THE PROSTHETIC PROBLEM—ITS FORMULATION AND SUGGESTIONS FOR ITS SOLUTION

M. M. DeVan, D.D.S.*


IT IS A LONG WAY FROM the first perception of the nature of a problem to its clear formulation. It is another long way from there to its solution.

While this article may be said to contain meager information concerning the solution of the prosthetic problem, its chief merit is the information it contains leading to a clearer formulation of the nature of the problem. This clearer formulation is possible because of the science of our times. Science has found new tools to formulate and better to solve prosthetic problems which in the past were mainly subjects of conjecture.

NATURE OF THE PROBLEM

Let us first give our attention to the formulation of the prosthetic problem. This problem is to provide a patient with a substitute for his dentition, where the mucoperiosteum has replaced the periodontal membrane as the attaching medium (Fig. 1).

The prosthetic problem revolves about this basic fact—that, willy-nilly, the substitute dentition (dentures) must be related to the underlying bone through the mucoperiosteum and not through the periodontal membrane as the natural dentition is related; and any formulation of the denture problem that does not begin with this essential difference, between the natural and the artificial teeth, is illogical and misleading.

MODERN TRENDS SENSING THE PROBLEM

Three modern trends tend to support the statement that the nature of the prosthetic problem has long been sensed, even though it has not been clearly formulated.

These trends are: (1) Resorting to complete mouth rehabilitation by means of fixed partial dentures. By so doing, the mucoperiosteum is by-passed as the attaching apparatus, the missing teeth are replaced by substitutes soldered to the remaining natural teeth which are attached to the enveloping bone by means of the periodontal membrane. (2) Resorting to implant dentures. Where all

*Chairman of Prosthetic Dentistry, Graduate School of Medicine.
the natural teeth and their periodontal membranes are missing, an attempt is made to by-pass the mucoperiosteum as the attaching apparatus by placing the implant next to the underlying bone. Implants have possibilities in the prosthetic field and only time will tell if they will continue to remain functional and acceptable.

(3) Resorting to modified tooth factors. Most present-day complete dentures have one or more deviations from the anatomic tooth factors such as: (a) having a contact clearance between the upper and lower anterior teeth; (b) leaving the second molars out of occlusion; (c) using cuspless teeth. All of these measures tend to show that there is a sensing of the need for compromise where the mucoperiosteum instead of the periodontal membrane is used for the attachment of teeth.

SUPPORT OF THE PROBLEM AS PROPOSED

Our problem is this: How to build a substitute for a dentition that will continue to function on osseous tissue where the associated connecting tissue membrane is the mucosa instead of the periodontal membrane.

Before advancing suggestions for the solution of the problem, the nature of the problem needs further support and justification. The nature of the prosthetic problem cannot be understood unless the nature of the hard and soft tissues, composing the foundation of a dentition, is understood.

THE ROLE OF CONNECTIVE TISSUE

Certain characteristics of connective tissue must be clearly perceived for comprehension: (1) Connective tissue is the connecting medium between the teeth (both natural and artificial) and the underlying bone. We cannot attach to bone directly but only through connective tissue of some sort. (2) Connective tissues vary in thickness, rigidity, area, and site of attachment. A cognizance of these differences is of extreme importance in perception and formulation of the nature of the problem. (3) Connective tissue possesses the property of elasticity—that is, it has the capacity to bounce back to its rest form, when the displacing force is removed. Displaced connective tissue is energized tissue. The moment the displacing force is removed, sufficient hydrostatic force is available to bring it back
to rest position. (4) In composition, connective tissue contains over 80 per cent of what clouds and rivers are made of, namely, water. The laws of hydrostatics partially apply under these circumstances, wherein force is transmitted undiminished as equal pressure acting in all directions.

**MATHEMATICAL SUPPORT**

The following facts have been gleaned from Synge's significant and brilliant mathematical analysis as condensed and edited by Gabel. (1) Connective tissue membranes associated with teeth manifest a greater resistance to axial or vertical loads than to transverse or horizontal loads. Synge's mathematical calculations reveal a difference of 61 to 1 in favor of axial loads. He assumed that the periodontal membrane had the same rigidity as rubber (230 pounds per square inch). Synge and Dyment using the periodontal membrane of lambs and young calves came up with a differential of 17.5 to 1 in favor of axial loads. These figures make one point clear—if we would avoid unduly displacing an oral connective tissue membrane, it would be wise to plan the tooth factors in such a way as to direct the force essentially axial to the natural tooth and essentially perpendicular to the ridge. (2) When a connective tissue membrane is interposed between two relatively rigid bodies (teeth and bone), any increase in thickness will result in increasing the factor of displaceability by the cube of the increase in thickness. (3) When a connective tissue membrane is interposed between two relatively rigid bodies (teeth and bone), any decrease in rigidity will result in a corresponding increase in the factor of displaceability. Only in the light of the above facts can we realistically appraise the task of stabilizing a substitute for a dentition that must perforce function with the mucoperiosteum interposed between the bone and the teeth.

If we arbitrarily assumed a difference of 5 to 1 in thickness and 1 to 2 in rigidity, the mucoperiosteum could be displaced by 1/250th part of a force that could displace the periodontal membrane.

The above statement is really an understatement, and even at that the difference is enormous. If we are to stabilize the complete denture to anywhere near the degree that the natural dentition is stabilized, we must plan the employment of tooth factors that differ markedly from the tooth factors associated with the natural dentition.

**CHARACTERISTICS OF BONE**

Likewise, certain characteristics of bone must be clearly perceived for comprehension of the nature of the prosthetic problem. (1) Bones form the framework of the body providing both attachment and support to the soft tissues. Bones serve as the passive levers for the exercise of muscular action. Bones support the weight of the body. (2) Essentially there are two types of bone: cancellous and compact. (3) The conversion of the original mass of cancellous bone into compact bone is the result of tensile and shear forces. (4) Cancellous bone is adequate to counteract compressive stresses (the type of stress that requires support). Compact bone is required to counteract tensile stress (the type of stress...
required to resist muscle pull). Compact bone arranged in a tubular form is required where resistance must be provided for compressive, tensile, and shear stresses combined. This combination of stresses must be resisted when the same bone must provide support to the weight of the body above it and attachment to the muscles around it. (5) Bone is essentially passive—it reacts but does not act of its own accord. It responds to force but does not initiate force. Thus, if bone is breaking down, the prudent will first look to the forces acting upon it. (6) Much of the bone of the alveolar process is essentially cancellous. Along with the connective tissue upon it or around it, and the bone underneath it, the bone of the alveolar process constitutes the immediate foundation of a dentition or a denture. (7) The alveolar process develops with the teeth but it need not necessarily go with the teeth. This bone remains when the natural teeth are lost and can support the artificial teeth. Its widespread disappearance is due to: (a) unwise surgical procedures during the removal of the natural teeth, (b) disuse or abuse atrophy or both.

RELATION OF BONE TO CONNECTIVE TISSUE MEMBRANES

While bone provides attachment and support to the soft tissue organs of the body, it cannot play its role without an associated connective tissue membrane. For without periosteum around bones, without articular cartilage about the articular surfaces of bones (except those that unite at sutures), without the periodontal membrane about alveolar bone, without the mucoperiosteum upon compact or cortical bone, osseous tissue could not function.

When bone remains exposed after surgery we are concerned; bone may be said to be “an undercover agent.” A connective tissue membrane is always present at the site of an attachment to a bone. The nature of the associated connective tissue membrane is important in finding out the kind of stress sustained by a given bone. If the connective tissue is articular cartilage as it is around the heads of long bones, then the type of stress sustained by the bone is compression. If the connective tissue is periosteum with Sharpey’s fibers, the type of stress sustained is tension.

If the connective tissue is tendinous, the type of stress is shear and tension. If the connective tissue is mixed—cartilage, tendon, periosteum, then the stress is mixed—compression, tension, and shear. Mixed stresses are sustained by long bones that help to support the weight of the body as well as to provide attachment for muscle tissue. The long bones illustrate clearly the different kinds of bone and the various types of stresses sustained by each. The cancellous bone found in their heads sustains compression primarily. The compact bone in tubular form comprising the shaft sustains a mixed stress of compression, tension, and shear.

ANALYSIS OF STRESS COUNTERACTION

It appears that the architectural pattern of bone is determined by the type of stress sustained. If the stress is compressive merely (when it supports solely), the bone is cancellous in structure. If the stress is tensile, the bone is compact in structure. If the stress is mixed, compressive, tensile, and shear, the bone is compact in tubular form.
The design of prosthetic appliances should be determined by the structure of the edentulous mouth. The design should not be planned on the basis of the structure that existed when the patient possessed his natural teeth with their enveloping periodontal membrane and alveolar housing (Figs. 2 and 3).

Fig. 2.

Fig. 2.—A maxillary basal seat eighteen months after the removal of all natural teeth. The program of stabilization begins with the removal of the teeth wherein attempts are made to salvage as much of the external cortical plates of bone as surgical circumstances will allow. The broad tabular tortuous ridge on the right will better stabilize the denture than the ridge form on the left.

Fig. 3.—A maxillary basal seat possessing a favorable form for developing retention of a complete denture. However, its narrow round nontortuous ridge form is inferior to that in Fig. 2 in developing stability.
Many dentures are built with the idea of restoring lost function without taking into consideration the fact that there has been an irretrievable loss of structure as well. Function should be predicated on existing form rather than on past structure. Function will not be adequate unless the existing structure is adequate. For continued comfortable mastication, structure is needed to stabilize either the dentition or the denture (Figs. 4 and 5).

Fig. 4.—A maxillary basal seat sixteen years after the removal of the posterior teeth. Note the broad tubular tortuous ridge forms. A partial explanation for this result is that through the use of the neurocentric occlusion concept, the maxillary denture possessed a marked degree of stability.

Fig. 5.—This maxillary basal seat is favorable for retention, but not for stability on account of its narrow round smooth structure. The consistency of the anterior part of the ridge is flabby, further decreasing the degree of stability attainable.
Artificial dentures are backed up by less bone than the natural dentitions. A fact of greater significance than diminution of bulk is that what remains to support the artificial denture must be employed through a connective tissue membrane that is thick, not rigid, and placed parallel to the surface of the denture. In contrast, the periodontal membrane attaching a natural tooth is thin, rigid, and the site of its attachment is within the body of the bony mass (Figs. 6 and 7).

Fig. 6.

Fig. 6.—A maxillary basal seat seven years after the removal of the teeth. A relatively stable denture was worn. Note the broad tabular tortuous ridge form. The program of preserving the external cortical bone was eminently successful in this case as is shown by the position of the incisive papilla in relation to the anterior ridge.

Fig. 7.—A maxillary basal seat wherein resorption of the bone of the residual ridge is complete in the anterior region. This result is not the inevitable consequence of the use of an artificial denture. It is partially due to a failure to stabilize the denture.
PERIODONTAL MEMBRANE

The loss of the periodontal membrane is indeed an important loss of structure. This membrane is unique among connective tissue membranes. Unlike other membranes, it must provide both support and attachment for the natural teeth. The teeth must be attached to the bone to prevent the force of gravity and the pull of adhesive foods from dislodging them. The teeth must also be supported against undue displacement during mastication. The lamina dura lining the housing of a tooth provides the site of attachment for the periodontal membrane. The lamina dura is compact bone, for attachment requires that type of bone, because of the mixed stresses involved. The enveloping bone around the lamina dura is cancellous, for its function is to support the tooth during mastication, and support requires the counteraction of compressive stresses solely.

THE SUBSTITUTE FOR THE DENTITION

Our problem then is to build a substitute for the dentition that will be relatively stable in spite of the fact that the mucoperiosteum is interposed between the teeth and the bone. Therefore, in the construction of dentures, it is important to take into account the difference between the mucoperiosteum and the periodontal membrane—their differences in thickness, rigidity, and site of attachment.

Excluding the relatively thin layer of stratified squamous epithelium, the mucoperiosteum is essentially composed of connective tissue containing some mucous glands.

MEANS OF SECURING STABILITY

This discussion will now center on ways and means of stabilizing a denture that must be attached to the mucoperiosteum. The attachment is by means of the forces of interfacial surface tension, adhesion, and atmospheric pressure.

A popular approach in prosthetic dentistry is to secure maximum possible attachment of the denture to the mucosa and thus secure the maximum of retention. By this scheme, the denture is not dislodged even though it is incessantly displaced during mastication. And the tragedy of this strategy is that it works—at least for the time being. There is more than ample time to satisfy the patient and to collect the fee involved. The breakdown usually comes later on. We say usually, for there is the exceptional case (roughly 1 out of 20) where there is no breakdown in spite of such abuse. In such cases stamina makes up for lost structure.

A PARTIAL SOLUTION TO THE PROBLEM

Keeping in mind the existing foundational circumstances as revealed by this discussion, we are now ready to propose at least a partial solution to the prosthetic problem. The solution lies in employing every possible means of stabilizing the denture and not being satisfied by merely developing sufficient retention.

RETENTION AND STABILITY DEFINED

The terms retention and stability need clarification. Retention refers to attachment; it is a relationship between the mucosa and the denture. As long as the denture does not lose its grip upon the mucosa, retention is sufficient. Stability
refers to stillness—lack of movement, during the use of the denture. Stability is a relationship between the bone and the denture. As long as positional relationships are maintained, stability is maintained. The reason why the factor of stability is often ignored is that dentures can function without being stabilized. The reason why retention is not ignored is that dentures cannot function unless they possess sufficient retention to prevent dislodgment. Ever since the Green brothers demonstrated, with the use of modeling compound, the remarkable degree of retention that could be secured with post-damming and maximum extension of flanges of dentures, we have been overboard with retention. Retention permits us to ignore stability for the time being, and to get away with it. This is possible, in part, because patients are unconsciously selecting foods on the basis of the stability of their dentures. A denture may be relatively stable with one type of food and unstable with another type of food.

A CASE HISTORY

A patient (77 years of age) had been struggling with unstable dentures for thirty years until resorption had reached such a point that new dentures required two units of denture base material for the lower, and a unit and a half for the upper denture. For the past seven years the patient has been wearing relatively stabilized dentures with comfort. A chance statement by him gave me the clue as to the reason why his present dentures were comfortable. "When I was a young man," he said, "I was very fond of steak, but now I can't bear the sight of it; probably because it reminds me of all the pain I suffered when I persisted in trying to chew it with artificial dentures."

There is little doubt in my mind that in the absence of systemic factors, the failure to stabilize is the local factor most responsible for the loss of alveolar bone and its sequel—dentures that do not function comfortably. The end result is the use of softer foods, rebasing or remaking of the dentures.

STEPS IN STABILIZATION

How do we go about stabilizing a denture? First, the mucoperiosteum in its rest form should be registered in the impression. This requires the use of impression materials like the hydrocolloids and the softer of the zinc oxide eugenol pastes—materials that will be displaced by the softest tissues in the mouth. In turn, the mouth tissues will not be displaced by them. Second, the palatal portion of the denture should simulate the natural palate in form but not necessarily in size, the artificial palate being generally smaller in size because of padding of the palatal vault. Third, the tooth factors employed should deviate from the natural tooth factors whenever such deviation enhances stability. It is not within the purpose or scope of this article to discuss tooth factors in detail. However, some comment needs to be made for the purposes of clarity. The tooth factors are: (1) position, (2) proportion, (3) pitch, (4) form, and (5) number.
There should be no hesitancy in changing the position of the posterior teeth where such repositioning will result in a greater degree of centralization of occlusal forces. Wherever possible the position of artificial teeth should satisfy the laws of statics by placing the teeth within and at right angles to support.

**Proportion**

The proportion or size of the occluding surfaces of the posterior teeth should be reduced. The occlusal reduction of the substitute teeth should represent roughly 40 per cent from that of the natural teeth. By this reduction, speed of mastication is exchanged for reduced pressure. Each masticatory stroke results in less work, resulting in less pressure on the ridges.

**Pitch**

The pitch or inclination of the posterior teeth should be made parallel to the plane of the underlying residual ridge. By paralleling the occlusal plane to the osseous base plane, the direction of the masticatory force is rendered more nearly perpendicular to the mean osseous plane. This approach involves the abandonment of the use of a compensating curve or the use of a functioning vertical overlap.

**Form**

The form of the posterior teeth should be devoid of inclines. This does not imply the use of flat teeth, but it does demand that all cutting edges be on a single plane. The absence of inclines will avoid deflecting the essentially vertical forces of mastication horizontally. As a consequence, masticatory forces are kept more nearly within, and at right angles to the supporting bone.

**Number**

The number of the posterior teeth may be reduced from four to three in each sector. A reduction in number helps to reduce the magnitude of the force. It also helps to centralize the points of application of masticatory forces.

**Conclusion**

This article is a plea for stabilizing dentures, that is, minimizing their movement in function. It attempts to show that retention as the sole goal in prosthetic dentistry is not enough. The fact that adequate retention has been achieved will not necessarily mean that the use of the denture will continue to remain comfortable and efficient. Nor will it imply the preservation of the remaining underlying bone. The natural tooth factors, of position, proportion, pitch, form, and number should be modified so as (a) to reduce the magnitude of masticatory forces, (b) to centralize these forces better, (c) to direct these forces more nearly perpendicular to the mean plane of the osseous foundation.

The prosthetic problem arises from the fact that the mucoperiosteum has been substituted for the periodontal membrane. The difference in thickness, rigidity,
and site of attachment between these two connecting tissue membranes makes necessary marked deviation from the anatomic tooth factors—this is in order to confer to the denture a measure of the stability that characterizes the natural dentition.

REFERENCES