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MECHANICAL PRINCIPLES OF SUPERPLANTS

by

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Superplant is the name adopted by the author, for a type of fixed saddle rigidly connected to one or more abutments, frequently with one or more subperiosteal implants (Fig. 1). The technical details and the clinical, histological and radiological studies of superplants have previously been described (3, 4, 5, 6, 15, 16, 17, 18, 19).

In replacing lost teeth one of two alternatives may be used: either a removable or a fixed structure. The conventional type of fixed bridge is of limited value because it is dependent upon a minimum amount of remaining teeth and their positions in the dental arch. Superplants aim to further develop the fixed structure design (Figs. 1, 2, 3). The clinical experience is decisive in determining what can be achieved in any one case. In some cases one abutment may be sufficient to successfully use superplants. With one or few abutments remaining, however, in many cases a combination is needed, with one or more implants (Fig. 2). It has been found that superplants have an additional value in that they cause a minimum of damage to the root and the periodontal membrane.

The only two factors which the dentist controls are hygienic conditions and mechanical effect of the prosthesis. The basic principle in superplants, as in conventional bridges, is an absolutely rigid connection to the abutment. As is well known the

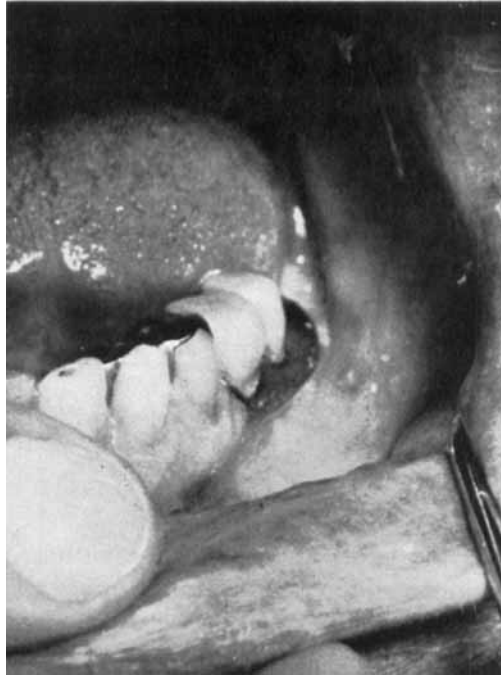


Fig. 1. Unilateral superplant with two premolar abutments and two molar saddle teeth.

discussion regarding the rigid and movable connections of tissue borne saddles is very heated. Some authors firmly believe in the rigid connection (1, 2, 7, 20, 22, 25) others in the movable (23, 24). To study these matters the author has made a theoretical and experimental analysis of the mechanical problems involved.



Fig. 2. Superplant including two intermediate and one free-end saddle combined with a subperiosteal implant. The implant shaped like a hook is separately made with the retentive part cemented in a little slot of the saddle.



Fig. 3. A lower superplant retained to one single cuspid, two distal and a buccal implant, visible below the right canine.

It is generally known from clinical experience that the transversal load, much more than the axial, causes an overload of a single tooth and the final destruction of the periodontal membrane. The cause of this destruction is obviously the transversal movements of the root. If therefore some dental structures cause larger transversal movements than others we are entitled to state that a design which causes larger movements of the abutments results in more destruction than one which causes smaller movements. It will also be concluded (see Fig. 12) that if a design reduces the transversal movements of an abutment to a lesser degree than that of a single tooth it means that the design has a supporting and rebuilding effect on the periodontal membrane.

The study of the transversal movements is therefore essential to understanding the mechanical destruction of the periodontal membrane. The movements have been studied by the author in four separate plastic models made in Epoxy (as explained in Fig. 4).

In discussions of traumatic load with different kinds of bridges and dentures only the axial load is usually considered ⁽²¹⁾. How-

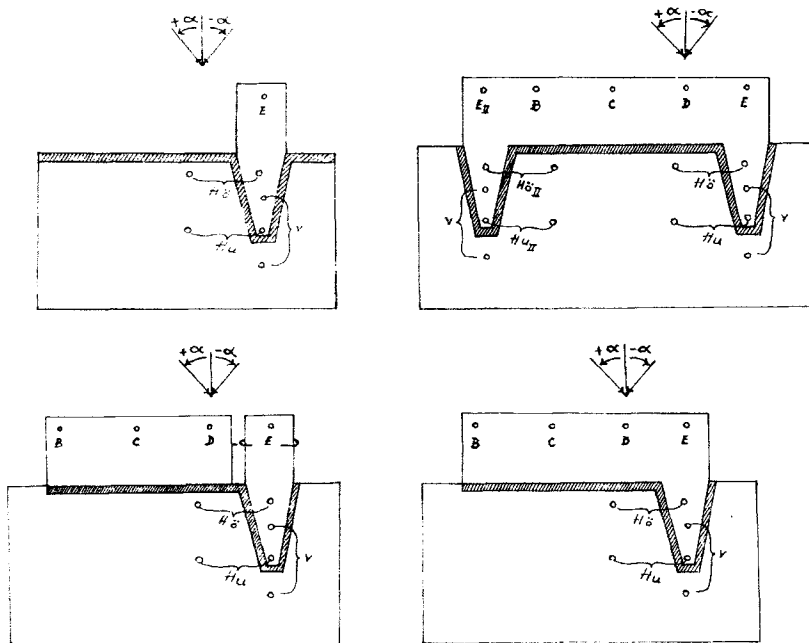


Fig. 4. Outline diagram of the four translucent Epoxy models referred to in the experiments. The model tooth (= E) and the saddle (= B C D) also made in Epoxy were separated and attached to the model base by a self-polymerized elastic rubber base giving a suitable elasticity between the model base, saddle and tooth simulating the actual conditions in the mouth.

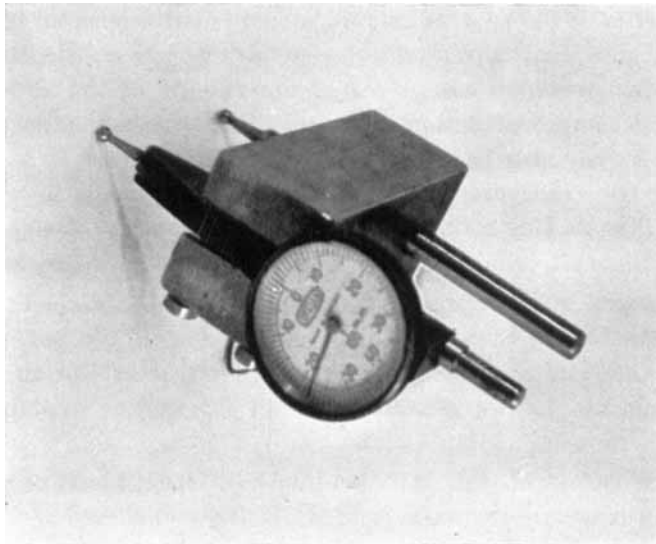


Fig. 5. The lateral extensometer used for measuring the movements of the model root.

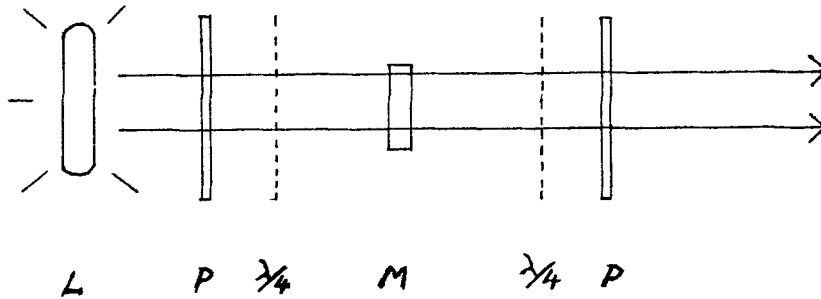


Fig. 6. Outline diagram of the arrangements in photographing the stress patterns. L = monochromatic (sodium) light, P = polarizer, $\lambda/4$ = quarter wave plate, M = Epoxy model. Quarter wave plates were used to get the isoclines (indicating the directions of the stress) separated from the isochromatics (indicating the intensity of the stress).

ever, since transversal loads also appear in the mouth, the load has been applied to the model tooth and saddle from different angles in the experimental studies by the author. In this experiment different movements between the base, the model root and the saddle, have been studied, and measured with a lateral extensometer with an accuracy of ± 0.01 mm. Fig. 5 shows the extensometer used. The shanks were placed in the indentations of the models visible in Fig. 4. Polarized monochromatic light was sent through the model according to the arrangements in Fig. 6. The model is placed between the polarizers and the quarter wave plates. The developed isochromatics are then photographed. Without discussing all the details or interpretations of such a photoelastic stress pattern it may be stated that the magnitude of the stress is proportional to the amount of dark fringes (isochromatics) on the white field which appears when the model is loaded (Fig. 7). For a complete understanding of the problems involved the reader is referred to the literature (8, 9).

The transversal movements of the single tooth as they appear in the model (Fig. 4: 1) are shown in Fig. 8. The center of the movements is located slightly above the apex. The corresponding photoelastic stress pattern is shown in Fig. 9. The center of the

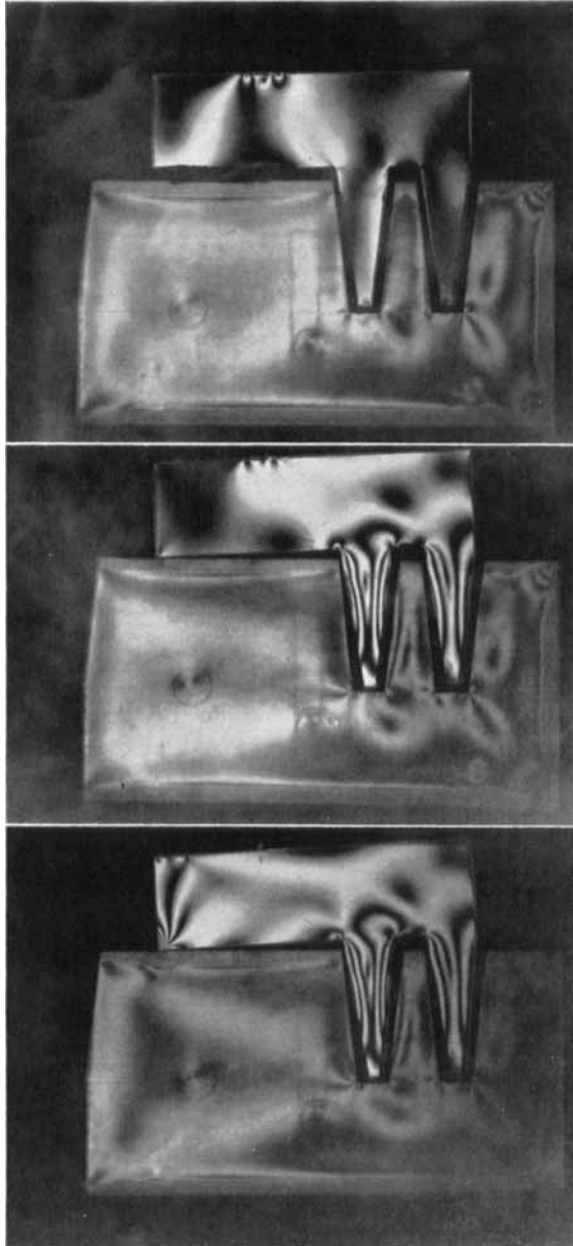


Fig. 7. Epoxy model with two abutments in polarized light. With no load on the saddle and therefore no stress the model appears dark. After application of the load white fields develop and with increased load also dark fringes (isochromatics) appear, their number indicating the intensity of stress.

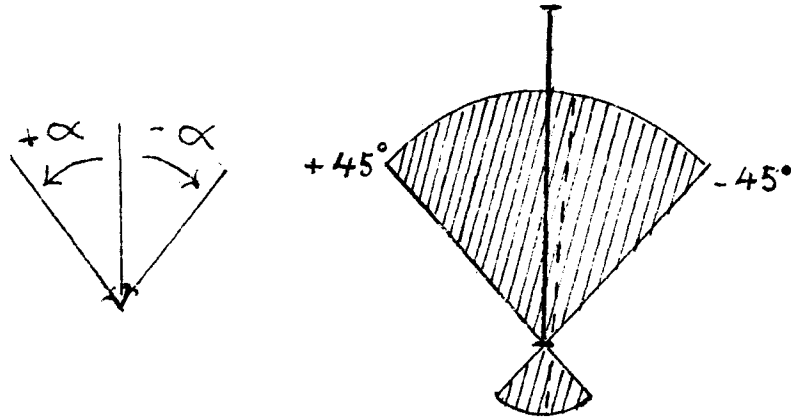


Fig. 8. Diagram of the movements of a single model tooth. The vertical black line indicates the original position of the tooth before load is applied. The dotted line shows the position of the root after application of the load. The shaded area indicates the extensions of the movements when transversal (horizontal) load was applied under different angles from $+45$ to -45 .

movements may, however, become displaced depending on the application of the load.

When two teeth or abutments are rigidly splinted (as is done by a conventional bridge; Fig. 4: 2) the stresses and the transversal movements are greatly reduced, as is shown in Figs. 10 and

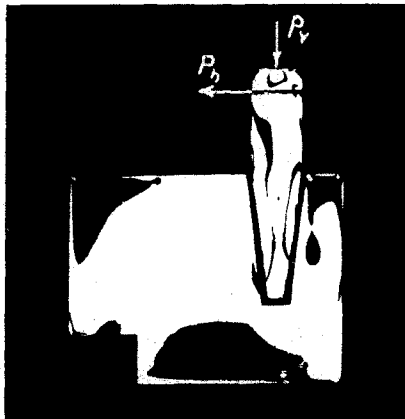


Fig. 9. Photoelastic stress pattern of a single tooth connected to the movements in Fig. 8.

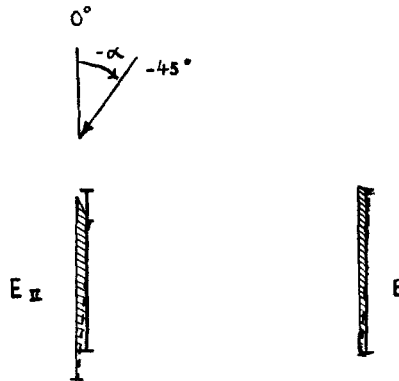


Fig. 10. The rigid splinting of two or more abutments reduces the transversal movements of the roots as compared with the single root in Fig. 8.

11. With the bridge in a single plane the splint acts only in this plane. When a single tooth abutment must be completely splinted, which is needed in case of periodontal disease, a transversal splint perpendicular to the first one is therefore required. The mechanics of the splints are likely to be fully understood by means of the author's experimental studies. The effect of the rigid and fixed anchorage has previously been confirmed by the extensive clinical studies of *Hildebrand* (12, 13). His results coin-

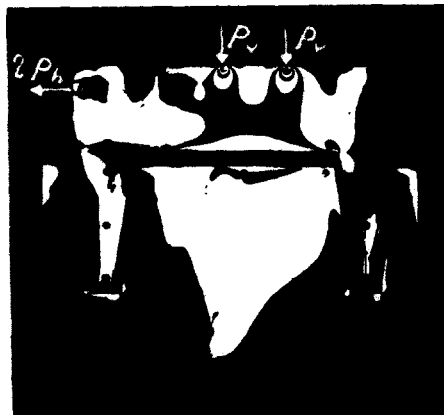


Fig. 11. Stress pattern of the model along with the movements of the roots in Fig. 10.

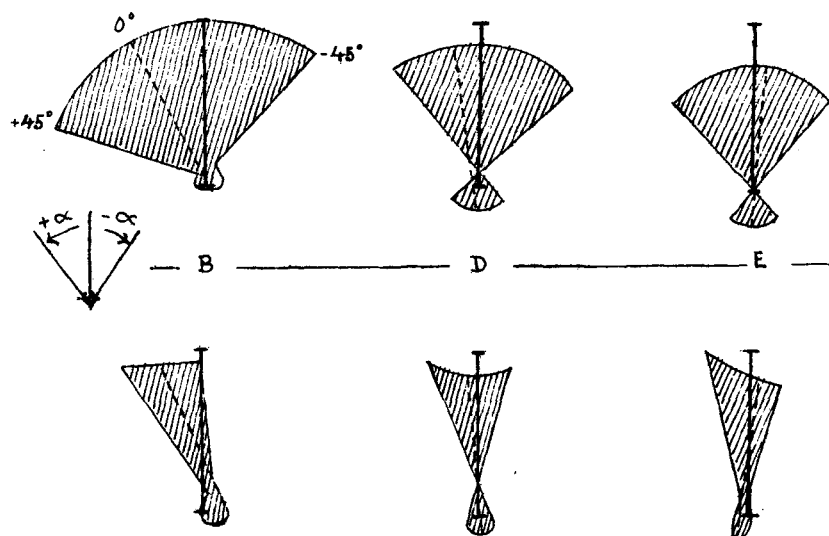


Fig. 12. Diagram of the movements of the root attached to a movable saddle (upper row) and a superplant (lower row) according to the arrangements in Fig. 4. The superplant reduces the transversal movements of the root as compared with the single tooth in Fig. 8, but the movably attached saddle increases the movements as compared with the single root.

side entirely with the experimental studies made by the present author.

Clinically it has been found that the superplants have a greater splinting effect on the abutments than that of a removable bridge or denture. An experimental study of the transversal movements of removable dentures and superplants has been done comparing and contrasting movable anchorage and superplants (see outline diagrams in Fig. 4:3 and 4:4). The movements of the root under different loads is shown in Fig. 12. For simplicity and clarity a single abutment was used in the experiments. However, the results will, as a matter of principle, be the same with many abutments. The same load is used in all the experiments, but it has been applied at different points and at different angles: namely on the outer end of the saddle = B, the inner end = D and the tooth itself = E. The movements of the root were then measured. The stresses, as disclosed optically, are shown in Fig. 13.

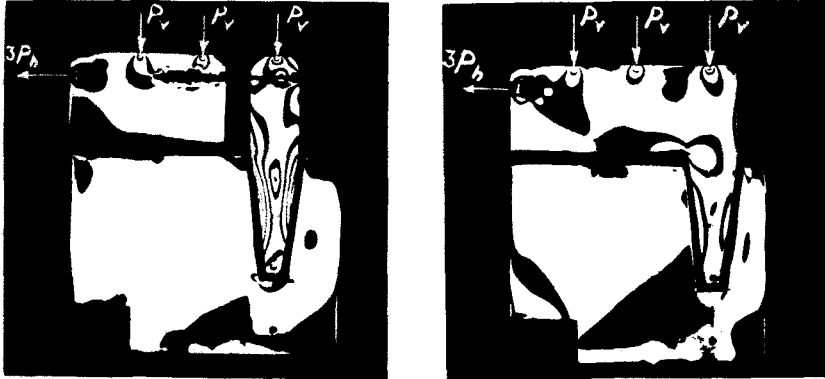


Fig. 13. The optical stress pattern developed with the arrangements in Fig. 12. More stress is induced in the root with a movable saddle (left) than with a superplant (right).

It is obvious from the experiment that the transversal movements of the root connected to superplants are less extensive than those connected to a removably and movably anchored prosthesis. The splinting effect, observed clinically, is explained by this experiment. It can also be seen from the diagram that

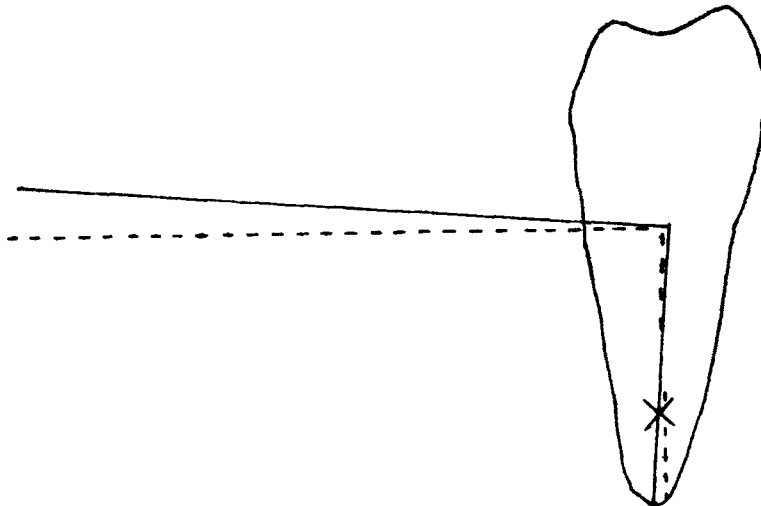


Fig. 14. Outline diagram of the movements of a root rigidly anchored to a saddle. The movements of the saddle are greatly reduced in the root.



Fig. 15. Stress pattern of a movable saddle (left) and a rigid saddle (right) when a heavy vertical load is applied on the outer end of the saddle resulting in extensive movements. In such cases the movements of the root often cannot be kept within physiologic limits. The rigid anchorage causes greater stress and movements. However, such large movements are not found in superplants (Fig. 12 and 13).

surperplants like conventional bridges are even able to reduce the movements as compared to a single tooth (see Fig. 12).

In literature the axial load is usually blamed for the destruction of the abutments in connection with free-end saddles; stressbreakers are therefore recommended. Such a statement is neither confirmed by the clinical findings with superplants nor by the author's experimental studies. A theoretical calculation also indicates that the movements in the outer end of the saddle, resulting from an axial load, are greatly reduced in the root and periodontal membrane (Fig. 14). This will also hold true for a torsional movement of the saddle and the root. With a very heavy load and extensive movements at the outer end of the saddle, however, a stressbreaker is justified, as is seen in Fig. 15. In addition, such a heavy axial load easily causes a sliding effect resulting in transversal movements which are much more dangerous than those caused by the primary axial load. Such extensive movements of the saddles, however, are not found in superplants because superplants are firmly adapted to the tissues. Since the soft tissues must therefore be as thin as possible, they

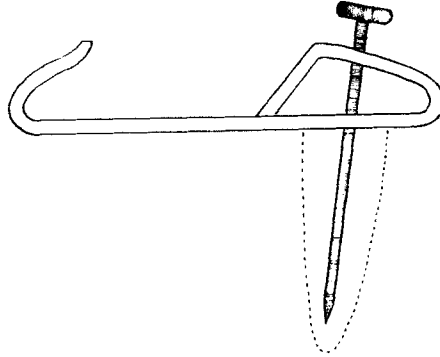


Fig. 16. The mechanics of a superplant and picture hanger (x-hook) are similar.

must usually be surgically adjusted. As long as the transversal movements of the root do not exceed the limits of the physiological movements, they will not injure the periodontal membrane.

The mechanics of the superplants can in principle be compared with the mechanics of a picture hanger. Just as the root is rigidly anchored in the superplant, the nail of the picture hanger is rigidly anchored in its frame increasing the strength (see Fig. 16). The harder the base (in the case of the picture hanger — the wall), the less the transversal loosening movements on the nail. Similarly with a superplant: the firmer the base, *i.e.* the

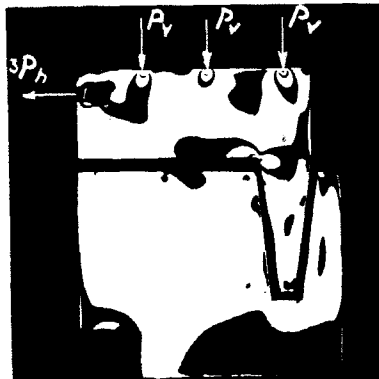


Fig. 17. Stress pattern of superplant with a harder base (hydrocal) as compared with rubber base used in Fig. 13. The harder the base under the saddle, the less the stress and movements of the root.

bone and the mucosa, the less the transversal movement, resulting in less stress and strain on the periodontal membrane (Fig. 17).

DISCUSSION AND CONCLUSIONS

From the technical point of view dental prosthetics has made rapid progress and reached a high degree of perfection. However, the science of evaluating the effect of different prosthetic designs, particularly on remaining teeth and abutments, has not advanced as quickly. 25 years ago a pioneering work was made by *Hildebrand* (12, 13).

He found that from a biomechanical point of view the fixed bridges have a distinct advantage as compared with removable prostheses. However, his findings have been slowly accepted. Basically, *Hildebrand* concluded that fixed bridges act as abutment savers and movable prostheses act as abutment destroyers (Fig. 18).

The clinical application of his principle has, however, a certain limitation. To make a fixed bridge of the conventional type a minimum number of remaining teeth used as abutments is necessary. With superplants, though, it is possible to make fixed structures even in cases with only a few remaining teeth. The author's 10 years of clinical experience with superplants has proven their supporting effect on the remaining teeth (Fig. 19). *Hildebrand* had similar experience with fixed saddles. He has treated about 30 cases, which are registered and will be published (14).

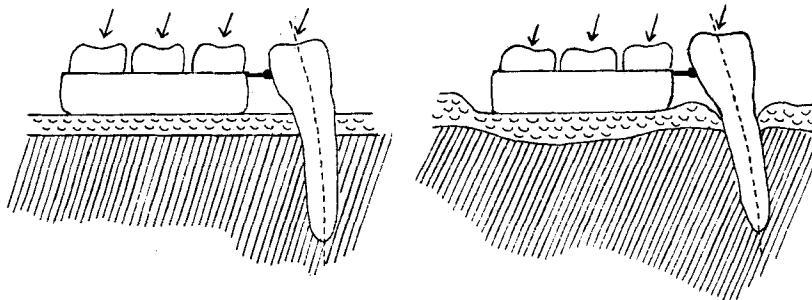


Fig. 18. Movable saddle causes larger movements (left) resulting in resorption of the base, *i. e.* bone under the saddle and finally loss of the root (right).

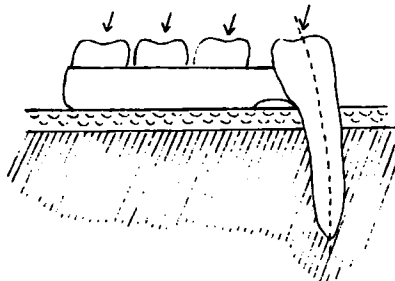


Fig. 19. Superplant acts as an abutment saver with no resorption of the underlying tissues.

A fixed prosthesis yields better chewing efficiency. Possibly the most important advantage, however, is the psychological effect. It has been shown that in many cases removable dentures are not tolerated. (10, 11).

The general mechanics of the superplants are shown in the experiments: it is evident that the fixed saddle must be rigidly connected to cause the least destruction on the abutments. In favorable cases even a splinting similar to that found in fixed bridges can be expected.

The principles of the attachment of the superplant and a picture hanger are very similar. A picture hanger is a simple nail with increased strength due to its rigid attachment. The superplant functions in a similar way. The superplant does not loosen the abutment as does a removable prosthesis, but supports it.

This supporting effect, due to the rigid anchorage, has not been easily observed clinically. According to the author the reason for this is that in removable bridges and dentures the rigid anchorage is not completely rigid. Therefore, the favorable effect of the absolutely rigid anchorage has failed to appear.

Acknowledgements

The author wishes to acknowledge indebtedness to Professor *G. Y. Hildebrand*, the Royal Dental School, Stockholm, and Professor *H. Hallendorff*, the Royal Institute of Technology, Stockholm for their counsel and suggestions and to Docent *R. Hill-*

scher and Teknologie Licentiat *L. Nelson* for their invaluable guidance and technical assistance.

DISCUSSION ET CONCLUSIONS

PRINCIPES MÉCANIQUES DES "SUPERPLANTS"

Du point de vue technique, la prothèse dentaire a fait de rapides progrès et a atteint un degré élevé de perfection. Mais la science concernant l'évaluation des effets que les différents types de prothèse ont, en particulier sur les dents restantes et sur les ancrages, n'a pas avancé aussi rapidement. *Hildebrand* (12, 13) fit, il y a 25 ans, un travail de pionnier. Il constata que, du point de vue biomécanique, les bridges inamovibles présentaient un avantage net sur les prothèses amovibles. Cependant ses conclusions n'ont été acceptées que lentement. La conclusion fondamentale d'*Hildebrand* était que les bridges inamovibles se comportent comme des agents de protection des piliers, tandis que les prothèses amovibles se comportent comme des agents de destruction des piliers. (Fig. 18).

Il y a cependant une certaine limite à l'application clinique de son principe. Pour faire un bridge fixe du type conventionnel, il est nécessaire d'avoir un nombre minimum de dents restantes à utiliser comme piliers. Avec les "superplants" cependant, il est possible de faire des constructions fixes même dans les cas où il n'existe que quelques dents restantes. L'expérience clinique de l'auteur en ce qui concerne les "superplants", s'étendant sur 10 ans, a démontré leur action comme agents de protection sur les dents restantes (Fig. 19), *Hildebrand* a fait la même observation avec les selles fixes. Il a traité environ 30 cas dont il existe un rapport et qui seront publiés (14).

Une prothèse fixe assure une mastication plus efficace. Mais de plus grand avantage est peut-être l'effet psychologique. Il a été démontré que dans de nombreux cas les prothèses amovibles ne sont pas tolérées (10, 11).

Les principes mécaniques généraux des "superplants" sont mis en évidence dans les expériences: il est évident que la liaison de la selle fixe doit être rigide afin de réduire au maximum

l'action destructrice sur les piliers. Dans les cas favorables, on peut même espérer un effet de contention semblable à celui observé dans les bridges fixes.

Le principe de l'ancrage du "superplant" est très analogue à celui d'un "crochet X": celui-ci est un simple clou dont la résistance est augmentée grâce à la rigidité de l'ancrage. Le "superplant" fonctionne d'une manière similaire. Le "superplant" ne mobilise pas le pilier comme une prothèse amovible, au contraire il le soutient.

L'action de soutien, due à l'ancrage rigide, n'a pas été facile à observer en clinique. D'après l'auteur, la raison en est que, dans les prothèses et bridges amovibles, l'ancrage rigide n'est pas complètement rigide. C'est pourquoi l'effet favorable de la rigidité absolue de l'ancrage a fait défaut.

ZUSAMMENFASSUNG

MECHANISCHE GRUNDSÄTZE DES SUPERPLANTATES

Vom technischen Gesichtspunkt aus hat die prothetische Zahnheilkunde grosse Fortschritte gemacht und einen hohen Vollendungsgrad erreicht. Die Wissenschaft, verschiedene prothetische Konstruktionen zu beurteilen, besonders ihre Wirkungen auf dem Restgebiss, hat aber nicht denselben Fortschritt gemacht. Vor 25 Jahren hat Hildebrand eine Pionierarbeit geleistet. Er fand, dass die festen Brücken vom biomechanischen Gesichtspunkt aus bestimmte Vorteile im Verhältnis zu den abnehmbaren Konstruktionen haben. Eine Beurteilung seiner Entdeckung ist aber noch nicht ganz erfolgt. Allgemein hat Hildebrand bewiesen, dass feste Brücken als "Pfeilerzähne-Retter" und eine abnehmbare prothetische Konstruktion als "Pfeilerzähne-Zerstörer" wirken.

Die klinische Anwendung dieses Grundsatzes ist jedoch begrenzt. Für die konventionelle feste Brücke ist eine Mindestanzahl von Zähnen erforderlich. Mit Superplantaten kann man feste Konstruktionen machen, auch wenn nur wenige Zähne da sind. Die zehnjährige Erfahrung des Verfassers mit Superplantaten hat die stützende Wirkung auf die Pfeilerzähne bewiesen. Hildebrand hat ähnliche Erfahrungen mit festen Sattelbrücken gemacht. Er hat 30 Fälle behandelt, die registriert sind und veröffentlicht werden sollen.

Eine feste Konstruktion leistet besseres Kauen: wahrscheinlich ist der grösste Vorteil jedoch die psychologische Wirkung. Es ist bewiesen, dass in vielen Fällen abnehmbare Prothesen nicht geduldet werden.

Die wesentliche Mechanik der Superplantate ist durch Experimente bestätigt worden: es ist offenbar, dass der prothetische Sattel für die geringste Zerstörung starr mit den Pfeilerzähnen vereinigt werden muss. In günstigen Fällen kann mit einer Fixierung wie mit konventionellen festen Brücken gerechnet werden.

Die mechanischen Grundsätze des Superplantates und eines X-Hakens sind sehr ähnlich. Ein X-Haken ist ein einfacher Nagel mit gesteigerter Stärke, durch die starre Befestigung bedingt. Das Superplantat wirkt auf dieselbe Weise. Das Superplantat bewirkt keine Lockerung der Pfeilerzähne, wie die abnehmbare Prothese, sondern eine Fixierung.

Diese stützende Wirkung, durch die starre Verbindung bedingt, war früher nicht leicht zu entdecken. Die Ursache dafür ist, laut Verfasser, dass mit abnehmbaren Brücken und Prothesen die starre Verbindung nicht vollständig starr ist. Aus diesem Grunde ist die günstige Wirkung der starren Verbindung nicht immer sichtbar.

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