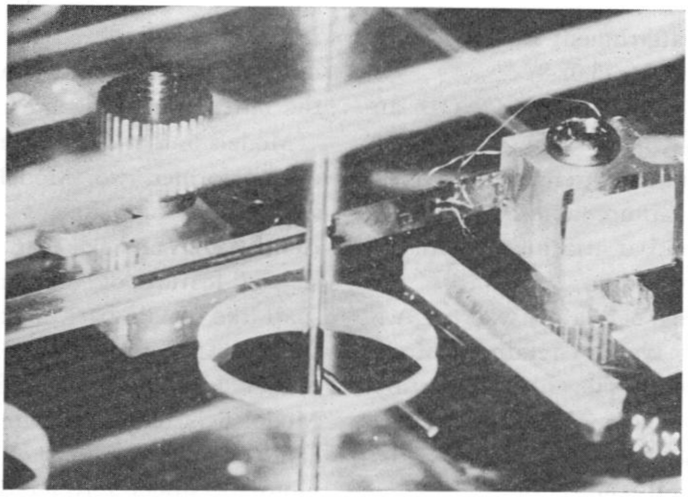

Fig. 2. Tooth displacement transducer in the simulated model.

to the median saggital plane. Continuous loading from 0 to 150 g was done repeatedly.

SELECTION OF RETAINERS

Next, the lateral force transmission was examined when the test denture was loaded, that is the force was applied indiretly to the abutment. Test force application was as shown in Fig. 3. Continuous loading from 0 to 450 g was done repeatedly.

RETAINERS USED

Many kinds of retainers were used in a partially edentulous jaw with only few teeth. As to the connection between the abutment and prosthesis, three types of connectors were considered:

1. Movable connection
2. Articulatory connection
3. Rigid connection

In this study, seven types of retainers were prepared. The models are as follows:

Model 1. Clasp retainer, 0.9 mm Cr-Co wrought wire clasp without the rest

Model 2. Conical telescopic crown

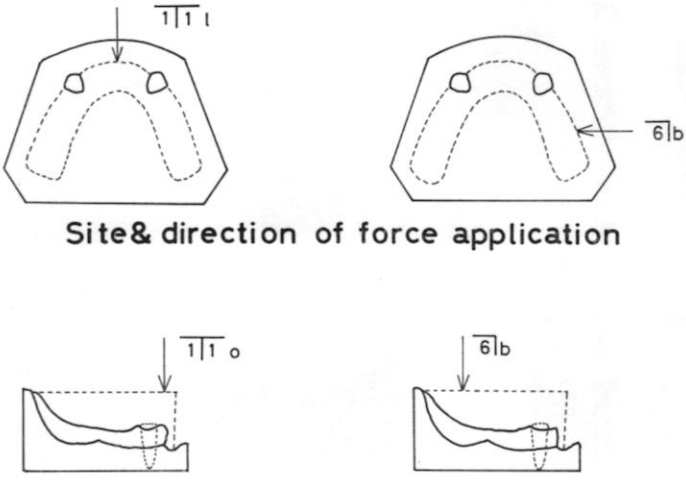

Fig. 3. Site and direction of force application.

Model 3. Stud attachment BONA 604 anchor (CM 43.02.8)

Model 4. Stud attachment CONOD anchor (CM 31.01.5)

Model 5. Round bar attachment (copied after Gilmore and Ackerman)

Model 6. Round bar attachment with distal extension

Model 7. Milling bar (after Gaerny, A.)

Of these seven types of retainers, Model 1 belonged to the movable connection. Models 3, 5 and 6 belonged to the articulatory connection. Models 2, 4 and 7 belonged to the rigid connection.

From the other point of view, Model 1 is a wrought wire clasp without the rest is characterized by its soft retaining action. It was a typical movable connector. Model 2. A telescopic crown was recommended as a retainer for the few teeth remaining in the dentition by Kemeny[14], Rehm[15], Böttger[16] and Hofmann, M.[2] Körber, K. H.[17] reported "Konuskronenteleskop" as a new and rational telescopic retainer. In this study, this conical telescopic crown was used.

Models 3 and 4. The stud attachment BONA 604 and CONOD anchor are commonly used in the clinic, the former permitting an articulatory movement while the latter permitting no movement.

Models 5, 6 and 7. The bar attachment of the former two, Models 5 and 6, is a simple bar attachment like Gilmore's, Ackermann's and Baker's[18]. It has a round shaped feature of the male part, and a snap like female part, bended according to the form of the residual alveolar ridge. Model 5 is for intermediate basic use. Model 6 is for distal extension use as recommended by Preiskel[18] and Matsumoto[19]. Model 7 is a milling bar with a tissue contacted retaining bar attachment with its paralleling wall, being advocated mainly by the European prosthodontists. In this case, the method of fabrication was devised by Gaerny, A[20].

Results and Findings

1. *Reduction rate of lateral force transmission and splinting effect of abutments.* Test loading was as mentioned before. The C-R ratio, when the root length was constant, was varied as follows and the splinting effect of the abutments was observed:

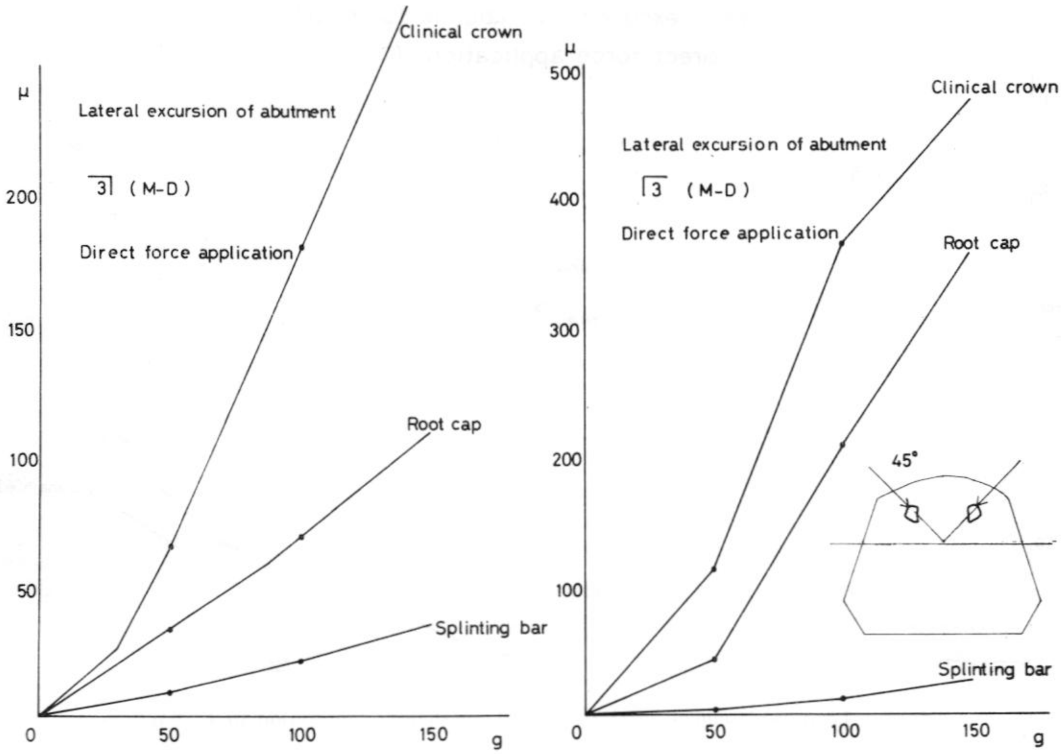

Fig. 4. Mesio-distal excursion of abutments, while a force is applied directly.

Model (a) with a clinical crown (prototype)

Model (b) with a root cap

Model (c) two root caps splinted through a bar

RESULTS

Fig. 4 shows the mesio-distal lateral excursion. The greater the loading force is, the greater is the value of the lateral excursion. The problem of C-R ratio was apparently compared between Model (a) and Model (b). The splinting effect was observed by comparing Model (b) and Model (c). Fig. 5 shows the value of the lateral excursion in percent, when a constant force (150 g) is applied. Model (a) with a clinical crown (prototype) was assumed as 100%.

2. *Lateral force transmission (indirect force application)*

The relationship between the load and displacement was obtained, when the various points of the test denture were loaded.

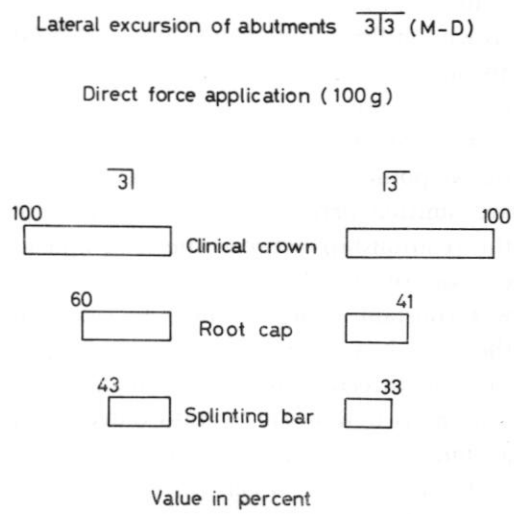

Fig. 5. Lateral excursion of abutments. Model (a) with clinical crown is assumed as 100%.

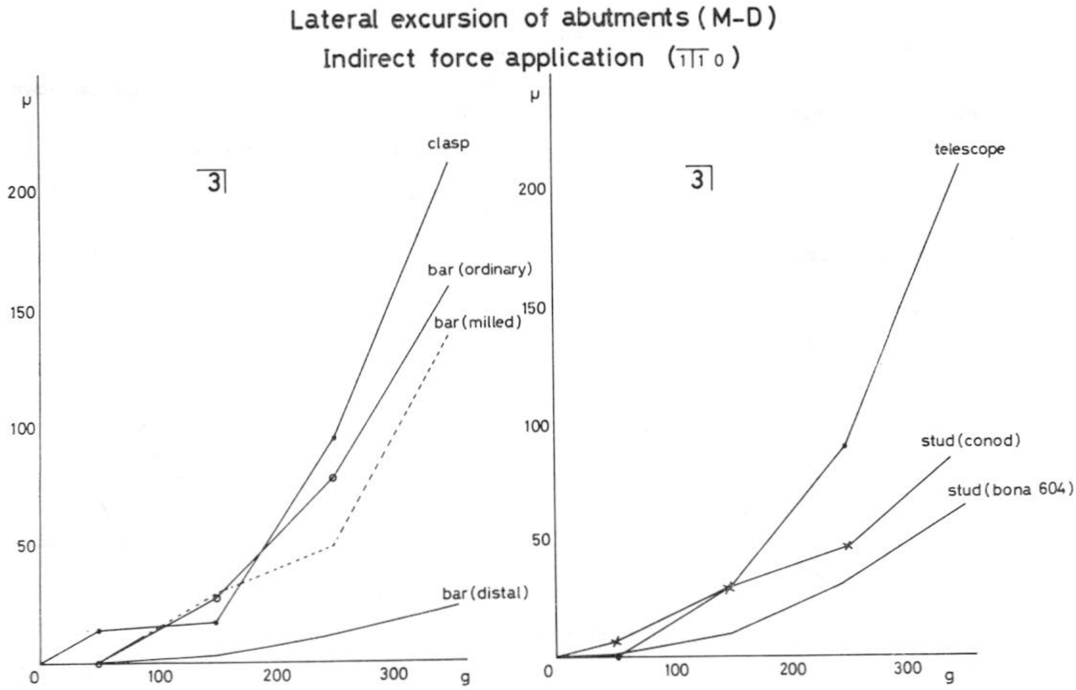

Fig. 6. Load-displacement curve of $\overline{3|}$. (Lateral force application to $\overline{1|1}$ o.)

For example, Fig. 6 shows the load-displacement curve of the lower right canine, when the interincisal point of the denture was loaded vertically.

The value of the lateral excursion was reduced from the clasp, conical telescopic crown, milling bar, round bar, CONOD anchor, BONA anchor to the round bar (dist. ext. use).

Also, relationships other than the loading at point $\overline{1|1}$ o were obtained. They are omitted here. Fig. 7 to Fig. 10 show the relationship between the load and excursion of the abutments when the load was constant (350 g). These figures show the lateral excursion as the vector indicating the direction of the excursion. The vertical as well as the lateral excursion was assumed as 100% in the clasp retainer.

(1) *Point $\overline{1|1}$ o vertical loading of interincisal point.*

Fig. 7 shows the result. The value of the lateral excursion was reduced as follows: clasp 100>telescopic crown 90>milling bar 66>bar attachment (intermediate) 41> BONA 36>bar attachment (dist. ext. use) 15. The vertical excursion also showed in figure. The value with the clasp was assumed as 100%.

(2) *Point $\overline{1|1}$ l sagittal loading of interincisal point.*

Fig. 8 shows the result. The value of the lateral excursion was reduced as follows: clasp 100>bar attachment (intermediate) 35>bar attachment (dist. ext. use))29> BONA 26>milling bar 21>telescopic crown 18>CONOD 9.

(3) *Point $\overline{6|}$ o vertical loading of right first molar.*

Fig. 9 shows the result. The value of the lateral excursion was reduced as follows: CONOD 203>telescopic crown 190>clasp 100>BONA 54>bar attachment (dist. ext. use) 51>milling bar 50>bar attachment 34.

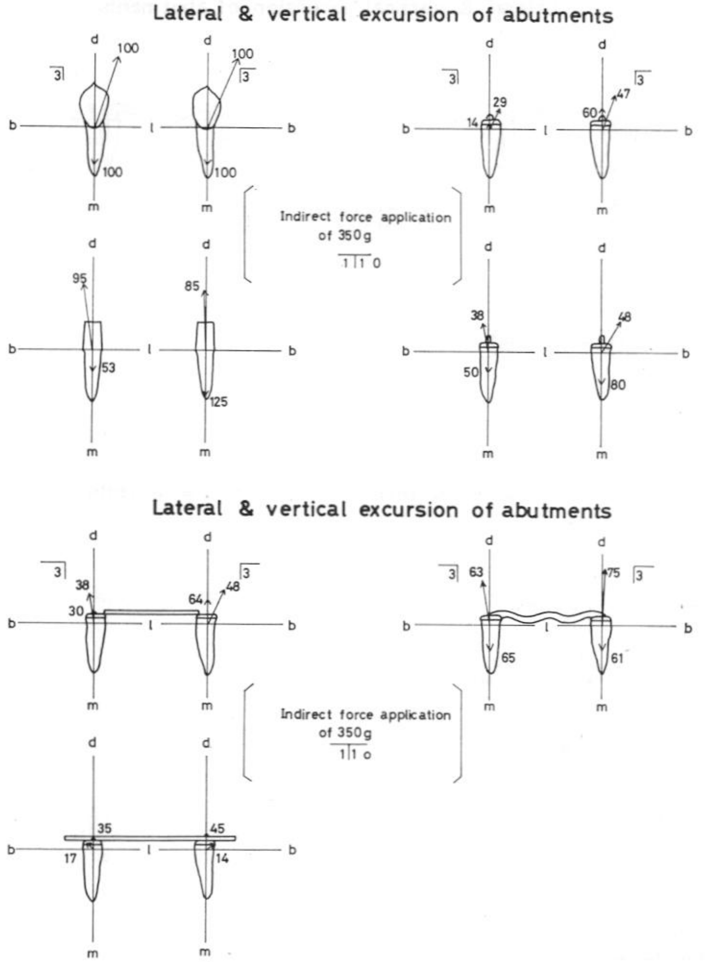

Fig. 7. Lateral and vertscal excursion of abutments while a force is applied indirectly through a test denture. ($\overline{1 | 1}$ o).

It was apparent that the rigid onnector, CONOD, and the telescopic crown showed two times greater value than with the clasp.

(4) *Point* $\overline{6|}$ *b lateral loading of right first molar.*

Fig. 10 shows the result. The value of the lateral excursion was reduced as follows: clasp 100>telescopic crown 45> BONA and CONOD 23>bar attachment (dist. ext. use) 14>bar attachment (intermediate) 12>milling bar 11.

Discussion

(1) *Direct force application to the abutments*

It was apparent that the amount of the lateral excursion of the teeth is low, when the ratio of the clinical crown and the root length is in a favourable condition and when each side of the retainer is connected. How the score is obtained is shown in Fig. 5. Dolder and Schärer[21] reported that this reduction of the tooth mobility in vivo study utilized a parodontometer by

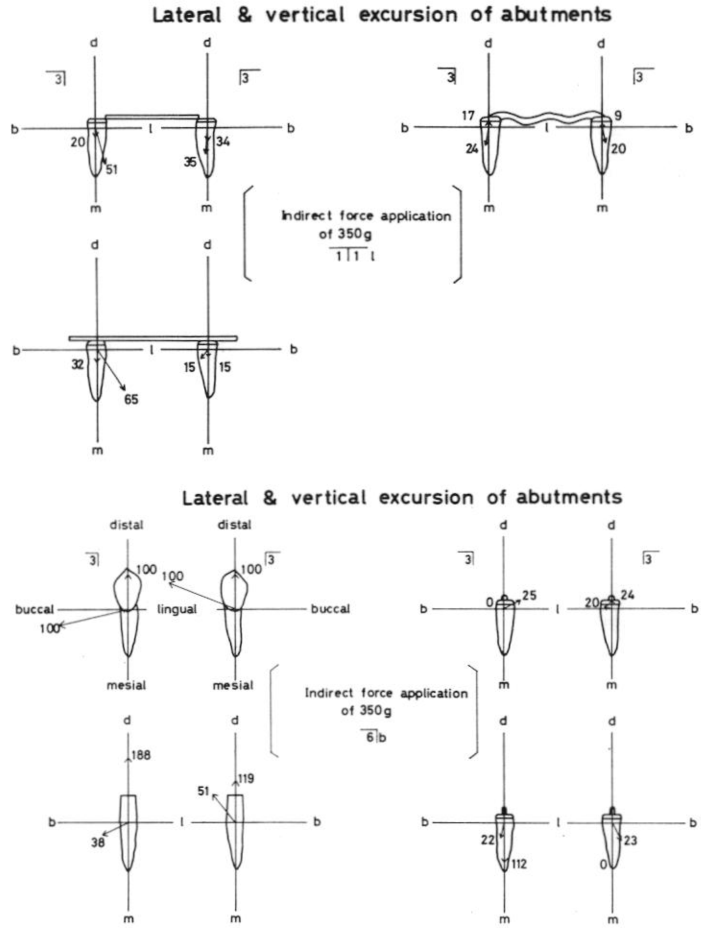

Fig. 8. Lateral and vertical excursion of abutments while a force is applied indirectly through a test denture. ($\overline{6|}$ o).

Mühlemann[22]. They reported that when a tooth was cut down to the root the tooth mobility was reduced from 100% to 60% and when the tooth was joined by a bar the tooth mobility was reduced to 40%. Dolder stated that the reduction of the clinical crown was the keystone of the bar joint denture as well as the splinting effect by the bar. This means that when the teeth are lost to few in number and the preservation of these teeth is difficult, the best way is to reduce the coronal parts of the abutments.

Sholle[23] reported in his follow-up investigation that the anchor tooth of the bar joint denture had a better prognosis than that of the stud anchor in their apical involvement. He said that it was the splinting effect of the bar which were able to cancel the damaging lateral force effectively. But a splinting bar is not perfect. Jörger[24] reported about the problem of hygienics when the bar attachment denture was fabricated. He said that there was often accumulation of the dental plaque under the bar and around the root cap and hypertrophy of the gingigva under the bar. Among other things, the most polluted site

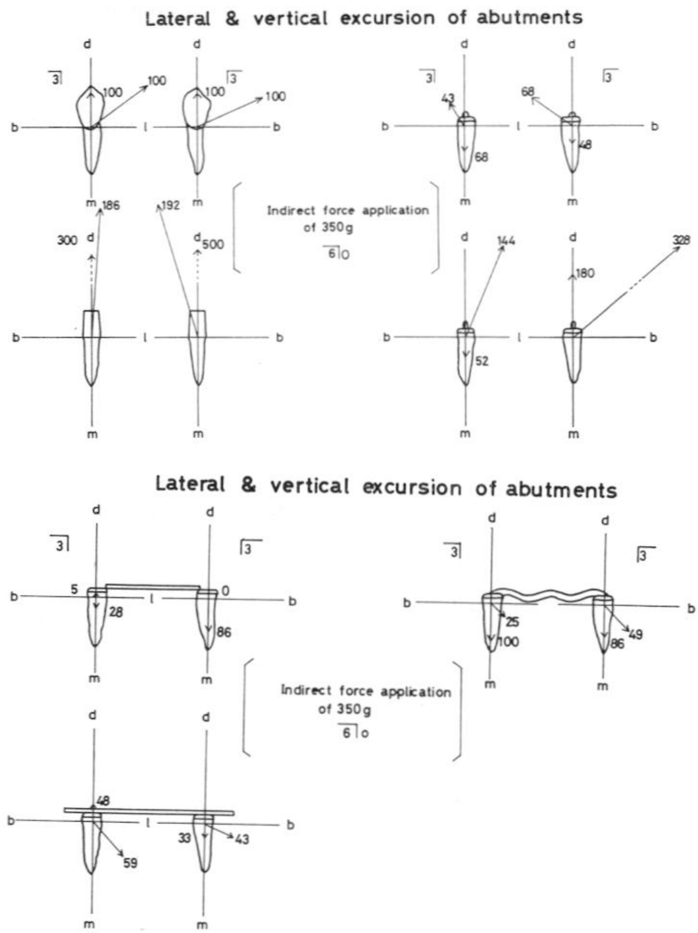

Fig. 9. Lateral and vertical excursion of abutments while a force is applied indirectly through a test denture. (1 | 1 1).

is the junction of the root cap and the bar. There are hardly any bar joint dentures being fabricated in recent years in the author's department. The reason is the difficulty in prophylaxis and maintenance by the patients. Although, the bar attachment reinforces each of the abutments and reacts well to the apical periodontium, a tendency toward pollution of the dental plaque is almost unavoidable.

When we utilize this art of splinting for the dentition with only few teeth, the problem of hygiene should be given due recognition[25].

(2) *Indirect force application to the abutments*

(Tendency of abutment displaceability when the prosthesis is loaded.)

1. *Comprehensive survey*

In all cases, the clasp retainer shows the greatest value of lateral excursion of the abutment. The reason is the unfavourable ratio of the clinical crown and root length. When a prosthesis is loaded, the abutment acts as follows: (1) When the force is applied to the most distal part of the free-end saddle, the abutment rotates lingually. (2) When a prosthesis is displaced horizon-

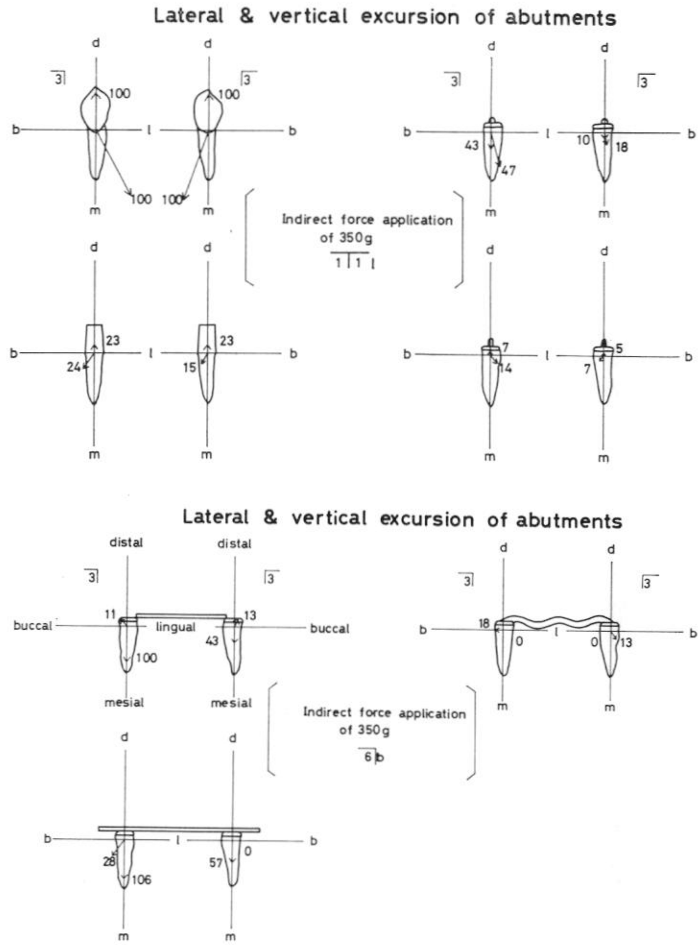

Fig. 10. Lateral and vertical excursion of abutments while a force is applied indirectly through a test denture. ($\overline{6}|$ l).

tally, the bracing part of the clasp pushes lateral force to the higher part of the clinical crown. (3) Each of the abutment is independent of the other, the abutment amplifies the amount of the lateral excursion to each other (Dolder, 1969[21)]). In this situation, the clasp retainer acts as a long-acting tooth forcep, when there are only few teeth in the mandible. From the view of the preservation of the abutment tooth, this type of retainer reveals great disadvantages.

It is said that retainers other than the clasp show a less lateral excursion of the abutments. This tendency holds good for every retainer. The results are summarized in Table 1.

2. *Occlusal loading*

The clasp retainer shows the largest lateral excursion. Then follows the rigid connector group; i.e. the telescopic crown, CONOD anchor and milling bar. Since there is no latitude of passing between the patrix and matrix, the functional load will directly affect the abutments. With the clasp, there is frequently more deviation in value obtained from the mean value of the lateral excursion of the abutments than

Table 1. Lateral excursion of abutments, while a constant force is applied. (350 g) Crown with wrought wire clasp is assumed as 100% in excursion.

Lateral excursion of abutments (Indirect force application of 350g)				
Retainers used	Site of force application $\overline{1\vert1}$ o	$\overline{6\vert}$ o	$\overline{1\vert1}$ l	$\overline{6\vert}$ b
Crown with wrought wire clasp	100	100	100	100
Conical telescopic crown (Konuskrone)	90	190	18	45
Stud attachment Bona 604	36	54	26	23
Stud attachment Conod anchor	41	203	9	23
Bar attachment (Ackermann type)	41	34	35	12
Bar attachment (distal extension use)	15	51	29	14
Milling bar (Gaerny)	66	50	21	11

value in percent

from the rigid connector group. With the clasp, the amount of the lateral excursion of the abutment varies in value from time to time. On the other hand, the rigid connector group shows mostly the same value, with reproducibility to some extent, in each of the retainer.

2–1–a. Indirect force application of the abutment is greater when the ratio of the clinical crown to the root length is in undesirable condition. Also, the value obtained is greater in the rigid connector group than in the articulatory connector. This is the effect of the relief space between the patrix and matrix of the attachment. Which is the more effective factor influencing the tooth mobility, the C-R ratio or the rigidity of connector? A telescopic crown and a CONOD anchor are compared, which have more or less the same rigidity. Fig. 7 apparently indicates the superiority of the C-R ratio.

In the rigid connector group, the value decreases in the order of the telescopic crown, milling bar and CONOD anchor. In this respect, the C-R ratio is more effective than splinting by the bar attachment. In the articulation group, two types of bar joint and BONA 604 show a lower value. Among them the distal extension type of bar joint attachment shows the least value.

2–1–b. Indirect force application to point $\overline{6\,|}\;0$

In the rigid connector group, the individual anchors, i.e. CONOD anchor and telescopic crown, show a higher value than the clasp retainer Fig. 8. This means that while the distal part of the prosthesis is loaded occlusally, the rigidity of the connection influences more effectively than the C-R ratio. Also with this rigid connector, the milling bar shows a lower value and the other two types of bar attachment have this tendency. The vertical excursion of the abutment appears as follows: the CONOD anchor and telescopic crown are floating, while the milling bar is sinking. This tendency means that the lateral force to the abutment is reduced markedly, when each abutment is joined by the bar attachment and this defletive lateral force is converted to the vertical excursion (intrusion effect, Böttger *et al.*[16]). A bar attachment in ordinary use showed the least amount of lateral excursion.

3. *Lateral loading of prosthesis* (*indirect force application*)

The clasp retainer shows the greatest value of lateral excursion of the abutments, when point $\overline{1\,|\,1}$ L and point $\overline{6\,|}$ B are loaded. The value obtained is a few to ten times greater than the other retainers. With the rigid connectors, i.e. the telescopic crown, CONOD anchor and milling bar, very little lateral excursion is seen, when the force is directed to the labial side of the interincisal point $\overline{1|1}$ L. In the bar attachment group, i.e. the milling bar and ordinary bar attachment, very little lateral excursion is seen, when the torquing force is applied to the abutments through the prosthesis. It is said that the rigid connectors, i.e. the CONOD anchor, telescopic crown and milling bar which have the same rigidity show different value when the various points of prosthesis are loaded. When the prosthesis has not enough strength against the functional load, the lateral excursion of the abutment differs in value between the individual anchor group, i.e. the CONOD anchor, telescopic crown and the primary splint group, i.e. the three types of bar attachment. The former is integrated through the prosthesis. In the experiment, this tendency is seen because of the insufficient strength of the prosthesis.

3–1–a. Indirect force application to point $\overline{1|1}$ L (labial)

With the clasp retainer, the value of the lateral excursion of the abutments is from three to ten times greater than with the other retainers. The retentive arm is loaded directly on the higher part of the clinical crown of the abutment. In this force application, the splinting effect of the abutments influences the reduction of the excursion more effectively than the rigidity of the connection. The value obtained reduces in the order of the clasp, bar attachment, BONA 604, milling bar, telescopic crown and CONOD anchor.

3–1–b. Indirect force application to point $\overline{6|}$ B

With the clasp retainer, the value of the lateral excursion of the abutments is from a few to ten times greater than with the other retainers. In this situation, the better the C-R ratio is and the more splinting through bar is done, the less the value is. The bar attachment group resists the force torquing the abutments more effectively than with the other retainers.

In comparison with the CONOD anchor and milling bar, which have almost the same rigid connection and which are also integrated by a prosthesis, the milling bar shows very little lateral excursion. When the BONA 604 and the round bar attachment are compared, there is also this tendency. This means the prosthesis must have sufficient strength against the load as the patrix part of the milling bar construction has, when all abutments are to be integrated through a prosthesis. Without sufficient strength, the first intention of the abutment integration is hard to obtain.

Conclusion

The lateral excursion of the abutments is discussed when the various points of the prosthesis are loaded. In actual chewing, the functional load on the abutments through a prosthesis is not so simple as in this experiment. But to some extent, the tendency of lateral excursion in this experiment may be approximately the same as what happens in the mouth. In this respect, the results obtained are evaluated as shown below:

(1) With the clasp retainer, the value of the lateral excursion is always great against every type of loading. Every time the abutments are loaded markedly by a prosthesis. A clasp retainer is simple and easy to make, so it is widely used in practice even today. But through this laboratory study, the prognosis is very poor in regard to the abutment tooth mobility. At least, when there are only few teeth in the mandible, the clasp retainer could be inadequate in regard to the preservation of the teeth.

(2) With the stud attachment and bar attachment, the value of the lateral excursion is less than half compared to the clasp. Among these, the splinting effect is shown markedly in the bar attachment, which shows the least value of lateral excursion of the abutments in this experiment.

(3) With the rigid connectors, i.e. the CONOD anchor, telescopic crown and milling bar, the lateral excursion is shown with reproducibility while the prosthesis is loaded. This happens so as to reduce and cancel the lateral excursion of the abutment.

ACKNOWLEDGEMENT

The author thanks Prof. Isamu Nakazawa for his constant interest, guidance and kind advice in this study. His thanks are also due to Dr. Makoto Matsumoto and Dr. Tadamasa Goto for their kind guidance and encouragement.

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