The Dentoscope

Volume 19 | Issue 2 Article 1

7-1939

Root Resorption in Vital Permanent Teeth

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ROOT ABSORPTIONS IN VITAL PERMANENT TEETH*

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THE RECOGNITION of resorption of the roots of vital permanent teeth is not of recent occurrence. This is shown by the statement of John Tomes in 1859 that, "The removal by absorption of more or less of the root in teeth, the crowns of which have been injured by disease, has already been mentioned, but cases arise from time to time in which, while the crown of a tooth is perfectly sound, the root is attacked."

A case report and an extensive discussion of physiological and pathological resorption of tooth roots was presented in 1914 by Rodriques Ottolengui. The report described a case under orthodontic treatment in which root resorption of the upper anterior teeth had occurred.

However, the subject of root resorption in vital permanent teeth did not arouse much interest until a decade ago when Albert H. Ketcham presented a report of investigation of apical resorption. He had radiographic evidence that of 385 patients under orthodonic treatment 21% had root absorption of this type. This stimulated investigation of the problem by such men as Marshall, Becks, and more recently Rudolph. The present day approach to the problem has been by means of radiographs of cases and by histologic sections of teeth affected by resorption. Becks used radiographs to determine presence of resorption and then followed up with a physical examination of the patient. Rudolph used radiographs to determine what percentage of the cases examined showed resorption. Marshall conducted his experiments on monkeys. He used appliances to move teeth, then killed the animals and made histologic sections of the teeth moved. Other investigations using orthodontic appliances on experimental animals have been conducted by Schwarz, Oppenheim, and Stuteville. Following a suggestion of Ketcham's considerable work has been done along these lines by Oppenheim and Stuteville, using human material.

*Presented as a faculty seminar, April 6, 1938.

At this point it may be well to discuss the process of root resorption.

According to Kronfeld root resorptions as well as bone resorption are characterized by the presence of special cells, osteoclasts, which seem to eliminate the calcified tissue at once, without any previous decalcification. It is thought that the osteoclasts develop either from the capillaries in the connetcive tissue itself by the transformation of osteogonetic cells or undifferentiated mesenchyme cells into osteoclasts. Osteoclasts may be either polynuclear (giant cells) or mononuclear cells. The giant cells have anywhere from two to a few dozen nuclei found in the centers of large protoplasmic cell bodies. These cells are found in bay-like excavations in the hard surface, Howship's lacunae. Mononuclear osteoclasts are small spindle shaped cells which resemble osteoclasts. They are found in shallow indentations along the hard surface. The difference between the two types of cells is not known. However, the resorptive process is much faster and greater in areas containing the mononuclear cells. Giant cells are found in those cases of rapid and extensive root resorption.

Root resorptions differ from bone resorptions in one respect, however. In bone new formation and resorption occur as a physiological process throughout life, whereas in the permanent teeth only new formation takes place physiologically, ie., formation of dentine and cementum. Any resorption is a sign of pathological process. Root resorptions cause loss of attachment of peridental membrane to the involved area of the root. The corresponding bone of the alveolus would also be resorbed due to loss of functional stimuli, acording to Orban. The peridental membrane thus becomes wider in the damaged areas. When repair takes place new cementum, in which new fibers are embedded, is deposited on the resorbed root surface, functional stimuli are again transmitted to the bone, which is regenerated until the original width of the functioning peridental membrane is established. This process is called functional repair. Often the reparative formation does not reach the level of the original root surface, in which case the bone projects into the depressed area of the root leaving a periodontal space of uniform width betwen the two hard tissues.

Root resorptions in vital permanent teeth may be due to systemic or unknown causes, and are then classified as idiopathic resorptions. On the other hand, they may be due to tissue injury, and are classified as traumatic resorptions.

Idiopathic root resorptions are characterized by rapid and extensive destruction, sometimes progressing to the loss of the entire root. Kronfeld states that, "Under this heading we must put all puzzling cases of root resorption that are observed from time to time in permanent teeth with intact pulps. Sometimes only one tooth in a full set is resorbed, sometimes several teeth are involved, but all cases have one thing in common; namely, it is impossible to explain the process by a local cause. It must be assumed that some internal disturbance led to the generalized resorptions. Sometimes the case history can be traced back to some accident (trauma) that might have started the process; it seems possible that a small traumatic resorption instead of being repaired, became larger and gradually involved the entire root."

In an extensive study of root resorptions of this type, Hermann Becks checked every posisble etiologic relationship in a large group of patients suffering from root resorptions. He states, "From a practical point of view it seems as though the question of determining factors which influence the individual susceptibility to root resorption is the most important one, because the nature of these factors determines to a large extent the frequency of these lesions. Very few attempts have been made to determine the biologic factors involved in the so-called idiopathic resorptions, or the resorptions following orthodontic treatment. Even fewer attempts, if any, have been made to determine whether or not both forms may have identical biologic backgrounds."

Becks was able to demonstrate that of one hundred patients having root resorption, (fifty with previous orthodontic treatment and fifty without previous orthodontic treatment) a great frequency of endoncrine disturbances and other systemic diseases which were found in co-existence with root resorption. Of all endocrine disturbances hypo-thyroidism showed the greatest frequency, 60% in the group having previous orthodontic treatment and 40% in the untreated group. The untreated group, however, showed a higher frequency of pluri-glandular disturbances. The percentage of systemic diseases and endocrine disturbances in each group was 94%. There was a high frequency of low basal metabolic rate in both groups.

Kronfeld reports a case of resorption in an individual permanent tooth. A boy, aged fifteen years, was observed with extensive resorption in the upper first bicuspid. The tooth appeared slightly

discolored showing a pinkish hue. The radiograph revealed a very indistinct root outline and an abnormal configuration of the pulp chamber. The tooth was in normal occlusion, the crown intact; all other teeth in the mouth were normal. The bicuspid was removed. Histological section showed that dentine of both the root and crown had been replaced by cancellous bone. In some places the process of detnine resorption was still going on. On the entire crown there was left a thin outer cap of enamel which also had been attacked by the resorptive process. The pink discoloration of the tooth was caused by the pressure of a highly vascular soft tissue inside the crown, that shone through the thin enamel. No cause could be given in this case.

Muller, Rony, and Kronfeld describe a case in which the patient, a woman aged 38 years, was observed over a period of two years during which time extensive resorptions appeared on the roots of several intact permanent teeth. The rapidity of the destructive process is shown to some etxent by radiographs. In January, 1929, a shallow defect was visible near the alveolar margin on the mesial side of an upper second bicuspid. On March 6, a similar defect had occurred on the distal side of this tooth. About three months later, on May 27, these two defects involved the entire thickness of the root, thus separating the root from the crown. The tooth was removed, together with some of the gum tissue, sectioned and studied under the microscope. The resorptive process had undermined the enamel of the crown. The only dentine remaining was that immdiately surrounding the pulp, which formed a hollow column. A higher magnification showed a great number and dense arrangement of giant cells.

The lower right cuspid and first bicuspid were observed radiographically over a period of about seven months. They showed the same rapid process of root destruction between January and July, 1929. A specimen consisting of these two teeth was removed in July, 1929. It showed evidences of beginning repair in places as well as the extensive resorption of tooth substance. This is still clearer in the upper right lateral of the same patient. This tooth was intact in January, 1929; in July, 1929, two deep resorption penetrating from the mesial and distal sides had almost completely separated the root from the remaining part of the crown. In February, 1930, the lateral incisor was removed and examined microscopically. A photograph of a section through the crown revealed the presence of extensive deposits of a bone-like substance (cemen-

tum) inside the hollow crown. In some areas where the undermining resorption of the crown had already attacked the enamel from the inside, extensive deposits of cementum had occurred on the inner enamel surface.

In the case described above there was a generalized rapid process of tooth resorption going on in almost all the teeth. On making a thorough metabolic and internal examination, a disturbance in the liver was found. In the summer of 1929 treatment of the liver was started. From this time repeated tests showed that the function of the liver improved and that the resorptive process on the teeth came to a standstill; no more teeth were attacked, and the destroyed areas were reduced by new deposits of hard tissue.

Whether the dental condition and the hepatic disorder were related etiologically remains to be proved. Such proof could be established only after the same two conditions were found associated in a series of cases.

The second group of resorptions, consisting of resorptions due to trauma or pressure embraces:

1. Resorptions caused by impacted teeth.
2. Resorptions in impacted teeth.
3. Those resorptions found in teeth in close proximity to tumors and cysts.
4. Resorptions caused by traumatic occlusion.
5. Resorptions caused by orthodontic appliances.

In attempting to erupt teeth often contact the roots of neighboring teeth causing their resorption. Occasionally resorption takes place in the impacted tooth itself.

Pathological growths and cysts that develop in the jaws are likely to cause resorption of the teeth in their neighborhood. A benign growth is more likely to displace teeth, rather than cause resorption. A malignant tumor on the other hand, due to its rapid and destructive growth, usually causes rapid and extensive resorption of the roots that lie in the direction of its expansion.

The mechanism of tooth resorption in such cases is the same as in the case of resorption by a moving impacted tooth. The tumor causes pressure upon the connective tissue between its surface and the root, stimulating the connective tissue of osteoclastic activity and resorption of the root.

Gottlieb and Orban conducted a series of experiments on dogs, in which occlusal trauma was produced. Continued trauma of this type caused root resorption. Examination of human teeth reveals

that resorptions may occur in root areas that are subjected to pressure as a result of occlusal stress.

In 1935 Albin Oppenheim published a paper dealing with tissue changes in human teeth and supporting structures, resulting from the use of orthodontic appliances. He conducted his investigation on a series of fifteen teeth which had been moved by orthodontic appliances using various measured forces, over varying periods of time. These teeth together with the tissues immediately surrounding them were sectioned serially and studied under the microscope. At the conclusion of this study reconstruction models were made of some of the specimens. The models showed in a striking manner the areas of resorption and their relative positions on the root surfaces.

Much progress has been made in the last few years along histopathological lines in increasing our knowledge of the reaction of tissues to definite orthodontic forces.

Gentle pressure causes the formation of an increased and enlarged blood-capillary net-work within the peridental membrane which acts as a buffer to intercept the pressure. Some regard this as a functional accommodating formation, which forms only as long as the reserve power of the cells has not been exceeded. By others it is regarded as an expression of local disturbances of circulation and injuries to the vessels. There is a relaxation of the peridental membrane fibers on the side of pressure and tension of the fibers on the side of pull. Along the alveolar wall in the pressure area osteoclasts appear. Heavier pressure may cause a compression of the peridental membrane between the surface of the root and the alveolar bone which inhibits the flow of blood in the vessels in the pressure area causing probably a necrosis of the part.

Application of mild pressures causes resorption of bone adjacent to the peridental membrane in areas of pressure, and a building out of bone in areas of tension. As a protective measure, in the labial, buccal, or lingual movement, bone is built on the outer surface of the alveolar process as a compensation for the resorption on the inner surface of the lamina dura. Heavy pressures do not allow action of the osteoclasts in the area of pressure, but undermining resorption takes place at the borders of this area, with subsequent heavy loss of bone.

In early experiments where teeth of monkeys or dogs were

moved with orthodontic appliances, the cementum was not resorbed. This led Gottlieb and Orban to state that "only the greater resistance of cementum in comparison to bone makes orthodontic tooth movement possible."

More recent experiments with human material have demonstrated that results obtained with animals may not be applicable to man. It was found that human cementum resorbed readily, as soon as pressure conditions exceeded physiological limits. Resorptions may also extend into the dentine. The position of the root resorption depends upon the type of movements and the character of the force applied. In simple tipping movements the resorbed areas are at the alveolar crest on the pressure side and on the opposite side of the apical surface of the root. Secondary resorption is produced on the root surface in areas diametrically opposite to the area of primary resorption when the tooth is in occlusion. In bodily movements the greatest resorption is at the apex on the pressure side.

In 1936 a comparative study in root resorption was published by C. E. Rudolph, dealing with cases studied at the University of Minnesota. The investigation was by means of radiographs taken from the diagnostic clinic of the school over a period of years. Excluding those cases which had a history of orthodontic treatment, 4,560 full mouth films examined showed an incidence of 12.6 per cent. This percentage deals with the number of cases, not the number of teeth involved.

No attempt seems to have been made to study the frequency of resorption from histologic material. It was the purpose of our investigation to determine from sections of human teeth to what extent root resorptions may occur as well as the location of such resorptions on the root surfaces.

An abstract of the work done on the problem is herewith presented:

The specimens used were all human material, and consisted of decalcified sections and ground sections, representing teeth of all types.

The jaws of several individuals obtained at autopsy were used in this study. The material was decalcified and sectioned so as to preserve both the teeth and surrounding structure. Some of the sections were cut mesio-distally and some bucco-lingually through the long axes of the teeth. The mesio-distal sections demonstrated the mesial and distal resorptions while the labio and bucco-lingual

sections showed the labial, buccal and lingual resorptions. The large number of serial sections for each tooth made it possible to examine the entire surface indicated and thus locate any resorption which might be present on that surface.

The ground sections were of miscellaneous extracted teeth. They were ground so as to preserve the central section of the tooth. The possibility of artefacts and root injuries due to the use of forceps during extraction renders this material less valuable than the decalcified sections.

Since this investigation was to deal not only with the incidence but also the location of root resorption, a method of localization had to be devised. Indication was made as to the root or roots involved in multi-rooted teeth, the surface involved and the position on the surface; ie., whether gingival third, middle third, apical third, or apex.

The extent of surface resorbed was measured at the widest point in milimeetrs. Accurate measurement of depth was not always possible, because large surface areas, particularly apical areas were sometimes resorbed, destroying the original contours of the root. Therefore, the depth was stated in relation to the tissues involved, as shallow cemental, deep cemental, shallow dentinal, and deep dentinal.

In the study of the decalcified sections an effort was made to determine the nature of the bone opposite the area of resorption, as to whether it was normal, resorbed or repaired.

The results of this study were compiled in eleven tables as follows:

1. Incidence of resorption for all teeth examined.
2. Incidence of resorption among teeth having resorptions.
3. Incidence of resorption among areas of root surfaces.
4. Incidence of resorption among surfaces of roots.
5. Incidence of resorption among areas of the buccal surfaces of roots.
6. Incidence of resorption among areas of the lingual surface of roots.
7. Incidence of resorption among areas of the mesial surface of roots.
8. Incidence of resorption among areas of the distal surface of roots.
9. Dimensions of resorptions.
10. Depths of absorptions.

11. Repair of root and bone resorptions on decalcified teeth.

A study of these tables brings to light the following facts:

1. Of 115 teeth examined 43.37% showed some resorption.
   (a.) Of 46 decalcified teeth 78.26% showed some resorption.
   (b.) Of 69 ground teeth 20.29% showed some resorption.
   The percentage of 43.47 is an average of a high incidence of resorption found in one type of material and a comparatively low incidence found in another type. The probable factor responsible for the high incidence in the decalcified teeth is the limited number of cases available. The probable factor responsible for the low incidence in the ground teeth is the limited amount of tooth surface available.
2. On the whole single rooted and multi-rooted teeth appeared to be equally involved.
3. Among the teeth showing resorption the upper and lower molars had the highest percentage of incidence, 32.86% and 32.56% respectively. The lowest percentage of incidence was in the bicuspid group, 13.88% for the lower bicuspids and 11.74% for upper bicuspids.
4. The teeth in general show an average of about two resorption areas each.
5. In the case of teeth showing resorption there was a gradual increase in the number of resorptions from gingival third to apex of the tooth.
6. In the teeth of both jaws apical resorption predominated distal, buccal, and mesial surfaces showed a little less resorption while lingual resorptions were in the minority.
7. The average dimension of all resorption areas measured was .5997 mm. The largest area measured was 4.9, while the smallest was .042 mm.
8. The upper centrals, laterals and cuspids showed largest areas of resorption. The lower cuspids, bicuspids, and laterals showed the smallest areas of resorption.
9. The dimensions of resorption in upper teeth were almost twice those in lower teeth.
10. The dimensions of resorption were greatest at the apex and in the middle third; smallest in the gingival third.
11. There were over twice as many shallow cemental as deep cemental resorptions, and about a third more shallow dentinal than deep dentinal resorptions.

12. The upper molars, upper centrals, lower molars, and upper cuspids had greatest dentinal resorption in the order named.
13. The greatest number of dentinal penetrations were found in the middle and apical third and the smallest number in the gingival third.
14. The number of root resorptions with no bone resorption in the areas opposite them was almost twice as great as the number with bone resorption opposite them.
15. In 41% of the root resorptions repair was in progress or had ben completed.

Of the etiologic factors involved, traumatic occlusion appeared to be the cause of the large majority of resorptions. One of the deepest resorptions observed was found in the gingival third of the root of a lower bicuspid which was in torsiversion. The antagonizing tooth had been eventually lost, so that resorption had ceased and repair by both primary and secondary cementum had partly retsored the lost tissue. Another resorption was caused by an erupting third molar exerting pressure on the root of the second molar. A shallow but very extensive resorption extending along the root of an anterior tooth appeared to be the result of a blow of some kind.

These investigations convince us that root resorptions are of practical importance. The rapidity of action in cases of the idiopathic type is responsible for much damage to the root or even its early loss. Without the anchorage afforded by the root, the tooth is soon lost. Of what lasting value are our operative procedures, restoring form and function to the crowns of teeth, the roots of which are subject to resorption of this type? Orthodontic procedures would certainly be contra-indicated. As for the traumatic type of resorption it is possible that it may serve as the exciting cause of the more extensive type in a patient predisposed to idiopathic resorption. However, much investigation needs yet to be done in this field.

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Combine Postgraduate study with a visit to the World's Fair. Attend the National Dental Association Convention, August 14-18, 1939, in New York City.