Tissue Changes Following Rotation of Teeth in the Dog*

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DURING the past two or three decades many investigations have been made of the changes which occur in the investing tissues of the teeth as a result of various types of tooth movements. It is interesting to note that as early as 1847, Flourens[1] stated that in tooth movement resorption took place on the side of the bone toward which pressure had been exerted with deposition of new bone on the opposite side. Curiously enough he apologized for this statement, considering it a closed problem at that time. Sandstedt,[4] in 1904, on the basis of experimental studies with dog material, proved the theory of Flourens to be generally true. This work of Sandstedt is of fundamental importance, but it would appear that it has received less consideration than it merits.

Oppenheim[3] added greatly to this earlier knowledge through a study of both animal and human material. Schwartz,[5] Gottlieb and Orban,[2] and subsequently Stuteville,[6] have also contributed considerable factual evidence on the subject. In no instance, however, have the results of rotation of teeth been discussed. Oppenheim seems to have felt that such a study would not prove to be of any great value, apparently because of the difficulty involved in orientation. However, regardless of this opinion, it did seem of interest, if not of value, to endeavor to determine just what might be discovered by some experiments along this line, and the facts thus disclosed are presented in this report. The conditions under which it was necessary to conduct these preliminary experiments were so varied that it is only possible to give the findings and point out one or two possible relationships. (Tables 1 and 2)

Table 1

Group	Location	Force	Time Days	Total Time	Distance Activated	Times Reactiv.	Time Retained	Degrees Rotated
1	E - L	250g	3	3	4.5mm	0	0	23
	E - R	160g	5	5	4.5mm	0	0	32
2	A - R	110g	37	37	1.0mm	5	0	27
	B - L	9g	21					
		13g	12	33	6.0mm	0	0	45
	B - R	16g	33	33	5.5mm	0	0	40
	C - R	15g	48	48	4.0mm	0	0	46
3	C - L	22g	14					
		33g	12					
		55g	21	47	4.0mm	3	0	65
4	D - L	250g	27	27	0.5mm	5	12	14
	D - R	20g	12					
		30g	10					
		50g	8	30	0.5mm	3	9	23

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The three types of appliances used in this study are illustrated diagrammatically in Fig. 1. The arch wires in each instance consisted of a round 18 gauge wire. Appliance A was activated by a 24 gauge precious metal spring ligated by an .007 stainless steel wire between the loop of the spring and the lingual staple. Appliance B was activated by an .010 stainless steel ligature passing directly from the lingual staple to the arch wire. In the application of both of these appliances, the arch wires were placed in contact with the labial surfaces of the teeth. Appliance C constitutes a more accurate and favorable means of inducing rotation. The arch wires did not contact the surfaces of the teeth. The springs consisted of .010 stainless steel, ligated by .007 stainless steel wire to the staples on the labial and lingual surfaces of the teeth.

The material, consisting of the upper right and left second incisors from five animals, has been grouped into four classes (Tables 1 and 2) on a basis of the character and degree of the changes which occurred. This was

Table 2

Case	Type Appliance	Type Force
E - L	C	Heavy Cont.
E - R	C	" "
A - R	A	" Interm.
B - L	C	Light Cont.
B - R	C	" "
C - R	C	" "
C - L	C	Med. Cont.
D - L	B	Heavy Interm.
D - R	B	Med. "

done in an endeavor to see, if possible, what factors influenced these changes, and the particular mechanical methods responsible for the relatively similar tissue changes found in each group. Group 4 consists of two teeth from the same animal which were retained for twelve and nine days respectively. The groups with the respective data of each experiment comprising them, including the force applied, the activation and the time and degree of rotation obtained are indicated in Table 1. It should be understood that all of these factors, with the exception of time, are subject to error, although as much care as possible was taken to insure accuracy. This is especially true where type B appliance was used. As a matter of fact, some doubt may be expressed as to whether it is possible to measure the force exerted by such an appliance. Table 2 indicates the type of appliance and the character of the force, i.e., whether light or heavy, and whether continuous or intermittent.

In general, the reactions which occurred were similar in character to those which usually result from all other movements of teeth, consisting in the main of compression and necrosis of the peridental membrane, resorption of tooth surface, bone-resorption and bone building. A certain amount of tipping, especially with the use of Appliances A and B, occurred. This happened to a lesser degree with Appliance C, but even here a certain

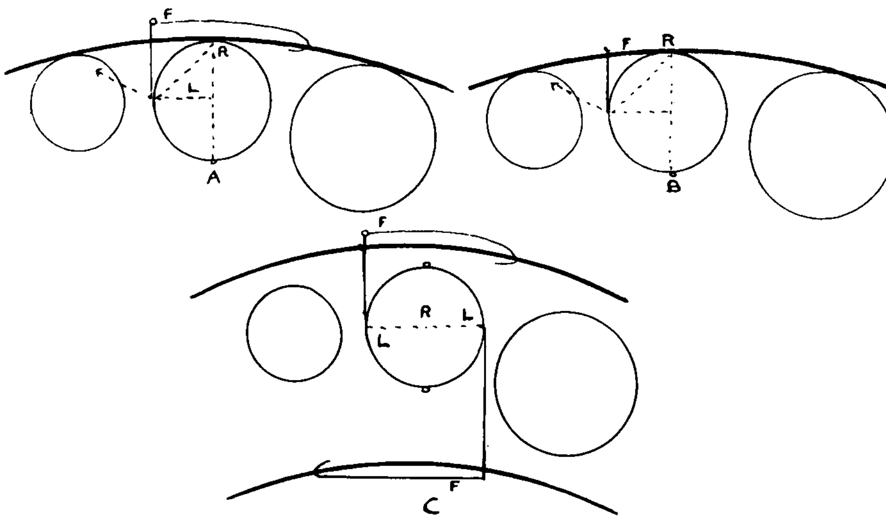
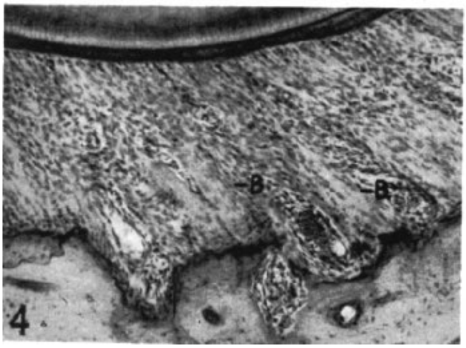


Fig. 1.—Types of appliances and arrangement in relation to the teeth. Arch wires—18 gauge, round. Appliance A—spring, 24 gauge precious metal; ligature, .007 stainless steel wire. Appliance B—.010 stainless steel ligature. Appliance C—springs, .010 stainless steel; ligatures, .007 stainless steel wire.

amount of tipping will take place unless the labial and lingual forces can be accurately equalized. It would appear, as Stuteville has stated, that the distance through which a tooth moves, in the main, is the deciding factor in the ensuing degree of injury. But from the results of these experiments, is would also seem advisable to give some consideration to the duration of time through which a given force is active. This should become apparent in the following description of tissue changes in Group 1.

Figures 2, 3 and 4 indicate, in general, what occurred under circumstances involving relatively heavy, continuous forces, active for a short space of time, i.e., 250 and 160 grams activated to 4.5 mm. for three and five days respectively (Table 1—Group 1). The amount of rotation obtained in the first instance was 22° and in the second 32°, a difference of 10° in the movement of the teeth. Although the resulting injuries and changes were very similar, they were slightly more pronounced in the second instance with the compression and necrosis of peridental membrane because of the pressure of tooth against bone on the pressure sides, Figs. 2-P and 3-A, being more extensive. Underlying resorption of the bone, Fig. 3-R, has already set in, but in this time limit bone formation in the traction areas, Figs. 2-T and 4-B, has only just begun, as indicated by the hyalinization of the fibres of the peridental membrane.

The fact that the changes were slightly more emphasized in the second experiment of this first group (Table 1) in spite of the fact that less force was used and the activated distance was the same, would tend to indicate that in this instance time was the more important factor. A greater amount of rotation was obtained in five days with a lesser amount of force than was obtained in the first instance in three days with a greater force.



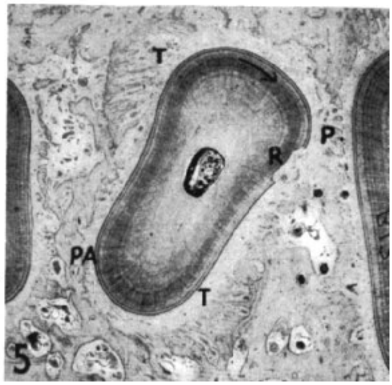


Fig. 2.—Characteristic of Group 1 (Table 1). Arrow, direction of rotation; T, traction areas; P, pressure areas. (See figures 3 and 4.)

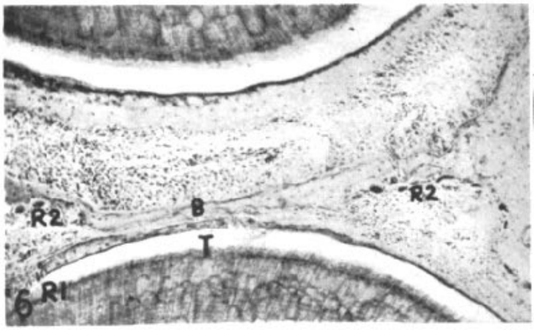
Fig. 3.—Pressure area. A, compressed and necrotic peridental membrane; R, undermining resorption from medullary spaces.

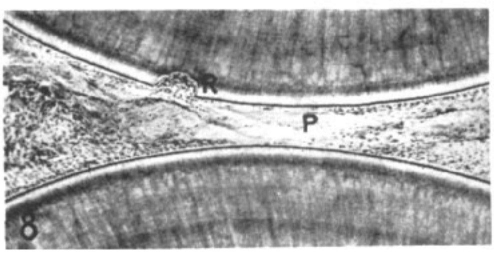
Fig. 4.—Traction area. Early stage in formation of bone, B, in hyalinization of the fibres of the peridental membrane.

Fig. 5.—Characteristic of Group 2 (Table 1). Arrow, direction of rotation; T, traction areas in which there appears considerable new bone (See figure 10); P, PA, pressure areas; R, root resorption.

Figure 5 represents the changes in general which occurred in the next group (Table 1—Group 2) as the result of continuous and intermittent forces varying between 11, 15, 16 and 110 grams. The duration of time covered was 33, 48 and 37 days respectively with activated distances of 1 to 6 mm. The degree of rotation obtained ranged from 27° to 46°. Tooth resorption near the area of greatest pressure, i.e., where tooth and bone came into closest contact, was of common occurrence, Fig. 5-R, while on the side of less pressure, compression and necrosis of the peridental membrane only were found (Figs. 5-PA and 3). In the traction areas, Fig. 5-T, more or less new bone had been laid down in a trabecular form similar to that shown in Fig. 10-B.

It may be of interest to consider the factors of force, time and distance back of the movement of the teeth in two of the cases in this group. In one instance, a force of 15 grams activated to 4 mm. over a period of forty-eight days resulted in a rotation of 46°. In contrast to this is the second instance in which 110 grams of force, activated 1 mm. and reactivated a similar distance five times over a period of thirty-seven days, resulted in only 27° of rotation, yet in both instances (Fig. 5), the changes which occurred were practically similar. It would seem necessary to take into consideration both time and distance in these particular cases. In the





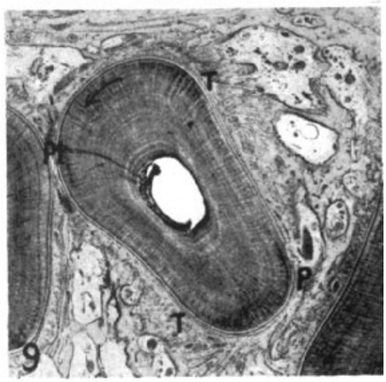


Fig. 6.—Characteristic of Group 3 (Table 1). Arrow, direction of rotation; T, traction areas; pressure greater at P1 than at P2; R1, root resorption. (See figures 7, 8 and 9.)

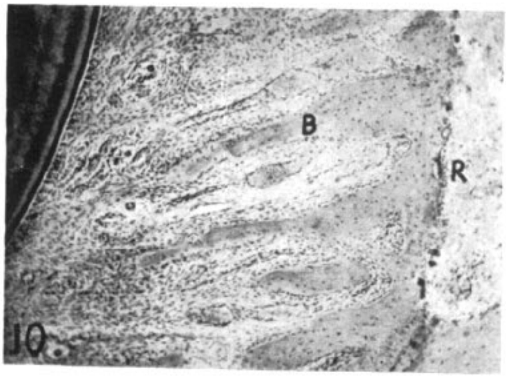
Fig. 7.—Area P1 of figure 6. Tooth, T, in close contact with bone B; R1, root resorption; R2, undermining bone resorption.

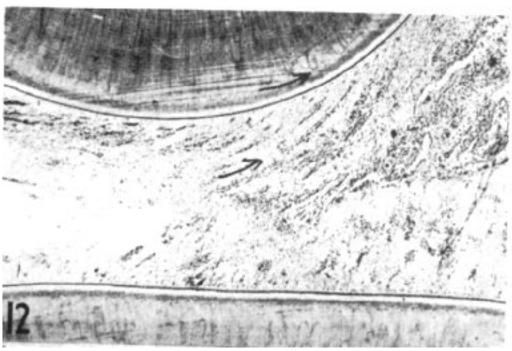
Fig. 8.—Higher level of tooth in figure 6. Excessive trauma P1. (See figure 9.)

Fig. 9.—Area P1 of figure 8. All bone between the two teeth has disappeared. P, compression and necrosis of peridental membrane; R, root resorption.

latter instance, time and reactivation would seem to have made up for the greater distance of activation in the case of the former. In the remaining two cases in this second group the distance of activation of 6 and 5.5 mm. respectively would appear to be the more important factor.

Figures 6, 7, 8 and 9 illustrate the most severe tissue disturbances which took place in this series of experiments (Table 1—Group 3). The time element was forty-seven days. Under a reactivated force of 22 grams for fourteen days, 33 grams for twelve days and 55 grams for twenty-one days, a total of forty-seven days, activated to 4.0 mm., a rotation of 65° was obtained. Here, all told, was a relatively light force acting over a period of time no greater than in some of these other cases, but which resulted in a greater





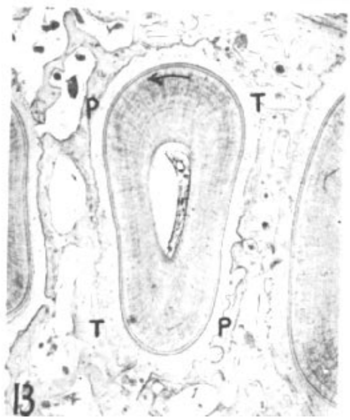


Fig. 10.—B, new bone formation in trabecular arrangement on a traction side, with compensating resorption, R, in medullary space.

Fig. 11.—A compression area undergoing repair, A, by resorption by osteoclasts. Bone on peridental membrane side has levelled off corresponding to width of new space, and a compensating formation, B, is taking place in the medullary space.

Fig. 12.—Trans-septal fibres in rotation. Arrows indicate direction of rotation and arrangement.

Fig. 13.—Characteristic of Group 4 (Table 1). Retention. T, original traction areas; P, original pressure areas. (See figure 14.)

movement of the tooth and produced more outstanding changes. In this case it would appear that the actual distance, not the activated distance, through which the tooth moved was the principle factor in bringing about these conditions.

Figure 6-P1 shows the tooth and the bone in close apposition with undermining resorption affecting both structures (Figs. 7-R1 and -R2). At a slightly higher level (Figs. 8 and 9), all bone had been lost between the two teeth, with resorption of the root of the rotated tooth (Fig. 9-P and -R), and the intervening peridental membrane, P, compressed and necrotic. In a study of the entire series of sections these areas of necrosis and bone and tooth resorption are quite extensive in an inciso-apical direction, as well as in a circumferencial direction.

Figure 10-B illustrates a characteristic late stage in the bone building process which occurs in traction areas (Figs. 5, 6 and 8). To compensate for the increased thickness of new bone, a thinning down by means of resorption frequently takes place in adjacent medullary spaces (Fig. 10-R).

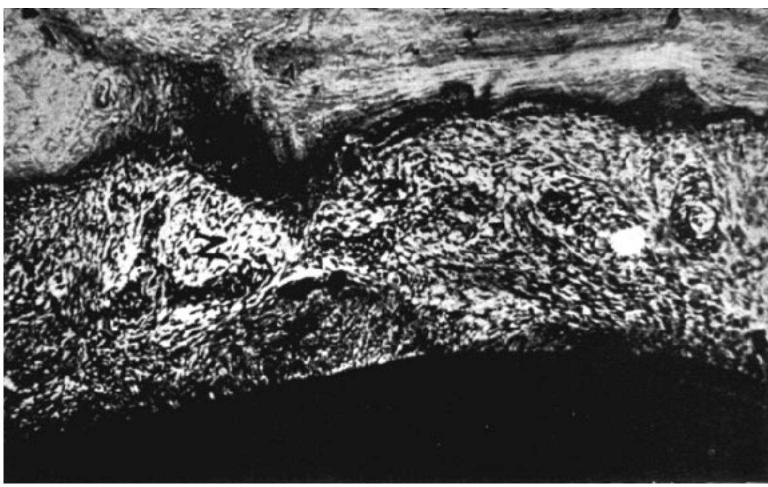


Fig. 14.—Area P in figure 13. Regeneration of a compressed area of the peridental membrane; N, new fibers.

The new bone is laid down in long trabeculae, paralleling the direction of the taut peridental membrane fibres. Subsequently, a smoothing-out will take place through lateral development of bone which will bridge and unite these trabeculae. In compression areas, when bone on the peridental membrane side of the alveolus is resorbed, the lost bone is usually compensated for by the building of new bone in the medullary space (Fig. 11-B).

Figure 12 illustrates to some extent the direction taken by the transseptal fibres in rotation, the arrows indicating the directions. It might be expected that such a tension on these fibres would result in some movement of adjacent teeth. However, in these experiments such effects were not observable.

In most of the former studies along this line, little has been said in regard to what happens during retention. It can be agreed upon that the important consideration is not what occurs during the movement of teeth but how the tissues and structures involved recover. Therefore two cases were carried through on this basis. One was under heavy force of 250-300 grams, reactivated five times over a period of twenty-seven days; the other a relatively light, reactivated force of from 20 to 50 grams over a period of thirty days. The activated distance was only .5 mm. and the degree of rotation obtained, 14° and 23° respectively, was relatively small. The periods of retention were twelve and nineteen days. The results obtained in both cases during the retention are fully illustrated in Fig. 13. All the evidence which remained of the changes which may have existed was a final smoothing-out process, as it were, in the presence of osteoclasts here and there in the pressure areas, P, with new, young peridental membrane occupying the area that was previously necrotic (Fig. 14-N), and a rounding off through bone building in the tension areas, Fig. 13-T. No tooth resorption had occurred in these cases and the short distance over which the tooth had been activated and moved probably had prevented any particularly great tissue disturbance.

These studies indicate that it is quite feasible to satisfactorily study rotation movements of teeth. Furthermore, they serve excellently to throw further light on the details of tissue change which may occur in any movement of the teeth. They also seem to indicate that the distance through which a tooth moves and to a certain extent, the time involved, are factors to be given consideration in order to avoid creating too much injury to the structures in question.

Further experiments, better controlled than those constituting this preliminary survey, are now being conducted.

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