# Tissue Rearrangement During Retention Of Orthodontically Rotated Teeth*

Kaare Reitan, M.S.D., Ph.D.,

*Oslo, Norway*

The mechanical procedure of rotating malposed teeth has seldom been considered a problem in orthodontics. On the other hand, it is well known that the rotated tooth frequently shows a tendency to move back toward its original position after removal of the appliances. This occurs especially in cases where the respective tooth has been rotated rapidly and through a considerable number of degrees. In some textbooks overrotation has been recommended as a measure against these secondary changes in tooth position.

Other methods have been suggested for stabilization of rotated teeth. Hence, Skogsborg (1927) advocated surgical transection of fibrous and bone structures in the septal area on both sides of the root, after rotation, in order to prevent relapse of the tooth moved. Recently Hallett (1956) discussed the results obtained after immediate torsion of twenty-three teeth, the so-called "redressement forcé"; the teeth thus rotated had been retained by fixed splints. The descriptions of these two methods tend to stress that there are problems connected with rotation of teeth, but that these problems are related chiefly to the retention period. The present investigation is based on animal experiments and deals with some histologic observations made in the supporting structures of orthodontically rotated teeth.

Up to the present few histologic experiments on rotation have been reported. One series was performed twenty years ago (Skillen & Reitan 1940), the findings of which are partly discussed in this study. In addition, a new series will be described, also including experimental teeth that were retained after rotation. Except one dog, two and a half years old, the experimental animals were around one year old. The new series comprises sixteen experimental teeth, six of which represent experiments on retention.

## Rotation of teeth

Various factors are involved in the movement of rotation. Of these the anatomical and mechanical factors should be considered here. The anatomical factor is primarily related to the position of the tooth, its form and size. Except the upper central incisor and to some extent the first and second lower premolars in man, most roots, seen in cross section, have an oval form. In the present series the upper second incisor in the dog was selected as the experimental tooth, the first and third incisors serving as control. In cross section the second incisor of the dog has an oval contour, Fig. 1. Because of this

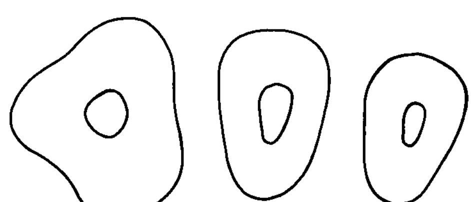


Fig. 1 Cross sections of the first, second, and third upper incisors of the dog.

* From the Norwegian Institute of Dental Research, Oslo.

form a parallel movement between the root surface and the inner alveolar bone surface takes place chiefly on the buccal and lingual sides of the root. Another anatomical detail to be mentioned is the arrangement of the periodontal fibers.[6] It is well known that the major group of the periodontal fiber bundles runs from the root surface to the inner alveolar surface. The free gingival fibers, however, are attached in the gingival soft tissues and the periosteum. As shown later, this variation in the attachment of the fibers plays an important part especially during the retention period.

The mechanical factor primarily influences the degree of rotation. For the sake of clarity, the root may be divided into two halves, one lingual and one labial. It is found that the mechanics of the appliance will determine which portion of the root will be moved the most. The appliances used in the experiments are seen in Figure 2. Two of the experimental teeth were ligated directly to a 0.7 mm. labial arch. By this type of appliance some movement was obtained, mainly of the lingual portion. Traction exerted by one spring would increase the movement of the lingual portion, a method applied in two cases. Still more rotation was obtained when this force was counteracted by a spur resting on the labial surface of the tooth, Fig. 2B.

Eleven teeth were moved by springs exerting traction in opposite directions,

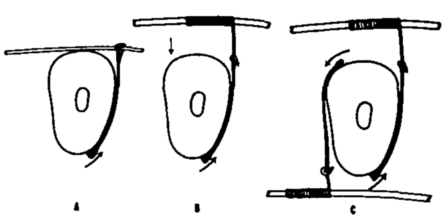


Fig. 2 Methods applied for rotation. Upper arrow, B, indicates spur counteracting traction by spring.

by which a considerable rotation could be obtained, Fig. 2C. Each of these springs exerted forces around 30 g. The degree of rotation obtained varied between fifty and seventy degrees. By grinding occlusal surfaces, the tooth to be rotated was kept out of occlusion as long as the experiment lasted. Figure 3 represents the average degree of rotation. The time periods required for this movement varied between eight to twelve weeks in the younger animals. Slightly more time was required for rotation of the teeth in the older animal, an observation which is well

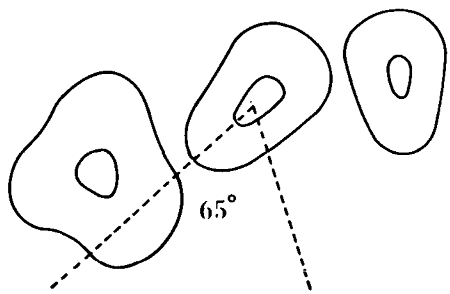



Fig.3

known from other experiments.

The areas to be examined may be divided into marginal, middle and apical regions, Fig. 4. In the free gingival fiber group of the marginal region, a marked displacement and stretching of fibrous structures was observed in all cases. Because the free gingival fibers are continuous with the whole fiber system of this area, stretching will cause displacement of fibrous structure at some distance from the rotated tooth, Fig. 5. This seemed to be caused primarily by the fiber group attached to the lingual or labial surfaces of the root, Fig. 6. It was even found that tension had been exerted on the epithelial processes, which were inclined as a result of traction by subjacent fibrous structures.

In the middle region, usually bone

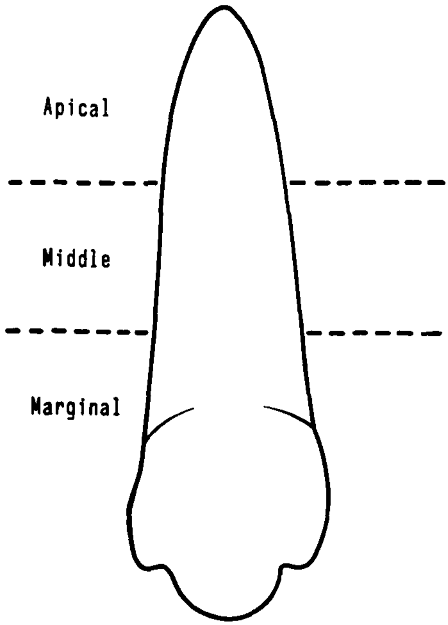



Fig. 4


Fig. 6 Cross section of the marginal region, well-spaced teeth. A, fiber bundles adjacent to the rotated tooth, arranged obliquely. B, normal arrangement of periodontal fibers adjacent to the control tooth, C. D, undistinct layer between stretched and relaxed fiber bundles.

resorption was observed in two pressure areas, while there was stretching of periodontal fibers and bone formation in two corresponding tension areas, Fig. 7. Great variations existed in the degree of tissue response on the pressure sides. In a few experiments of short duration compressed cell-free fiber bundles were found in one pressure area and direct bone resorption in the other. Frequently direct bone resorption was observed in areas where the root was moved parallel to the bone surface or where the pressure was moderated because the tooth moved contacted the proximal tooth. A typical direct bone resorption of the lingual area is seen in Fig. 8. Indirect resorption had taken place more frequently in the labial than in the lingual pressure areas. Because an indirect resorption process will last for two to three weeks,[5] undermining of compressed areas was completed in all experiments of longer duration. Shallow root resorptions were observed in some cases together with an extensive undermining of bone tissue. Two teeth, not included in this series and rotated nearly 90°, exhibited corners that were flattened by resorption during tooth movement, Fig. 9. Such aftereffects of an indirect bone resorption can hardly be avoided and represent a typical reaction follow-

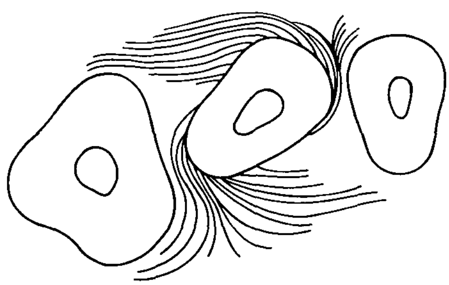
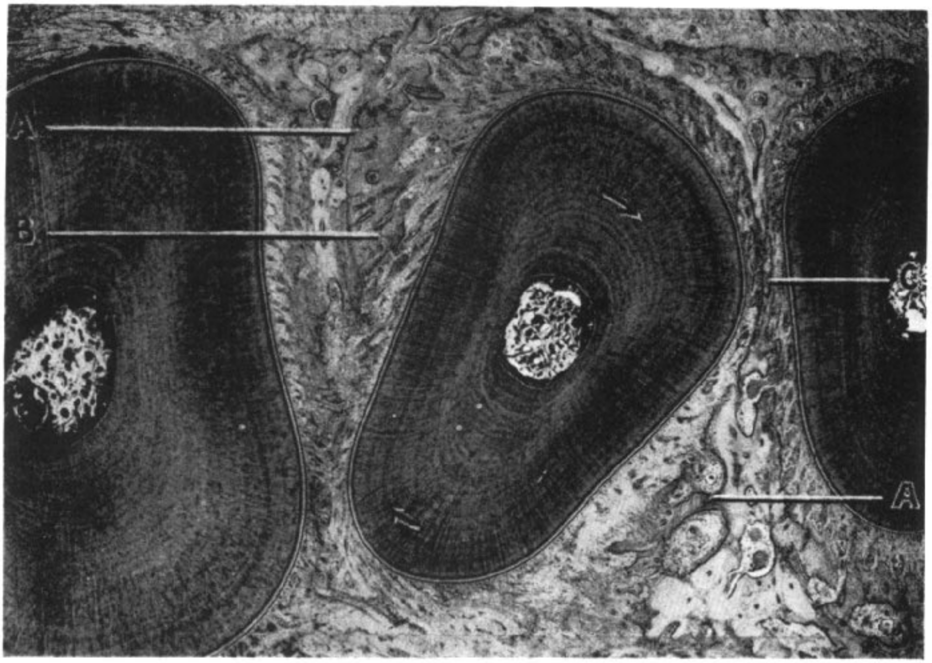


Fig. 5 The arrangement of free gingival fibers following rotation of teeth.



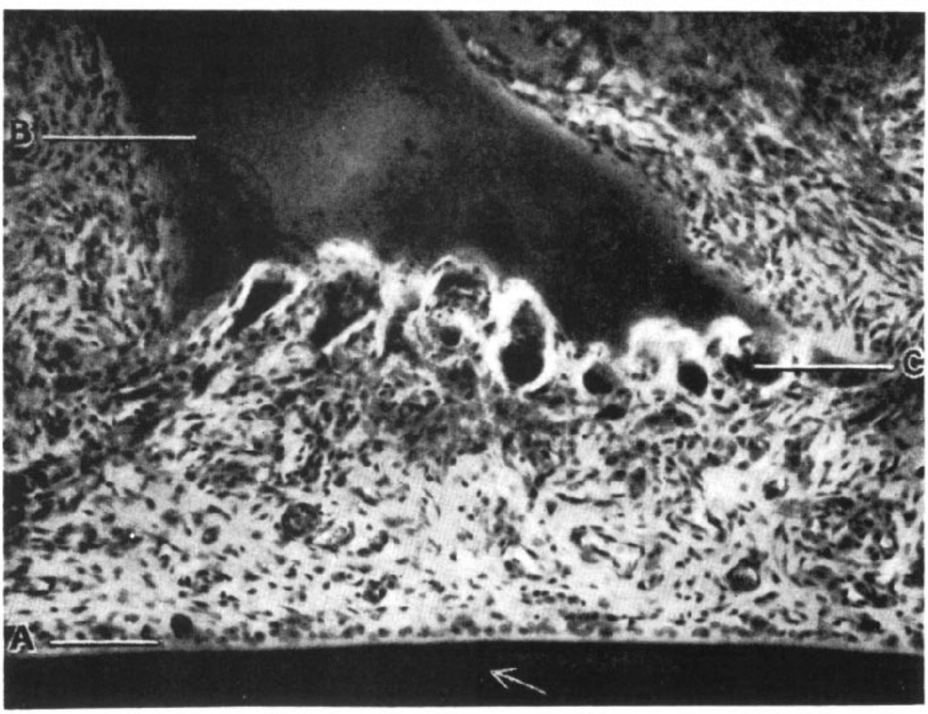




Fig. 7—Above. Section of the middle region. A, resting lines between old and newly formed bone, B. C, thin bone layer between control tooth and rotated tooth.

Fig. 8—Below. Cross section of a pressure area. A, thin cementum line along the root surface; the tooth moved as indicated by arrow. B, protruding bone spicule under direct resorption by large osteoclasts, C.

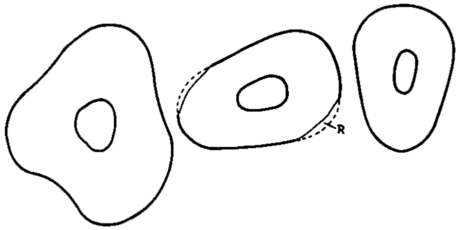



Fig. 9 R, amount of root substance removed by resorption following extensive rotation.

ing an extensive rotation of teeth. In some instances resorbed areas of the root were already repaired by cellular cementum.

The changes taking place on the tension sides were greatly influenced by the traction exerted on fiber bundles. A demarcation or resting line was observed between old and new bone layers. New bundle bone and osteoid tissue were found arranged in tongue-like spicules along stretched fibers, Fig. 10. Hence opposition of new bone is stimulated by the traction exerted by fiber bundles.[3,4] This traction will also stimulate formation of cellular cementum along the root surface. In some cases a marked increase in the thickness of the cementum layer was found

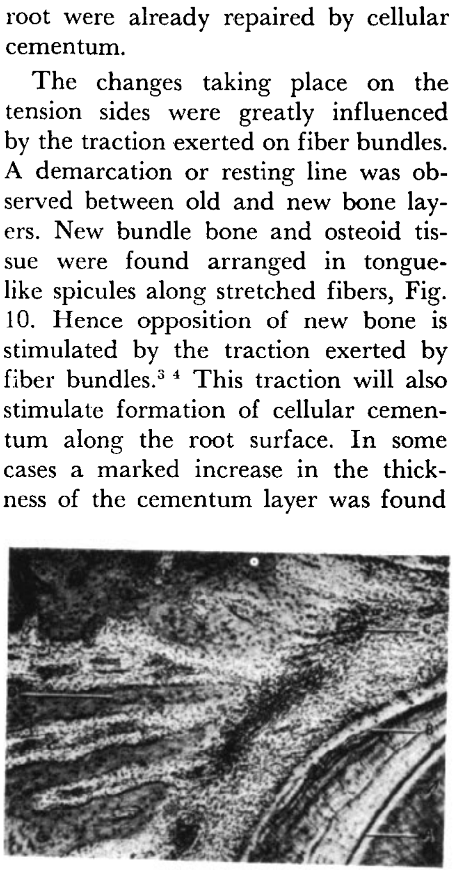


Fig. 10 Tension side, middle region of upper second incisor in older animal. A, line indicating thickness of cementum layer; B, demarcation line between old cementum and rapidly formed new cementum layer; C, zone with proliferating cells; D, new bone spicules formed as a result of tooth movement.

on the tension side, Fig. 10, while very little cementum had been deposited on the pressure side, Fig. 8.

In the apical region the supporting fibers were arranged obliquely. A moderate increase of new bone layers was observed in certain areas of the inner bone wall.

Since rotation causes extensive changes in the alveolar bone, with elongation of fiber bundles in the periodontal membrane as well as stretching and displacement of the free gingival fibers, it is obvious that the rotated tooth must be retained while rearrangement of these structures takes place. In experiments on retention one should be able to observe the length of time required for a rearrangement of the structures involved.

### Retention after rotation

The retention appliance consisted of bands cemented on the first and second upper incisors. The rotated tooth was maintained in position by two short pieces of wire, one soldered to the lingual sides and one to the labial sides of the bands. The end of the labial section rested on the labial surface of the third incisor. In cases where the tooth had been rotated in the opposite direction, the end of the lingual section rested on the lingual surface of the third incisor. An examination of the supporting structures of retained teeth may be applied to the same areas as mentioned previously, i.e. the marginal, middle and apical regions. Two kinds of tissues are of special interest, the fiber bundles of the periodontal membrane and the newly formed bone tissue.

*Fibrous tissue.* As seen from Table I six teeth were retained for periods varying from 15 to 232 days. Rearrangement of fibrous tissue means that the periodontal fiber bundles are again running more or less perpendicular from the root surface, as seen in the

Rearrangement of Fibrous Tissue

| Tooth | Retention | Marginal Region | Middle Region | Apical Region |
|---|---|---|---|---|
| +2 | 15 days | | | |
| 2+ | 28 days | | ++ | ++ |
| +2 | 57 days | + | ++ | ++ |
| 2+ | 83 days | + | ++ | +++ |
| +2 | 147 days | + | +++ | +++ |
| 2+ | 232 days | + | +++ | +++ |

Table I + indicates partly, ++ fairly well, and +++ completely rearranged fibrous tissue after retention.

supporting structures of the control teeth. In Table I the marginal region comprises the areas of the gingival free and transversal fibers. It was found that no rearrangement of fibrous structures had taken place in the marginal region after retention periods of 15 and 28 days. The periodontal fibers were running obliquely, partly parallel to the root surface. In the other cases some rearrangement was observed, chiefly on the mesial and distal sides of the root. It was noted that the fiber bundles attached to the labial and lingual sides of the root were still under tension.

In areas where the teeth were well spaced, the transversal fiber group was arranged in two layers, one running obliquely from the experimental tooth, the other perpendicular from the surface of the control tooth. A similar arrangement is seen in Fig. 6. In other areas where the tooth position was narrow, silver impregnation staining would disclose that the transversal fiber bundles were elongated and running obliquely from the rotated tooth to the control tooth. In areas close to the bone crest the transversal fibers gradually assumed a more normal arrangement. It is of interest to note that the free fiber bundles of the teeth, retained for 147 and 232 days, still remained stretched in accordance with the previous movement of rotation. This especially applies to the fiber bundles attached to the labial and lingual surfaces of the root, Fig. 11.

In the middle region of the root (Table I) the periodontal fibers were still arranged obliquely after a retention period of 15 days. After 28 days the fiber bundles were fairly well rearranged. This applies to the retention periods of 57 and 83 days as well. Complete rearrangement was found after periods of 147 and 232 days.

In the apical region a rearrangement similar to that observed in the middle region had taken place. Figure 12 shows an area from the labial side of the root retained for 147 days. The orientation of these periodontal fibers can hardly be distinguished from that of a control area.

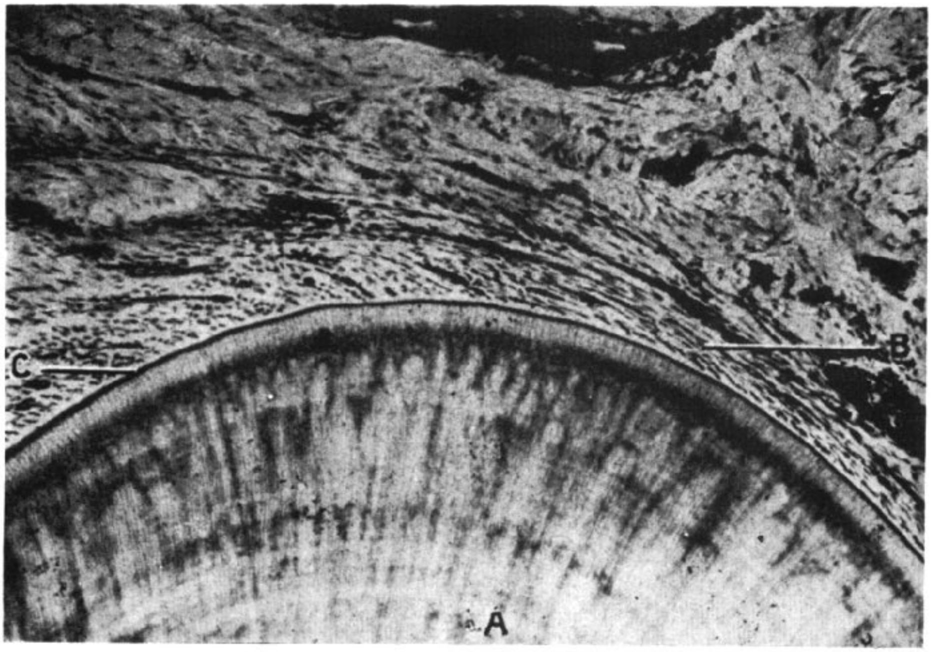
## Bone Tissue

The observations made of bone changes are listed in Table II. In all regions very little rearrangement was observed after a retention period of 15 days, with partial rearrangement after 28 days; a more advanced bone reorganization had occurred in the other cases. It was seen in the first section of this study that new bone was formed along stretched fiber bundles. This tongue-like bone formation was observed in the experiments on retention after periods of 15 days. After retention for 28 days new bone had been

Rearrangement of Bone Tissue

| Tooth | Retention | Marginal Region | Middle Region | Apical Region |
|---|---|---|---|---|
| +2 | 15 days | | | |
| 2+ | 28 days | | + | + |
| +2 | 57 days | + | ++ | ++ |
| 2+ | 83 days | ++ | ++ | ++ |
| +2 | 147 days | ++ | ++ | +++ |
| 2+ | 232 days | ++ | +++ | +++ |

Table II + indicates partly, ++ fairly well, and +++ completely rearranged bone tissue after retention.



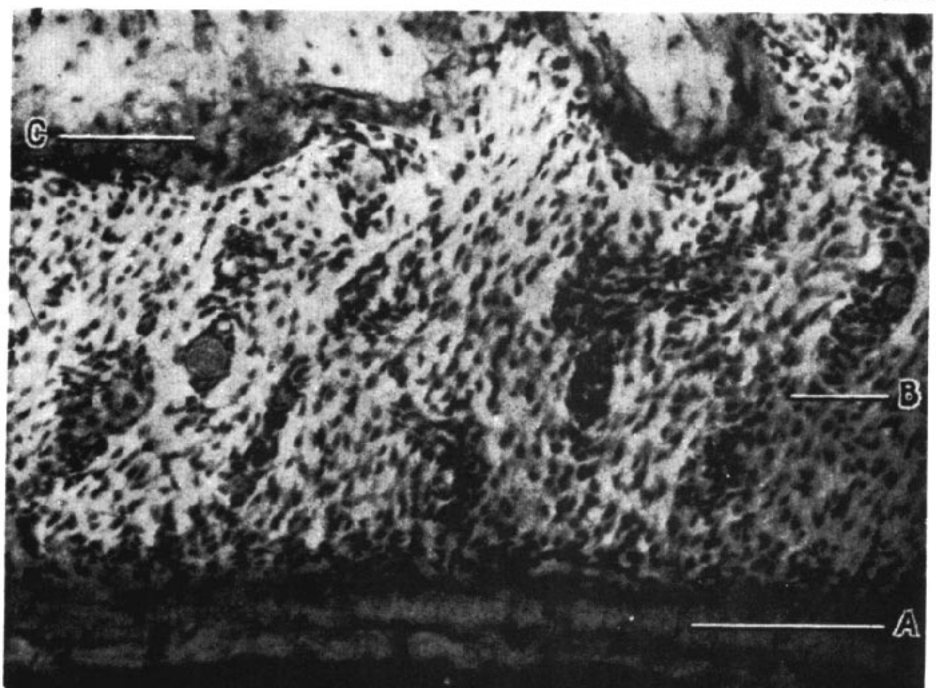




Fig. 11 — Above. Marginal region, cross section of rotated tooth, A, retained for 232 days; B, elongated and stretched fiber bundles; C, thin cementum layer along the root surface.

Fig. 12—Below. Apical region, cross section of tooth retained for 147 days; A, cementum layer of root surface; B, rearranged fiber bundles of periodontal membrane; C, rearranged alveolar bone tissue.

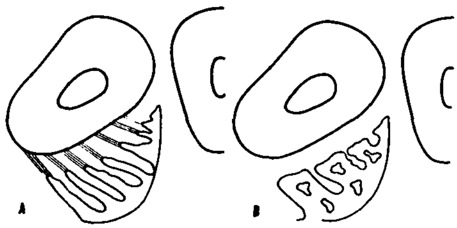


Fig. 13 A, illustrating how bone spicules are formed along stretched fiber bundles; B, rearrangement of bone tissue following retention of the tooth moved.

added between these first bone spicules. Figure 10 shows an area of the tension side in one of the non-retained cases. In a corresponding area of the tooth retained for 57 days, new bone had filled out the spaces between these spicules. The transformation of bone structures may be illustrated as seen in Fig. 13. After retention periods of 147 and 232 days a still more complete reorganization of bone tissue had taken place, Fig. 12.

## Discussion

In a discussion of the present findings one may question to what extent the supporting structures of animals can be compared with human tissues. It appears that the arrangement of the supporting structures in man and the dog is fairly similar. The changes taking place in the alveolar bone are also quite similar. The periodontal fiber bundles, however, are coarser in the dog than in man and the bone tissue in the dog is frequently denser. One should also remember that in practice rotated teeth are usually moved to a position of greater mechanical advantage. The opposite is frequently the case in experimental tooth movement. These reservations must be taken into consideration when experiments on rotation are evaluated.

It has been shown in the series of retained cases that the arrangement of the structures in the gingival fiber group is different from that seen in other areas. The persistence of stretching and displacement of fiber bundles in the marginal region indicates that complete rearrangement of the supporting structures requires a longer period of retention than 232 days.

Why free gingival fibers remain in a stretched position may be explained by the fact that they are attached to a movable fibrous system which, to some extent, may be displaced even at some distance from the tooth moved. In addition, the supra-alveolar structures contain elastic fibers which may yield to traction during rotation. The result of this will be a tissue that will remain stretched during the retention period. Forces leading to contraction of these fiber bundles will enter into action at the moment the tooth is released, by which relapse of the tooth moved may occur.

On the other hand, the periodontal fibers, running from the root surface to the bone surface will be fairly well rearranged after a retention period of twenty-eight days. It is therefore not likely that relapse of a retained tooth is caused by contraction of principal fibers, but primarily by a persisting displacement of supra-alveolar structures in the marginal region.

In his articles on this problem, Skogsborg (1932) advocated transection of fibers and bone structures in the septal areas of the tooth moved. According to the present findings this is certainly necessary if the rotated tooth is not retained at all. Because contraction of the gingival fibers may be strong enough to cause resorption of new bone layers adjacent to the rotated tooth even after a retention period, it would seem advisable in extreme cases to transect stretched fibers in the marginal region. Surgical transection of bone structures would hardly be necessary following a retention period.

The easiest way, however, to solve the problem of rotating teeth would be to correct the tooth position as early as possible, preferably before the apical portion of the root is developed. New periodontal fibers would then be formed after rotation and thus prevent relapse of the tooth moved.

## SUMMARY

Experiments on rotation and retention of rotated teeth in young dogs reveal that some of the gingival fiber bundles will remain displaced and stretched even after a retention period of 232 days. Periodontal fibers running from the root to the bone surface will be rearranged within a retention period of 28 days. Relapse of the rotated tooth after retention seems to be caused primarily by a contraction of displaced gingival fibers and other supra-alveolar structures. According to these findings overrotation of teeth would seem advisable in order to ensure a correct tooth position after the retention period. It would also be an advantage to transect stretched fibers around the tooth moved. Early correction of a rotated tooth position would prevent relapse of the tooth moved because new fiber bundles, formed in the apical region, would assist in retaining the rotated teeth.

*Radhusgaten 8*

## REFERENCES

1. Erikson, B. E., Kaplan, H. and Aisenberg, M.S.: Orthodontics and Transeptal Fibers. *Am. J. Orth. & Oral Surg.*, 31, 1, 1945.
2. Hallett, G. E. M.: Immediate Torsion: A Preliminary Report on Twenty-three Cases. *Dent. Practitioner* 7:108, 1956.
3. Macapanpan, L. C., Weinmann, J. P. and Brodie, A. G.: Early Tissue Changes following Tooth Movement in Rats, *Angle Ortho.* 24: 79, 1954.
4. Reitan, K.: The Initial Tissue Reaction Incident to Orthodontic Tooth Movement. *Acta Odont. Scand.* Supplementum 6, 1951.
5. ————Some factors Determining the Evaluation of Forces in Orthodontics. *Am. J. Ortho.* 43: 32, 1957.
6. Sicher, H.: The Principal Fibers of the Periodontal Membrane. *The Bur*, 55: 2, 1954.
7. Skillen, W. G. and Reitan, K.: Tissue Changes Following Rotation of Teeth in the Dog. *Angle Ortho.* 10: 140, 1940.
8. Skogsborg, C.: The Permanent Retention of the Teeth After Orthodontic Treatment. *Dental Cosmos* 69: 1117-1129, 1927.
9. Septotomy in Connection with Orthodontic Treatment. *Int. J. Ortho.* 18: 1044-1057, 1932.
10. Thompson, H. E., Myers, H. I., Waterman, J. M. and Flanagan, V. D.: Preliminary Macroscopic Observations Concerning the Potentiality of Supra-alveolar Collagenous Fibers in Orthodontics. *Am. J. Ortho.* 44: 485, 1958.