The Mechanism of Adjustment to Wear and Accident in the Dentition and Periodontium*

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INTRODUCTION

This discussion will be an attempt to give the reader one aspect of a dynamic or functional concept of the oral mechanism. The dental student in his educational background is exposed to the anatomists' description of the teeth and jaws, the histologists' story of their microscopic form and the prosthodontists' concept of the functional forces of occlusion based upon artificial dentures. Where in the dental curriculum is the functional aspect of the natural dentition presented? Where is it correlated with the basic background provided by the anatomists and histologists? A logical place for the presentation of this material seems to be in the undergraduate orthodontic course.

Tooth morphology is usually taught as a pure memory course with the student being required to carve the various teeth by blindly copying models or pictures in texts. If the possible significance of tooth form was stressed along with a functional concept of the denture, the material would be retained longer by the student, and would be more apt to be put to practical use in his clinical years.

The complexity of the dental mechanism dictates that any dynamic analysis of occlusion must be based upon as many facts as it is possible to gather and correlate. Part of the discussion to follow may be labeled teleological by some; however, even this can be justified if it helps to build in the student's mind a functional concept of occlusion.

MECHANISM OF ADJUSTMENT

All forms of life must have some mechanism of adjustment to wear and accident. Without such a mechanism it would be impossible to prolong life for a very long period of time. Examples of these mechanisms are so obvious in the human that it is not necessary to review them here. When the dentition is considered, however, it is not so easy to analyze the repair mechanism. It is quite obvious, for example, that the enamel does not have the ability to replace itself. How then is the loss of tooth structure through wear compensated for in maintaining a normally functioning denture?

Teeth may be classified according to their various mechanisms of adjustment. There is a perpetual succession of teeth in the fish, reptile and in certain mammals such as the elephant. In these animals as a tooth is lost, due either to an accident or being worn out of occlusion, a new one takes its place. In some species teeth are found that are continually growing, such as the rodent's incisors and the tusks of the elephant. In other species we find teeth which are continually erupting throughout life. The ungulates' dentition possesses this characteristic. Teeth of limited growth and eruption are possessed by the modern carnivores and omnivores. Man, of course, falls into this latter category. When the above four machines of adjustment are ana-

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lyzed, it should be obvious that under normal environmental conditions these mechanisms maintain a relatively constant mandibular relationship to the cranium during growth of the particular species. The mandibular condyle is, therefore, held in a rather constant relationship to its articulation. Adjustment in the temporomandibular joint is possible, however, as is clinically evident in cases where ectopic eruption of teeth has caused the mandible to be displaced from its so-called normal position.

Examples have been given of tooth adjustment to wear, but it must be remembered that these adjustments are dependent upon the type of bone which hold these teeth. If the law of bone design is accepted, a difference must be expected in the form and arrangement of trabeculae of the bones holding these various types of teeth. This law states, "The form of a bone may be taken to represent the least amount of material, most efficiently arranged to carry the peak of the loads of its various functions." The functional forces in a carnivorous dentition are essentially in a lateral direction. The bone trabeculae are so arranged as best to withstand this lateral force; however, depression of these teeth is easily accomplished. The buccal teeth of herbivores are subjected to massive forces in a vertical direction, and of course, withstand depression. On the other hand, lateral displacement of teeth in these species is not difficult.

The Human Denture

The preceding material was presented in order to introduce a concept concerning teeth and bone. An attempt will now be made to apply this concept to the human denture. To give an understanding of the functional adjustment mechanisms present in the human dentition without first completely analyzing its component parts, would be

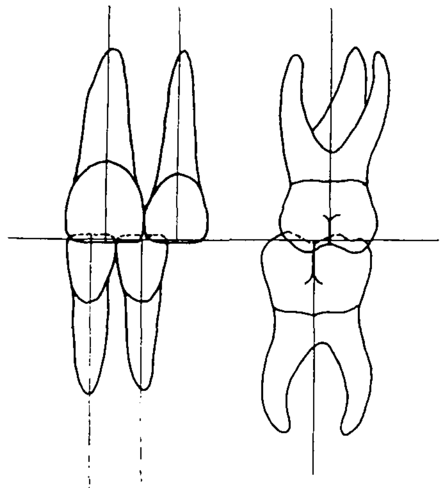

Fig. 1

the same as trying to explain to someone entirely unfamiliar with the operation of a gas engine, its function without discussing pistons, rods, rings, etc.

A comparison between primary tooth form and permanent tooth form reveals many interesting facts. Briefly, it may be stated that the primary teeth have symmetrical tooth crowns and root form and stand at right angles to the occlusal plane when viewed from the labial or buccal aspect (Fig. 1). The axial inclination of these teeth remains unchanged during the life of the primary dentition; hence, there is no individual drift tendency evident. When the permanent teeth are examined, an entirely different story is found.

Incisors

Starting with the maxillary incisors and analyzing their crown form, it is found that the mesial surfaces of these teeth are longer than the distal surfaces. It follows, therefore, that in order for these teeth to have their incisal edges parallel with the occlusal plane they must stand with a distal root inclination when viewed from the labial aspect.

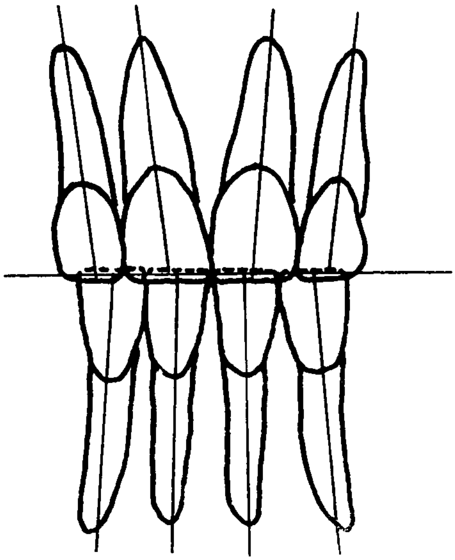

Fig. 2

excursion of the mandible places a mesial and labial force upon the crown of the maxillary incisors through the occlusion of the incisal edges of the mandibular left incisors (Fig. 2). If the right side is the functioning side, the reverse is true and the right maxillary incisors are placed under a mesial and labial force. When the incisors are used purely for incising food the mandible does not deviate laterally but has a chopping motion only, and the force created upon the maxillary incisor crowns by the mandibular incisors would tend to move them straight labially (Fig. 3). If these forces are present always during mastication, then there must be some mechanism to resist them. As has already been pointed out, the maxillary central incisors meet

The right and left incisors are mirror images of one another; hence, their distal root inclination starts at the midline of the denture and the central incisor crowns support one another through their contact (Fig. 2).

When the maxillary incisors are examined in the sagittal plane from a lateral aspect, it is found that the long axes of these teeth have a lingual root inclination; thus the crowns are in a labial position in relation to the apex of the roots (Fig. 3). What forces are placed upon these teeth by function and how are they resisted? Considering the left maxillary incisors, assume that the left side is the masticating side in this analysis. The mandible moves from centric to the left until the buccal cusps of the left buccal segments are almost end to end. The teeth then incise the food and come as closely as possible into contact, depending upon the consistency of the food, and the mandible moves back to centric relationship towards the right side. This medial

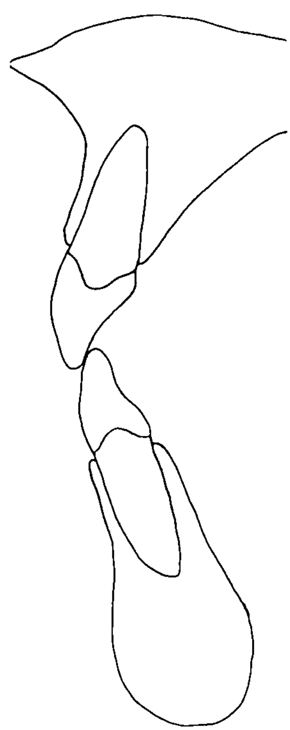

Fig. 3

at the midline with opposite axial inclination, and would thus tend to resist, by their contact points, the mesial force placed upon them through mastication. The labial force, brought about through the incisal edges of the lower incisor crowns striking the lingual of the maxillary incisors, is resisted by two mechanisms. The first and most obvious is the labial musculature of which the buccinator muscle is the most important in resisting this force. Secondly, an analysis of a cross section of the roots of the maxillary central incisor reveals a most interesting fact. If the roots in cross section were completely conical and round, there would be approximately half the periodontal membrane fibers resisting labial displacement. It may be observed, however, that the roots in cross sections are more triangular, so that two-thirds of the periodontal membrane fibers are located on the lingual surface, and hence provide more resistance to labial displacement of these teeth.

An analysis of the crowns of the mandibular incisors reveals a slightly different picture than was seen in the maxillary incisors. The mandibular central incisor crown, when viewed from the labial aspect, presents a rather symmetrical form. The incisal edge is at right angles to the long axis of the crown and root. The lateral incisor crown has a slightly longer mesial surface than distal surface, and the incisal edge meets the occlusal plane at right angles so the long axis of this tooth has a slightly distal root inclination (Fig. 2). When viewed from the sagittal plane both the mandibular central and lateral crowns have a labial inclination with their roots being more lingual (Fig. 3). The effect of functional forces upon these mandibular incisors is the reverse of what was seen for the maxillary incisors. Forces always being equal and opposite, there are lingual and distal forces upon these lower incisors during function. (Fig. 3) The lingual force on these incisors is resisted by what might be called the contained arch principle and possibly the tongue. The contained arch principle is based upon the fact that all of the lower teeth being in contact with one another have the effect of mutually supporting each other against a lingual force. A simile may be used by comparing the lower dental arch with the staves of a barrel; as long as all of the staves in a barrel are in contact with one another, the barrel remains intact. However, if one stave is removed the barrel will collapse. Another factor that helps the mandibular incisors resist this lingual force is their labial axial inclination in the anteroposterior direction. When the mandibular incisor roots are cut in cross section, it is found that they are much wider in a labiolingual direction than in a mesiodistal direction; hence, there are more periodontal fibers on the mesial surfaces of these teeth with which to resist a distal force. The mesial axial inclination of the mandibular lateral incisors, when viewed from the labial aspect, also has a tendency to resist the distal force that is placed upon these teeth.

Molars

The molars may be analyzed in much the same way. The maxillary molar crowns, when viewed from the buccal aspect, present a longer mesial surface than distal surface (Fig. 4). Here again this factor tends to make these teeth stand at a mesial axial inclination in respect to the occlusal plane. The mandibular molar crowns present the same characteristics in that they, too, have a longer mesial surface than distal surface and, hence, have a mesial axial inclination to the occlusal plane (Fig. 4). It should be obvious that when the molars meet in occlusion they create a force upon each other, the resultant of which is mesial in direction. Clinically, it is

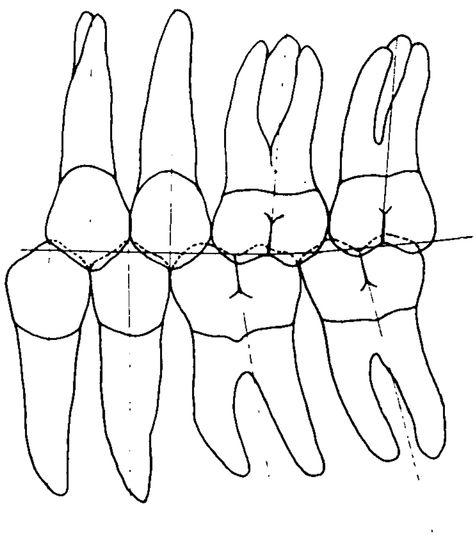

Fig. 4

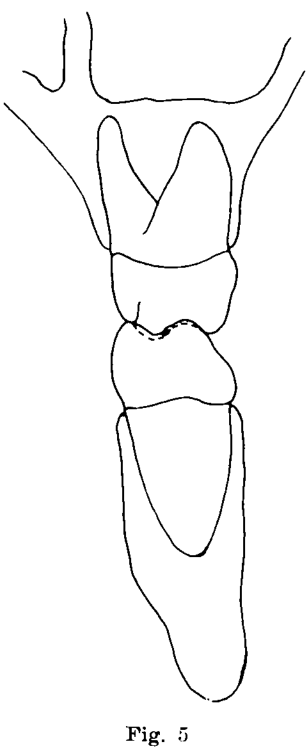

Fig. 5

evident that this mesial drift tendency is much more active in the mandibular arch than in a maxillary arch. In the maxillary arch this force is resisted by the contact relationship of the maxillary teeth and the large roots of the maxillary molars. In the mandibular denture the contact relation of the teeth helps to resist the mesial force. With this drift tendency being greater in the mandibular arch, the root form is also found to be a possible factor in its resistance. A cross section of the mandibular molar roots shows that they are two in number and that they are much wider in their bucco lingual dimension than in their mesiodistal dimension. It is evident, therefore, that the greatest number of periodontal fibers supporting these roots are located on the surfaces of the roots in the direction in which they tend to drift.

When viewing the maxillary and mandibular molars from the mesial aspect in occlusal relationship, one sees that the lingual surface of the maxillary molar is much longer than the buccal surface and that this tooth has a very definite lingual root axial inclination (Fig. 5). The reverse is true of the mandibular molar in that the buccal surface is longer than the lingual surface and the tooth has a lingual crown axial inclination to the occlusal plane. When the forces of occlusion during mastication are analyzed in regard to these teeth, it is found that as the mandible moves from an end to end relationship of the buccal cusps back towards centric occlusion, a force is created on the lingual incline planes of the buccal cusps of the maxillary molars and on the buccal incline planes of the buccal cusps of the lower molars. This force would tend to move the maxillary molars in a buccal direction and the mandibular molars in a lingual direction. The maxillary molars resist this buccal force in two ways. One, by having the largest and strongest root of the molar, namely the lingual root, located in such a relationship to the tooth crown as to resist buccal displacement; and, two, the resistance of the buccinator muscle. The lingual force on the mandibular molars is resisted by the previously mentioned contained arch principle and possibly some by the tongue.

The difference in the arrangement of the bone trabeculae in the carnivorous and herbivorous dentitions in response to tooth movement in varying directions was pointed out previously. This same principle holds true for the human dentition in that the bone trabeculae are arranged in such a manner as to resist the natural forces that are placed upon the teeth. In the molar region we find the bone to be more compact on the buccal of the maxillary teeth and on the lingual of the mandibular teeth.

Premolars

An analysis of the maxillary and mandibular premolar crowns shows that they are for the most part rather symmetrical, and that the long axes of these teeth, when viewed from the buccal aspect, are very nearly at right angles to the occlusal plane (Fig. 4). It may be interpreted, therefore, that they do not exert any mesial force because of their axial inclination or crown form. However, they do transmit the mesial force created by the molars to the anterior part of the arch. When viewed from a mesial aspect the maxillary and mandibular premolars have essentially the same relationship as was described for the molars. The forces of occlusion upon these teeth in this direction tend to drive or move the maxillary premolars bucally and the mandibular premolars lingually. This force in the maxillary arch is resisted by the buccinator muscle, and in the mandibular arch by the contained arch principle and possibly by the tongue. In general, when discussing the forces of occlusion, the premolars may be regarded as transmitters of force but not as creators of force. It must be remembered in all of this discussion that it pertains only to the human denture in normal occlusion. In malocclusion, any tooth, because of faulty inclined plane relationship, can act to disturb the effect of the natural forces of occlusion.

Canines

The canines, because of their position in the dental arches, are subjected to forces from several different directions. An analysis of the forces exerted upon them through function is rather difficult because the distal half of these teeth seems to belong to the posterior buccal segments, with the mesial half belonging in the anterior segments. Both the maxillary and mandibular canine crowns have a mesial surface which is longer and straighter than the distal surface. When viewing the normal alignment of the teeth from both a direct labial or buccal aspect, these teeth have a mesial inclination of their crowns.

An analysis of the forces created by function upon these teeth reveals a complex picture. Considering the maxillary canines first, there is the force which was discussed previously as the mesial drift tendency of the buccal segments. This force, arising from function through the axial inclination of the maxillary molars, is transmitted through the passive premolars to the distal contact of the canine and results in a mesio-labial force upon this tooth crown. When the mandible is functioning on the opposite side of the maxillary canine in question, it is evident that when it returns to its centric relationship it creates a mesial force upon the maxillary incisors of the functioning side which is transmitted through the contact points of the incisors to the mesial surface of the canine, thus creating a force in a disto-buccal direction upon the canine crown. These two forces, one in a disto-buccal direction and the other in a mesio-labial direction, would have a resultant in a forward labial direction. One other force is transmitted to the maxillary canines from mandibular function; this force is created by the occlusion of the lower canine with the upper canine. Thus, when the mandible is in a centric relationship or returns to a centric relationship during function on the masticating side, it causes a direct labial force upon the maxillary canines. This complexity of forces upon the maxillary canines requires a strong resistance in order to prevent their displacement.

An analysis of the structures involved reveals three possible resisting forces. (1) The maxillary canines have the longest and strongest roots of any teeth in the arch, and, hence, have more resistance to displacement. (2) A cross section of the maxillary canine root reveals that it is essentially triangular in shape with two sides of the triangle facing the lingual; therefore, approximately two-thirds of the periodontal fibers are resisting labial displacement of this tooth. (3) The buccinator muscle may be considered to play an important role in maintaining the maxillary arch form against the lower contained arch. It is reinforced in the canine region by the insertion of several additional muscles into the lips.

The mandibular canine crowns were considered with the maxillary canines; however, the forces exerted upon these teeth are somewhat different. From the mandibular molars there is a mesial force created during function that is transmitted by the passive premolars through the distal contact of the mandibular canine, thus creating a force in a mesio-labial direction. When the mandible, on the functioning side, moves from a lateral position into full occlusion, it creates a distal force on the mandibular incisors which is transmitted through the contacts to the mesial surface of the mandibular canine, producing a disto-buccal force upon this tooth. These two forces are nullified to a great degree by the fact that the maxillary denture lies entirely without the mandibular denture in the anterior region and, hence, tends to resist the labial displacement of the mandibular canines. When the mandible is in a centric relationship, or returns to a centric relationship during function, it also creates a direct lingual force upon the mandibular canines. Thus, the prevailing force upon all the mandibular teeth is in a lingual direction. This lingual force is resisted primarily by the contained arch principle, discussed previously, and possibly some by the tongue. The mandibular canine roots are not as long nor as heavy as those of the maxillary canines. An analysis of their form does not reveal any special aptitude in resisting displacement through functional forces other than the usual periodontal fiber attachment.

The Denture as a Unit

An attempt as been made to evaluate the various mechanisms of adjustment that are present inherently within the denture by analyzing its component parts. The following discussion will deal with the denture as a unit.

The mesial vector of force that has been discussed tends to keep all of the teeth in tight contact during the life of the denture (Fig. 4). Black pointed out that under natural conditions there is wear of the interproximal surfaces of all contacting teeth. He concluded that the amount of wear in the entire denture during a lifetime was almost equal to the width of a premolar in the vigorous masticator. As this wear takes place, the mesial force created by function is the mechanism of adjustment that maintains the denture intact.

Masticatory forces are not the only forces which have to be considered as affecting the denture. Even though the denture is used for mastication only a small fraction of time, during the act of swallowing the teeth are brought into contact many times a day. The action of swallowing which brings the teeth into centric relationship creates only a force along the long axes of the teeth. This force, in normal occlusion, would tend to maintain normal inclined plane relationship between the mandibular and maxillary dentures. It is evident, however, that if a tooth or group of teeth were in a malposed position, abnormal inclined plane relationship would be established and alter the effect of the forces of occlusion upon the denture as a whole.

The influence of the buccinator muscle in establishing and maintaining arch form and relationship should be emphasized. The buccinator muscle, arising from the pterygomandibular raphe on the medial side of the ramus of the mandible, runs forward and lateralward where it emerges to the buccal of the denture in the molar region. It secures more fibers from the molar region of both the mandible and maxilla and continues forward to where it divides into the upper and lower lip emerging on the opposite side as a single band of muscle, continuing back to the pterygomandibular raphe of that side. The superior constrictor muscle of the nasal pharynx arises from the anterior part of the spinal column and is directed forward and laterally to insert into the pterygomandibular raphe along the walls of the nasal pharynx. The buccinator and the superior constrictor are thus a continuous band of muscle surrounding the entire denture, being attached posteriorly to the spinal column. These muscles can thus be considered as an elastic force surrounding the entire denture and being responsible for molding the maxillary denture against the lower contained mandibular arch.

In order to summarize the functional forces of occlusion, it may be stated that generally speaking these forces create a buccal and labial force upon the maxillary denture and a lingual force upon the mandibular denture. It should be emphasized that the mandibular arch form is determined primarily by the lingual forces created by function. The contact of the mandibular teeth with one another produce a contained arch around which the buccinator muscle and the incline plane relationship of the teeth mold the maxillary denture.

It may be concluded that the normal human dentition has an adequate mechanism for adjustment to wear and accident providing abnormal forces are not created to disturb the state of balance that exists between the denture and its associated structures.

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