# Physiologic Migration Of Anterior Teeth*

Bernard Schneider, D.D.S., M.S. and
Harry Sicher, M.D., DSc.**
*Chicago, Illinois*

## Introduction and Review of the Literature

The study of the physiologic movement of teeth is not new. G. V. Black ('08) has shown by actual measurements an average loss of about 1 cm. in the length of dental arch due to proximal wear at the contact areas of the teeth by the age of 40 years. He reasoned that since the teeth were still in contact the teeth must have moved toward the midline.

In 1925 Stein and Weinmann in their work on the mesial drift of teeth gave histologic evidence for this clinical observation. Microscopic examination of horizontal and mesiodistal sections of teeth and their supporting bone revealed a distinct structural pattern of the supporting bone. From this they deduced that teeth migrated mesially. Since then their findings have been accepted as indicating a physiological process and this has been substantiated by numerous investigators.

From studies of madder-fed pigs Brash ('28) came to the conclusion that there is a constant movement of all teeth in three planes of space. Not only do teeth move vertically but buccally and proximally as well. A review of the literature revealed that other studies had contributed indirect evidence to the question.

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**Department of Orthodontics and Oral Pathology University of Illinois, College of Dentistry and Department of Anatomy, Loyola University College of Dentistry, Chicago, Illinois.

Bjork, ('47) employing cephalometric roentgenograms of a sample of 322 boys 12 years old and 281 conscripts between the ages of 22 and 23, found that the mean sagittal angle formed between the longitudinal axes of the upper and lower central incisors increased from 128.5° to 137.4°. This increase of 8.9° could only be explained by an uprighting or more vertical positioning of these teeth. Downs ('48) measured the same angle in 20 persons with normal occlusions with an age range of 12-17 years and found this angle to be 135.4°.

Noyes, Rushing, and Sims ('43) measured the same angle on 14 living people between the ages of 22-33 years and arrived at a mean figure of 129.3°. The measurement on 9 Indian skulls provided a mean of 131.4°. Both of these groups were composed of individuals with normal occlusion of the teeth. On 15 cases of Class II, Div. I malocclusion the angle was 132.2° and in 15 cases of Class III malocclusions it was 132.0°.

Schaeffer ('49) studied the behavior of the axes of human incisor teeth by means of serial cephalometric x-rays. His sample consisted of 47 series of lateral roentgenograms from the time the incisors were first in occlusion until 8 years later. He found that 18 individuals showed no change in the interincisal angle and in 21 individuals the interincisal angle increased. Eight individuals showed a decrease in the interincisal angle. A decrease in the angles denoted greater procumbency. It should be realized that the interincisal angle could change as a result of the axial change of either the upper or lower incisor as well as that of both. To determine where the change took place in any given case, Schaeffer was forced to relate the tooth axes to planes of reference. Thus, the upper incisor was related to the palatal plane, the lower to the mandibular plane. When he did this, he found that each of these angles may increase, decrease, or remain constant during growth, but the tendency once established was maintained. In other words, once an angle showed a decrease, increase, or stability, it continued to do so. Of the 13 possible combinations between the three angles all but 4 such combinations were found. This would tend to show an absence of a definite pattern of change in the inclination of the incisor teeth during growth.

Bjork ('47), Lande ('51), and Brodie ('53) on late growth changes in the face all revealed that the mandible became more prognathic with age. This tended to straighten the facial profile because the teeth and alveolar processes did not keep pace with the forward movement of the glabellar and chin regions. Such a differential growth pattern could quite conceivably influence the axial inclination of the incisors.

The present study was an attempt to determine whether a definite drift pattern of teeth existed in the labio-lingual direction. Because it was thought that single rooted teeth would yield a clearer picture, the study was limited to the upper and lower anterior teeth from cuspid to cuspid.

Because of the age range and distribution of the sample, the study is mainly concerned with changes that have taken place after growth has stopped.

## Material

The material used in this study was derived from the files of the University of Illinois, Department of Oral Pathology, and from that of the Loyola University Dental School.

It consisted of 48 human teeth and their supporting tissues sectioned in a labio-lingual direction. The slides chosen were central sections which passed through the full length of the teeth from apex to incisal edge whenever possible. These 48 teeth were taken from 29 different cadavers. All were males.

Photographs of the maxilla and mandible in open and closed position and a brief history of the individual was available in most cases.

The age range of the sample was from 12 to 74 years with the majority of individuals falling between the ages of 30 and 55. The age of one individual is unknown. The photographs of 4 individuals were unobtainable.

The sections were stained with hematoxylin and eosin.

## Method

The study consisted of the microscopic examination of each individual section and was entirely qualitative. Each slide was enlarged 30 X by means of a micro-projector on a large piece of paper. The outline of the tooth and the surrounding alveolar bone was traced, particular attention being paid to details indicating resorption and apposition of bone. By this method a clear picture of the drift or tipping tendencies of the tooth was ascertained in the majority of the sections.

A good example can be seen in the tracing of section #2b (Fig. 4). The lines present along the lingual alveolar wall and fundus can be diagnosed as resting lines and indicate where bone had been deposited. Their absence on the thin labial wall and the presence of scalloping indicate resorption. Thus it could be concluded that this tooth had undergone a labial drift and vertical eruption.

The use of resting lines in the alveolar bone as indication of previous movement of teeth is not new. The following definition of resting and reversal lines is taken from Weinmann and Sicher's book, "Bone and Bones".

> "A free and inactive surface of bone shows a peculiar staining reaction. The surface becomes increasingly basophilic and can be seen in a section stained with hematoxylin and eosin as a dark blue line, aplastic line, or limiting membrane. If, after some time new bone is laid down upon this surface, its layers are separated from the old bone by a dark blue cementing line, which is now called a resting line. It is straight or evenly curved.
>
> If bone tissue is resorbed and resorption ceases for a time, the resorbed surface shows the same reaction as previously described, that is, the appearance of an aplastic line. New bone apposed upon the resorbed surface is separated from the old by a cementing line which is called a reversal line. It is scalloped with its concavities corresponding to the former Howships lacunae. The convexities of the scalloped reversal line face the old bone."

Thus resting lines reveal two things: (1) that growth has occurred at a specific site and (2) that it has been intermittent.

The significance of bone growth and resorption at specific sites has been interpreted by Weinmann and Sicher as follows:

> "Growth of bone in circumscribed, exactly defined areas is the direct cause for tooth movement. The continuous growth potential of the cementum plays an important role in this process. The constant presence of a superficial layer of uncalcified cementoid renders the tooth relatively immune to resorption. Thus the pressure caused by growth (apposition) of bone on one alveolar wall is transmitted by the moving tooth to the opposite alveolar wall where it causes resorption."

However, the study told by resting lines is not a complete one because of the constant remodeling that occurs at all times. Thus some of the earlier resting lines have probably been removed when the bone underwent remodeling changes. Furthermore, the time interval represented by these lines is as yet undetermined. All one can say from existing resting lines is that the tooth had moved and in which direction but when this occurred is impossible to say.

Details of apposition and resorption occurring along the surface of the alveolar wall at the time of death was studied but is not reported in this paper for several reasons, a few of which bear explaining. There is a response in the periodental membrane that maintains the width of that structure within narrow limits under varying conditions of functional stress (Schour '56). The responsibility for this adjustment seems to lie in part with the cells of the middle zone of the membrane which have been shown to increase their mitotic activity with any increase of tension in the fibers (Reitan '51, Macapanpan '52). This leads to the formation of new fibroblasts which produce new fibers to adjust to the new position of the teeth, (Sicher '55). At the same time new bone is being formed on the alveolar wall and new cementum on the root surface. This activity occurs throughout life in the interest of maintaining adjustment of the teeth to changes in functional stresses (Gottlieb '43). With stimuli of short duration there is activity leading to minute absorptions and depositions but when the stimulus is of a continued nature, there is a more generalized involvement of the bone and cementum surfaces which can be read in the resting lines on the tension side.

Other factors tend to make difficult the determination of the direction of movement from an examination of the bone surface alone. When a tooth is subjected to a lateral stress, it does not move in a translatory manner but by tipping and the reaction of the alveolar bone is therefore scattered along both sides of the root. During this response the osteoclasts frequently remove more bone than necessary to reduce pressure to normal and, in consequence, short periods of reparative apposition follow periods of resorption. However, osteoclastic activity is more easily discernible because of the presence of Howship's lacunae whereas the thin layers of newly deposited bone by osteoblastic activity are difficult to see owing to the thickness of the sections and the faint staining reaction.

When an apposition or resorption pattern could be ascertained in spite of these complicating factors, it was merely indicative of the state of this tooth at one instant of time while the cementing lines provided a diagram of phenomena over a much longer period of time prior to death.

### Findings

(1) The study of the resting lines as revealed by microprojection showed a definite pattern of movement for all 48 teeth examined.

(2) The direction of movement was varied, 24 teeth showed some change in a lingual direction and of these 16 revealed a lingual tilt (Fig. 1), and 8 a lingual translatory drift (Fig. 2). There were 10 teeth which showed a change in the labial direction; three showing labial tilt (Fig. 3), and 7 a labial translatory drift (Fig. 4). Nineteen teeth showed vertical eruption (Fig. 5). Of these 10 had erupted in combination with a labial or lingual movement and 9 showed vertical eruption alone. Six teeth appeared entirely at rest (Fig. 6).

(3) When the reaction of upper teeth was compared to lower teeth, significant differences were apparent. Of the entire sample of 48 teeth 29 were uppers and 19 were lowers. The 29 upper teeth behaved as follows: 11 showed a lingual movement (6 tilt, 5 drift); 9 showed a labial movement (2 tilt, 7 drift); 12 showed vertical eruption and 3 were at rest. The 19 lower teeth showed a distinct difference in their behavior with 13 moving lingually (10 tilting and 3 drifting); 7 teeth showed vertical eruption; 3 were at rest and only 1 tooth had moved labially.

(4) When the sample was arranged in such a manner as to determine the effect of tooth position within the jaw, it was found that no definite pattern of behavior existed; central and lateral incisors as well as cuspids were shown to move in either a labial or lingual direction.

(5) Specimens from the same individual were studied next. There were 12 individuals from whom two or more teeth were derived. Of these the teeth behaved similarly in 5 individuals while in 7 they did not. The reasons for a difference of behavior of the teeth in these 7 individuals varied. Three individuals had at least two or more upper teeth that moved in opposite directions, one moving labially, the other lingually. The remaining 4 individuals showed a difference in movement between upper and lower teeth. In 3 of these 4 individuals the difference in movement was due to an opposite movement of upper and lower teeth (uppers labially, lowers lingually) while in the other individual the upper erupted, and the lower moved lingually. It it of interest to note that in two individuals (each with 2 specimens) both specimens were at rest even though in both cases one tooth was an upper and one a lower.

(6) The behavior of antagonistic teeth revealed a picture similar to the specimens from the same individual. A definite pattern of behavior could not be ascertained. Of the 8 sets of antagonists 5 sets showed a similar behavior while 3 sets behaved differently. The teeth that behaved differently did so by an opposite movement of the teeth, one moving labially while

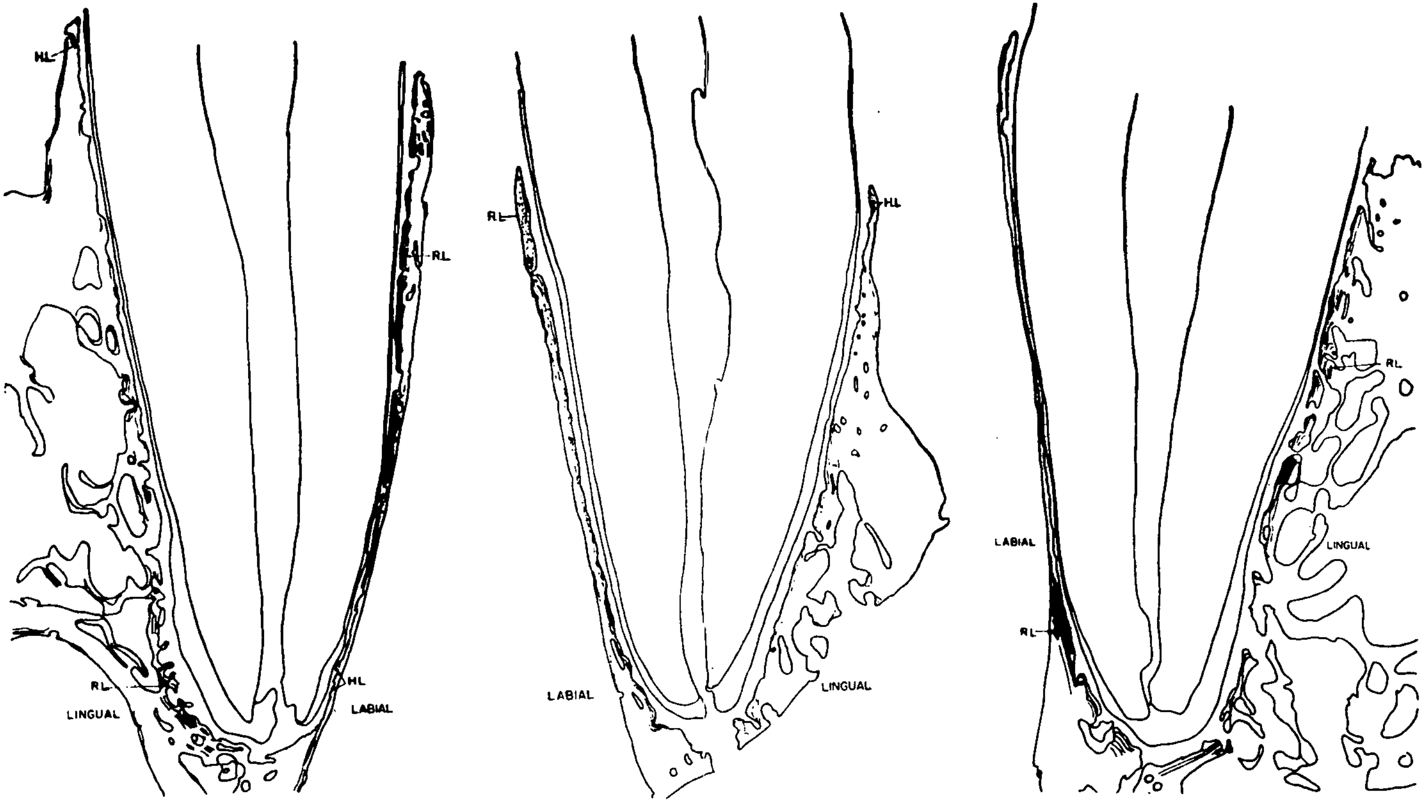


Fig. 1, left. Tracing of specimen No. 6, upper canine. Note resting lines (R.L.) in labial coronal half and lingual apical half of the alveolus, absence of such lines and the presence of Howship's lacunae (H.L.) in remainder of alveolus. Findings indicate a lingual tilt of tooth.
Fig. 2, middle. Specimen No. 7a, upper central. Note resting lines in labial alveolar wall, their absence, and presence of Howship's lacunae along lingual alveolar wall. Findings indicate a lingual drift. Fig. 3, right. Specimen No. 6b, upper canine. Note resting lines in labial apical third and lingual coronal half of alveolus and absence of such lines in remainder of alveolus. Findings indicate labial tilt of tooth.

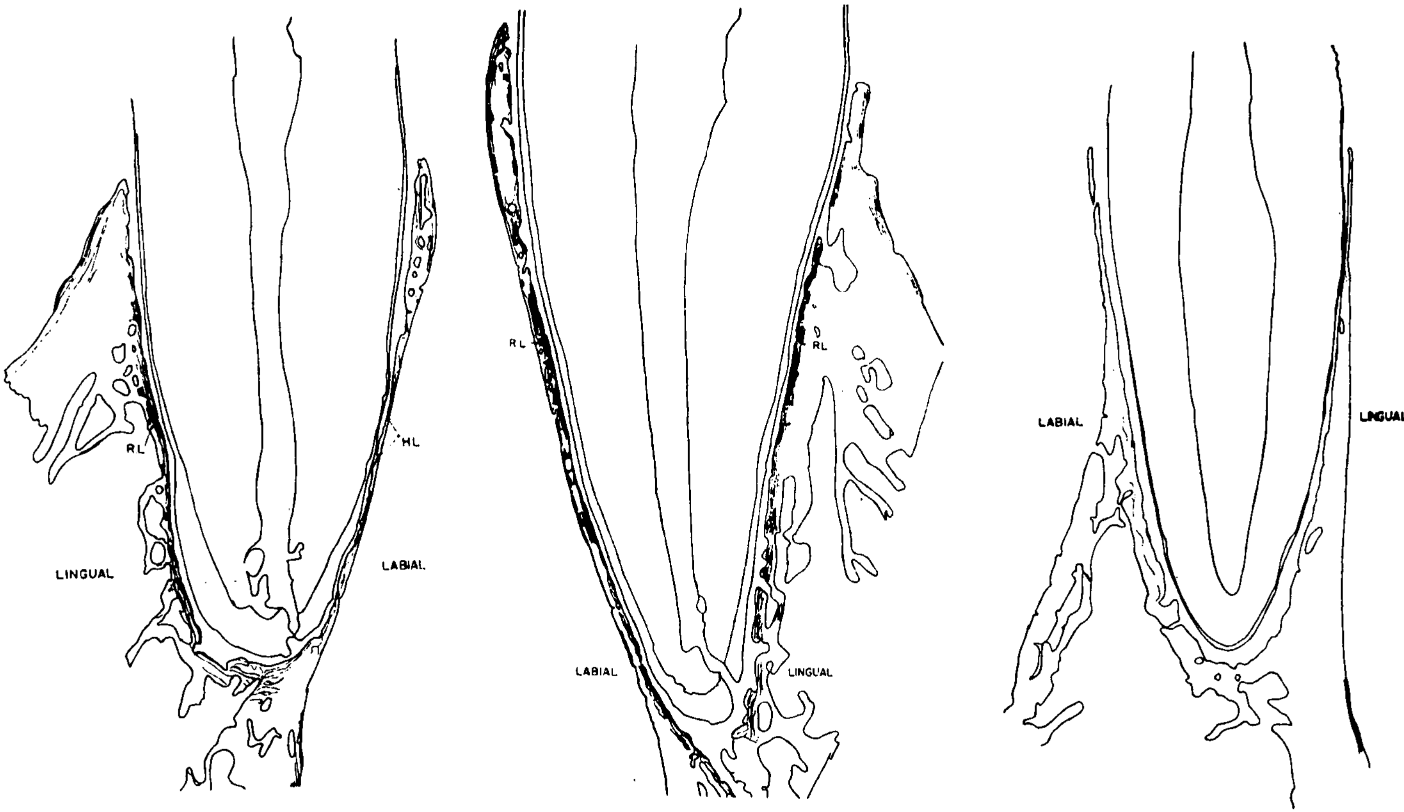


Fig. 4, left. Tracing of specimen No. 2b, upper lateral. Note resting lines (R.L.) along lingual alveolar wall, their absence, and presence of Howship's lacunae (H.L.) along labial alveolar wall. Findings indicate labial drift.
Fig. 5, center. Specimen No. 11b, upper canine. Note presence of resting lines along entire alveolar wall indicating vertical eruption.
Fig. 6, right. Specimen No. 1, lower central. Note absence of resting lines along alveolar wall indicating tooth is at rest.

the other moved lingually.

(7) The effect of attrition on the drift pattern once again revealed a lack of a definite tendency. Since the lower teeth showed a predominance of lingual movement, it was decided to study the behavior of attrition on the upper teeth alone. Of the 9 upper teeth from jaws showing only a slight degree of attrition 5 showed lingual movement (2 tilt and 3 drift), 2 showed a labial movement (both drift), 3 showed eruptive movement and 1 was at rest. Of the 13 teeth from dentitions with a moderate degree of attrition, 4 showed lingual movement (3 tilt, 1 drift), 6 labial movement (1 tilt, 5 drift), 6 an eruptive movement and 1 was at rest. There were only two dentitions with a severe degree of attrition; 1 showed a lingual drift and one vertical eruption.

(8) When the effect of alveolar bone loss on the drift pattern of the teeth was studied, there seemed to be a direct correlation between bone loss and labial movement. When the entire sample was studied, this correlation was not as clear as when the upper teeth were studied alone. Of the 7 upper teeth which had suffered a slight degree of alveolar bone loss, 5 had moved lingually, 1 had moved labially, and 3 had undergone vertical eruption. There were 11 upper teeth which showed moderate bone loss. Of these 2 had moved lingually, 3 labially, 5 showed eruption and 3 were at rest. Of the 11 upper teeth that had suffered severe bone loss, 4 moved lingually, 5 labially, and 4 showed eruption. Here it could be seen that the number of teeth showing labial movement increased as the bone loss increased. Only 1 out of 7 teeth moved labially when the bone loss was slight; when it was moderate, 3 out of 11 teeth moved labially, and when it was severe, 5 out of 11 teeth moved labially.

(9) The degree of mutilation (loss of teeth) seemed to have a correlation on the drift tendencies of the teeth studied. When the teeth were arranged in order of increased mutilation of their respective jaws, the tendency for labial movement of teeth seemed to increase. Lingual movement did not appear to be correlated with the degree of mutilation. Once again the upper teeth were examined alone, first in the order of increasing mutilation of the upper jaw and then in the order of increasing mutilation of the lower jaw. This was done to see whether the movement of the upper teeth was more dependent on the integrity of the maxillary dental arch or on the integrity of the lower arch which supports it. In both cases the labial movement of the upper teeth was directly correlated with the degree of mutilation while the lingual movement was inversely correlated.

Of the entire sample only two teeth were taken from jaws which contained a full complement of teeth. They were specimen #12, a lower cuspid taken from Jaw A 7, and specimen #4, an upper central incisor taken from Jaw K T. Specimen #4 showed vertical eruption while specimen #12 exhibited a labial tilt plus eruption.

(10) Finally, the sample was examined to see if any racial tendencies existed. Of the 29 individuals comprising this sample 10 were Caucasian and 5 were Negroid. Unfortunately the racial status of the remaining 14 individuals was unobtainable. Fourteen Caucasion teeth were studied. Of these 6 showed lingual tilt; 2 showed labial drift; 4 showed eruption and 4 were at rest. Of the 8 Negroid teeth studied 3 showed lingual movement; 3 showed labial tilt; 3 showed eruption and 2 were at rest.

## Discussion

The most consistent finding was the lingual movement of the lower teeth.

The upper teeth moved labially or lingually with equal frequency. This would tend to confirm Bjork's findings of an increase in the interincisal angle with age. Schaeffer's work also demonstrated that of the 46 individuals studied serially, 21 had an increased interincisal angle, 17 remained constant and only 8 decreased. This again would seem to point to a lingual movement of either the upper or lower incisors or both since such lingual movement would lead to an increase of the angle.

However, the findings in this study must be evaluated in the light of the sample used. If the teeth studied here had all been derived from jaws possessing unmutilated dentitions, the findings could be considered truly representative of normal physiologic behavior. However, only 2 individuals of the 29 studied had a full complement of teeth; these were jaws A 7 and K T. Unfortunately, only 1 tooth from each jaw had been sectioned in a labio-lingual direction. Specimen #12, taken from jaw A 7, was a lower left cuspid. This tooth showed a labial tilt, plus eruption. This was the only lower tooth to show a labial movement. Specimen #4, taken from jaw K T, was an upper right central incisor and showed vertical eruption. The remaining lower teeth all came from lower arches with one or more teeth missing. Of the 18 remaining lower teeth 13 showed a lingual movement; 3 were at rest and 2 showed vertical eruption, (5 others showed eruption combined with lingual movement.)

These findings furnished histological evidence for the clinical observation that the lower arch collapses lingually with the loss of its continuity. A word of explanation is due here: in the normal dentition we find that the upper dental arch overhangs the lower dental arch by one half cusp buccally. Thus the lower arch is considered a "contained" arch lying wholly within the upper. When we consider the effect of occlusion upon these arches, we note a tendency for the upper teeth to move buccally while the lower teeth are forced lingually. Thus the lower teeth are being forced into an arc of a smaller radius making the continuity of this arch an extremely important factor in resisting the tendency for lingual movement. With a loss of continuity (due to loss of one or more dental units) a lingual collapse of the lower teeth generally takes place. When the reaction of such a collapse on the lower anterior teeth is considered, the situation is further aggravated by the anatomy of the maxillary incisors and cuspid teeth. Their oblique lingual surface will guide the lower teeth lingually and upward. The reaction of the upper teeth to this collapse is dependent upon a multiple of factors. The deep overbite may be due entirely to movement of the lower teeth. In this case, the upper teeth will be at rest. On the other hand, since the equilibrium of the denture has been disturbed by a collapse of the lower arch, it is possible that the upper teeth will, in turn, tilt lingually until a new equilibrium has been established. A third alternative is that, as the lower teeth ride up the lingual surface of the upper teeth, these in turn will be tilted labially due to a new vector of occlusal force. As is so often true with biologic reactions, there is no single invariable reaction. All probably occur, singly or in combinations, in different individuals. Examination of the behavior of the upper teeth in this sample in which all except specimen #4 were associated with a mutilated lower arch seemed to bear out the above contention. Of the 28 remaining upper teeth, 11 showed lingual movement, 9 labial movement, 5 vertical eruption, 6 showed eruption combined with a labial or lingual movement and 3 were at rest. Further evidence was found in the examination of the 8 sets of antagonistic teeth. Six of the lower teeth showed a lingual movement, and 2 were at rest. In the cases in which the 2 lower teeth were at rest, both upper teeth were also at rest. In the jaws in which 6 lower teeth showed lingual movement, 3 upper teeth also showed lingual movement while 3 upper teeth showed a labial movement, once again illustrating the variability of movement of the upper anterior teeth.

The behavior of resting teeth is of interest. In two cases where there was more than one specimen from a jaw and one of these teeth was at rest, the other was also at rest. More significant was the fact that in both cases one tooth was an upper and one a lower. The explanation for this might be that a state of equilibrium had been reached in the individual denture that had persisted for quite some time. Both sets of resting teeth were from severely mutilated jaws although in one individual the missing teeth had been replaced by fixed bridges; thus the resting picture might have been caused by that restoration.

When the sample was arranged according to an increase in alveolar bone loss, there appeared to be a direct correlation between labial movement and the increase in alveolar bone loss. Because the lower teeth exhibited an almost uniform lingual movement, a study was made of the upper teeth alone. This study revealed that as the alveolar bone loss increased, there was an increase in the number of teeth exhibiting labial movement. Of the 7 teeth showing slight alveolar bone loss, only 1 showed such labial movement. Of the 11 teeth exhibiting moderate alveolar bone loss, 3 showed labial movement. Five of the 11 teeth with severe bone loss exhibited labial movement. A possible explanation for this may be that as the supporting bone loss increases, the teeth are less resistant to occlusal forces, and therefore are more easily forced labially.

A very similar pattern was shown when the teeth were arranged in order of increasing mutilation. Once again, the lower teeth were excluded in the hope that the uppers alone would show a clearer picture. This time the upper teeth were arranged according to increased mutilation in the upper arch, and then according to increased mutilation in the lower arch. Both showed an increased labial movement with an increase in mutilation of the arch.

The examination of the micro-projection tracings reveals a wide range in the number of the resting lines designating the previous positions of the teeth. This gives the impression that one specimen has undergone considerable movement while another has moved only slightly. It must be remembered, however, that bone is a dynamic tissue, undergoing constant remodeling and with this remodeling there is a loss of resting lines. Thus their appearance at the time of sectioning does not give a quantitative answer to such questions as the amount of movement that has occurred or when it had occurred.

## Summary and Conclusions

(1) The present study was based on a histologic examination of 48 anterior teeth and their supporting tissues sectioned in a labio-lingual direction.

(2) A study of the resting lines in the alveolar bone by means of the micro-projection technic allowed the reconstruction of a concise and quite accurate picture of the movement of teeth.

(3) The general tendency of a lingual movement of lower teeth was apparent in the sample studied. At the same time, the upper teeth showed a

tendency to move either labially or lingually.

(4) Resting teeth from the same individual seemed to exhibit a strong tendency to behave similarly. This probably reflects a state of equilibrium that has been reached in the individual's denture.

(5) The increase in alveolar bone loss of upper teeth seemed to promote a labial movement of the upper teeth.

(6) The mutilation of the arches (upper and lower) had a direct correlation with the labial movement of the upper teeth.

(7) The present study, while conclusive as to the difference in behavior of upper and lower teeth, is hampered by the nature of the sample. To see whether these differences would be equally apparent in a sample taken from complete dentitions is of interest and requires further study.

*808 S. Wood St.*

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