A scanning electron microscopical study of initial changes in human premolars teeth after orthodontic tooth movement

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Abstract:

A scanning electron microscope was used to study the effect of orthodontic tooth movement by using a force of 50 grams on the pressure side of 21 upper left premolar teeth for 5- 75 days while the contralaterl side 14 teeth were used as a control. In order to study the morphology and occurrence of root resorptions, the organic tissue was removed using sodium hypochlorite and the denuded root surface were re-examined in the scanning electron microscope. Initially, tissue affected by pressure was mainly located in the marginal region and subsequently the mid- portion of the roots became generally influenced. The resorption process of cementum begins after 5 days as around cavities measuring about 4μ. Further resorption in cementum was characterized by numerous small, thin-walled round lacunae which confluence into extensive, shallow resorptions after 25 days and more.

Keywords:

Scanning electron microscope, orthodontic tooth movement, premolar teeth.

Introduction:

During orthodontic tooth movement tissue changes on the pressure side of the roots will include all the structures in localized areas of the periodontal membrane, whereby the cementum & the dentin may also be affected[1]. Changes in the connective tissue are essential for tooth movement, and of special significance are resorptive processes [2].

The reactions of the supporting tissues during the application of orthodontic forces have often been discussed. The magnitude of the applied force is believed to be an important factor in this context. Many studies have been published on the relationship between the magnitude of applied force and either the amount of tooth movement or the presence of adverse tissue reactions, i.e., root resorption[3].

The etiology of root resorption in relation to orthodontic treatment is an important issue for both the orthodontic specialist and for the patient. Apical root shortening may occur but that it is infrequent, however, root resorption along the root surface in the pressure zones is very common although it is sometimes not observed in intraoral radiographs but resorption in the apical region are occasionally so marked that the effect may be observed by radiograph, that the density and morphology of the dento-alveolar complex are not significant factors in the etiology of external apical root resorption[4].

Most investigations of tissue reactions during orthodontic tooth movement have been performed on

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animals [5,6]. There are, however, important functional and morphologic differences between human beings and animals. For a better understanding of the development .of early tissue reactions in orthodontics, a study on a representative human material in a clinical everyday situation with good control of the force seems indicated [1].

The aim of this study was to study the morphology and occurrence of root resorptions due to orthodontic tooth movement on the pressure side upper premolar teeth using the scanning electron microscope.

Material and method:

The sample consisted of 35 teeth from individuals aged between (12-25) years that required extraction of the upper first premolars right and left as part of the treatment of their malocclusions. Clinical and radiographic examination revealed normal findings of the teeth applied in this study. Twenty one of the upper left premolar teeth (three teeth in each observation period) were moved buccally by an appliance consisting of a spring (0.16) modified from lundgren *et al.* [1] fixed to the first molar. It was ligated to twin arch bracket on the experimental tooth and exerted a force of 50 grams in lateral direction. The force was measured with a strain gauge [7], while fourteen upper right premolars served as control group, one tooth for each observation time.

After observation times of 5, 15, 25, 35, 45, 55, 75 days, both the experimental and control teeth were extracted, three premolars teeth were experimental and one tooth served as a control for each observation time.

After extraction the teeth were fixed in 4% buffered formaldehyde (PH 7.3) for 24-48 hours. Specimens containing the vestibular marginal and middle portion of the premolars were dehydrated in graded solutions of ethanol and ether and mounted on metal holder with colloidal silver. The specimen were coated with carbon and gold- palladium under continuous tilting and rotation and studied in the scanning electron microscope.

Removal of the organic components of the specimens was done by immersing the in 5% solution of sodium hypochlorite (NaOCl). All specimens were rinsed in the soxleth system with water and drying repeated before the specimens were recoated with carbon and gold- palladium. When operating the scanning electron microscope care was taken to obtain records which would permit comparison between the roots before and after the organic tissue components were removed. The surface extension and depth of resorption were measured by using the morphmetric parameters of the image analysis system [8].

Results:

After an experimental period of five days the pressure zone of one root revealed one small, hyalinized area, another root surface three areas of similar size separated by narrow strings of organic tissue. In two specimens of 15 days, a resorption of the cementum beneath was indicatd.The root surface generally became more markedly influenced with increasing observation time. Exposed cementum and resorbed surfaces were also observed but in those taken from teeth of the longest experimental periods; the resorbed lacunae were covered by fibers.

In teeth that undergo force for short duration the compressed areas were usually located in the marginal portion became generally affected. The resorption lacunae become apparent after removal of the organic tissue permitting study of the morphology of the resorptions.initially they were small, round cavities which had been formed by undermining processes outlined by thin, bright subsequently extensive lacunae were observed.

Resorption of the dentin attained characteristic honey comb appearance outlined by bright lines which were wider than those observed in the cementum (fig1) with remnants of organic tissues (honey comb appearance).

Figure (1): Outer layer of cementum and dentin from the resorptive cavity.

The resorption observed in the specimens before denudation were frequently characterized by the presence of a fine network of fibers from which the minerals located most superficially had been removed, indicating that the mineral component is being removed before the organic component of the cementum.in some teeth, however, the resorption lacunae were even and smooth. In areas of dentin that resorbed, the walls of the dentinal tubules were particularly excavated.

There was no significance difference between the experimental and the control side after 5 days, but after 15 days several small lacunae were present on the experimental side.

Following 25 days observation period the two roots contained numerous small cavities. After still longer experimental periods the resorption lacunae were generally extensive. In teeth longer than 35 days all root surfaces denoted extensive resorptions (Table 1).

Initially the marginal root portion became influenced. After 25, 35, 45, and 75 days the resorption defects also involved dentin, but they were not particularly deep.

Table (1): The extension and depth of resorption lacunae for each observation time (*nm*).

Observation Time	Resorped area	
	Extension	Depth
05	03.70	02.33
15	07.04	05.10
25	09.51	08.44
35	12.7	10.52
45	13.56	11.63
55	17.91	15.03
75	20.82	18.10

Discussion:

This clinical study showed that root resorption is an early and frequent iatrogenic consequence of orthodontic treatment. Regarding the cause of root resorption, some reports claim that not only the magnitude but also the duration of the applied force is an aggravating factor for root resorption and the time of the force application has been regarded as amore critical factor than the magnitude of the force [9], especially in connection with long treatment periods.
In this study the examinations was only restricted to the marginal and middle region of the root which are ordinarily covered by a thin layer of a cellular cementum,precementum and lining cementoblasts and it is shown that such tissue resist resorption more readily than the cementum[2]. The present investigation revealed that all marginal root surfaces became resorbed following orthodontic tooth movement. The finding is in accordance with observations of Jimenez-Pellegrin and Arana-Chavez[10] who found that resorption areas were located mainly at the medial root third, in regions that corresponded to the prominent zones of the roots tissue will appear in the pressure side and this will disappear later on.

Resorption of the cementum take place and the resorption lacunae appearing in such areas were uniformly more extensive than they were deep and after 25 days the dentin also was affected, this finding confirms the observation of Jimenez-Pellegrin and Arana-Chavez[10] who found that resorption lacunae in the teeth moved for longer time periods were deeper, often affecting the underlying root dentin, and were mainly at the medial root third. In cementum the resorption defects were marked by thin walls separating the individual lacunae and it has been maintained that such walls may be free during tooth resorption,this finding was in agreement with Mavragani *et al*[11]. This mechanism can explain the rapid formation of extensive resorptions of cementum following removal of the hyalinized tissue [2] showed that resorption spread out when reaching the dentin, a finding which indicate that such lacunae may be wider than they appear in the scanning electron microscope.

The number of resorptions lacuna increased with time, this is in agreement with earlier report Vardimon, et al [6].

Other investigations have, however, reported no association at all Lilja et al [12]. Root resorptions were also observed in the control teeth but to a much lesser extent than in the test group and this was in agreement with Kurol *et al*[7]. There is individual susceptibility to root resorption, also there are differences in the susceptibility to root resorption due to local, anatomical factor and tooth type.

Conclusion:

The time has great influence on the occurrence of root resorption, so the longest the time of treatment, the more resorption will be. Other factors also may be considered like the amount of the force applied the type of the force whether continuous or interrupted & this depends on the type of the appliance used, also the individual variations should be considered.

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