

ROOT RESORPTION IN RELATION TO ORTHODONTIC TOOTH MOVEMENT

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Summary: Root resorption is an undesirable sequela of orthodontic tooth movement. The odontoclasts are responsible for root resorption and the process of hyalinization is known to precede the orthodontic root resorption. It is found that there are several predisposing factors, therefore an evaluation of these factors should be done by careful examination of personal medical history, severity of malocclusion and dental treatment (if any due to previous history of trauma), anterior crossbite etc. The evaluation becomes an essential factor as it helps the orthodontists in detecting the occurrence and severity of the root resorption and thereby plan out the treatment more effectively. Orthodontic tooth movements especially intrusion and other movements like tipping, torque are all known to influence the root resorption, therefore the detection using radiographs and repair of root resorption is of utmost significance as root resorption is a more serious problem from a medicolegal stand point of view. However some studies have shown that the repair process is known to occur after the cessation of orthodontic treatment by the deposition of cementum of cellular type. In the light of orthodontist's liability of what is basically an unpredictable phenomenon, it is necessary that the speciality define this uncertainty and protect its members against unnecessary and unjustified litigation.

Key words: *Apical root resorption, Orthodontic treatment*

Introduction

Root resorption is a physiologic or a pathologic process resulting in the loss of cementum and dentin. It was first described by Bates in 1856 and was co-related to orthodontics by Ottolengui in 1914. Also, Ketcham was the 1st to generate interest in apical root resorption, as a consequence of orthodontic treatment and it has since been the subject of substantial amount of research.

Root resorption is a multifactorial phenomenon. The root resorption can be classified as external and internal. Further, the external root resorption is of three types: surface resorption, inflammatory resorption and the replacement resorption.

The root resorbing cell is the odontoclast, it is similar to the cytologic and functional characteristics of osteoclast. Osteoclast adhesion, activation, subsequent root resorption are associated with the temporospatial expression and maturation of various extracellular matrix (ECM) proteins. The presence of bone sialoprotein and osteopontin throughout the periodontal ligament; with no specific pattern in permanent teeth helps to clarify why some patients experience severe root resorption whereas others do not during the same type of orthodontic treatment (18).

Root resorption relating to orthodontics

Root resorption relating to orthodontics is external apical root resorption. It is an undesirable sequela of orthodontic treatment, results in the loss of tooth structure and it is most commonly seen at the root apex. EARR in association with orthodontic treatment varies between patients and between different teeth in the same person or there may be severe resorption in a few teeth (21). Root resorption after orthodontic treatment can be often referred to as surface resorption or transient inflammatory resorption. It is believed to occur when the local areas of periodontal ligament are overcompressed (13, 17). The continuous pressure is known to stimulate the resorbing cells in the apical third of the roots and results in significant shortening of the root (11).

The tooth movement consists of three phases: an initial phase of very rapid movement within the alveolar socket because of the compression of the periodontal ligament, followed by a lag phase with a relatively slow or no movement at all, because of hyalinization of periodontal ligament and slow undermining resorption of the lamina dura. During the last phase, the post-lag phase, the movement increases gradually (15,16). In Orthodontics, for the tooth movement to occur, a force with an appropriate magnitude is required

to initiate a cascade of reaction locally, which allows remodeling of the tooth supporting tissues. This remodeling process occurs as tissue resorption on the pressure side and tissue apposition on the tension side of the tooth socket, while forces that are too weak and inconsistent are insufficient to move teeth, forces that are large are believed to cause excessive root resorption as an unwanted side effect. Schwartz suggested that the optimal force level for tooth movement should be between 7-26 grams per centimeter square of root surface area (16,17). Also when interrupted and continuous forces were applied during treatment, significant individual variations were found both in magnitude of tooth movement and amount or severity of root resorption (26). The magnitude and duration of the applied force is an aggravating factor for root resorption and duration of force is regarded as a more critical factor than the magnitude of force (12,16).

The root resorption has been recorded in 93% of treated adolescents (16). Moderate to severe apical root resorption (>2 mm to <1/3 of the root length) has been found in 12-17% of patients (22) and excessive root resorption(1/3rd of the root length) in 1-5% (29).

EARR is initiated 14 to 20 days after orthodontic force is applied and may continue for the duration of force application. It commences adjacent to an area of hyalinization and is more likely to occur in cases, where the compression is strong and of some duration (5, 10). The process of hyalinization is known to precede the root resorption process during orthodontic treatment (17). Three stages are described in the hyalinised zone: Degeneration, elimination of destroyed products and re-establishment. Hyalinised tissue elimination is related to root resorption process, whenever extensive hyalinization is expected, root resorption occurs. The elimination of hyalinised compressed tissue is carried by invasion of cells and blood vessels from the adjacent undamaged periodontium; thereby the removal of cementoid and mature collagen adjacent to the cementum results in subsequent alteration of normal barriers to root resorption (5).

Clinical features of Root Resorption

Teeth are asymptomatic and pulp is vital, unless pressure is high enough to disturb the apical blood supply. Radiographically, orthodontic pressure resorption is located in apical 1/3rd of root and no signs of radiolucency can be obtained in the bone or root. The removal of the source of the pressure results in cessation of resorption, therefore no root canal therapy or operative procedure is required (11). Besides the resorption craters that are evident in small quantities in the controls of light force group, demonstrates that resorption could be a naturally occurring physiological phenomenon (7).

Occurrence

The maxillary incisors most commonly show apical root resorption, after orthodontic therapy (21,24,30). The

maxillary lateral incisors have been reported to be more susceptible to root resorption than the central incisors (14) because of their relationship of root structure combined with the tip built into the pre-angulated bracket system (1).

Also, the maxillary incisors are most commonly used to determine the apical root resorption as:

1. EARR occurs most commonly on these teeth.
2. These teeth are easily visualized on a lateral cephalogram.
3. Maxillary incisors undergo more displacement than other teeth during extraction treatment (31).

Predisposing factors

The individual factors play an important role in the development of orthodontically induced root resorption. Some studies have shown that allergy could be an aetiological factor in increased root resorption induced by orthodontic forces. High or low root resorption response to orthodontic force of the same magnitude, duration and type revealed that allergy might play a role in root resorption (29).

The local and systemic factors are responsible for root resorption during orthodontic treatment, these factors include:

Tab. 1: Showing the predisposing factors for root resorption.

DENTAL HEALTH	a. Root morphology Eg: pipette shaped (32,36), blunt shaped, abrupt root deflection, narrow root (19,21,25). b. Trauma.
ORAL HEALTH	Gingivitis, Periodontitis
MEDICAL HEALTH	The systemic calcium is known to effect the root resorption (35).
HABITS	Nail biting, Lip/tongue Dysfunction and various other habits.
GENETICS	Highly significant evidence of linkage between the suspected gene and the clinical manifestations of external apical root resorption was obtained, showing that persons homozygous for the gene were at 5.6 fold increased risk of resorption greater than 2 mm (2).
OTHERS	Alcohol consumption in adults during orthodontic treatment tends to increase root resorption through vitamin D hydroxylation in the liver (6).

However, additional analysis is required to evaluate the cases with the greatest and least resorption. For example:

- i. Personal and family medical history, chronic and acute illnesses, genetic and metabolic disorders.
- ii. Dental treatment, if any due to previous history of trauma
- iii. Severity of malocclusion

- iv. Impacted or ectopically positioned canines.
- v. Anterior crossbite.

The analysis of differences that occur during treatment also helps to determine the extent of root resorption and these include:

- i. Intercurrent illness
- ii. Intercurrent trauma
- iii. Treatment mechanics (time, duration and force level of rectangular wire, class ii elastics, vertical elastics, utility arches, headgear, torque and method of retraction) (3).

Comparison of root resorption between the orthodontic techniques

Among the mechanical factors, the orthodontic techniques have been related to induced root resorption. Root resorption is not limited to specific techniques. Tipping, torque, incisor intrusion and other movements, in which the root surface is directly compressed against the alveolar bone are expected to generate root resorption. Torquing forces concentrate at the apex, which is the smallest and most resorption sensitive area of the tooth. Intrusive forces concentrate pressure at the conical apex and is responsible for root resorption (31). Few studies have evaluated the extent of apical root resorption based on orthodontically induced tooth movements (30,31). The comparison between the techniques is as follows:

- 1. Begg technique caused more root resorption than edgewise, while yet in another studies, no difference was found between the 2 techniques (4).
- 2. No difference has been found between speed and edgewise techniques (5).
- 3. More apical root resorption of both central incisors in the standard edgewise than in the straight wire edgewise group is seen (23).
- 4. The extent of root resorption for both sectional and full arch wire retraction methods visualized by radiograph shows that root resorption was high for the total sectional group and for the total full arch wire group. Also, differences in retraction mechanics showed no significant greater resorption activity. However a significant difference in resorption severity b/w the maxillary central and lateral incisors was observed in full arch wire treatment group (4).
- 5. The degree of apical root resorption is greater in cases of multiple aplasia (4-6 missing teeth) than in those with only 1 to 3 missing teeth, in particular in teeth with an abnormal root form and lengthy treatment with elastics and rectangular arch wires (19).
- 6. The movement of teeth with mature roots, extensive root movement and intrusive mechanics enhance the risk of EARR (8). Orthodontically, the incisor tooth intrusion in vertical plane and lingual root torque in sagittal plane cause apical root resorption (31).
- 7. Treatment mechanics associated with root resorption include Begg appliances (stage 1 and 3) (5).

- 8. Less root resorption is seen with removal appliances than with fixed appliances.

Detection of orthodontically induced root resorption and complication of orthodontically induced root resorption

Early detection of small root resorption during orthodontic treatment is essential for identifying teeth at risk of severe resorption (19). Conventional intra-oral radiography is the standard method used by orthodontists to detect external apical root resorption during treatment, but it has some inherent disadvantages. Intra-oral radiographs do not accurately diagnose early resorption and often fail to reveal surface resorption lacunae on the lingual and buccal aspects of the roots. Orthodontically induced root resorption after 7 weeks of treatment, verified histologically are not visible in periapical radiographs.

To monitor external apical root resorption associated with orthodontic treatment (with fixed appliances), the standard procedure is a radiographic examination after 6 months of treatment in teeth with an enhanced risk, a 3 month follow up is recommended (20). Interruption of active treatment can minimize adverse effects during subsequent treatment. The studies based on radiographic evidence has shown that orthodontically induced root resorption does not usually progress after appliance removal (19) and histological investigations show repair of resorption cavities after treatment.

Scanning electron microscopy has been shown to be helpful for detecting and localizing possible root resorption areas caused by orthodontic tooth movement. Also, the scanning electron microscopy techniques showed that the areas of root resorption that develop during orthodontic tooth movement are related to root morphology (13) and it is possible to detect the root resorption craters in a controlled human model by 3D volumetric measurements (7).

If orthodontic treatment leads to severe root resorption in maxillary incisors, it leaves a remaining total root length of 9 mm or less and there is a risk of tooth mobility. Less risk is associated with a remaining root length >9mm, with a healthy periodontium. Therefore after orthodontic treatment, teeth with severe root resorption should be followed up, clinically and radiographically (21).

Predicting diagnostic and treatment factors for root resorption

Predicting the various factors helps to determine and identify pretreatment factors that would allow the clinician to predict the incidence, location, severity of root resorption before treatment (33) and treatment factors are detectable on the periapical radiographs at the end of orthodontic treatment (34). These include:

- i. Maxillary anterior teeth are the most resorbed with 25% showing >2 mm of root resorption. Posterior teeth are relatively unaffected.

- ii. Dilacerated maxillary lateral incisors and pointed teeth show greater root resorption.
- iii. Blunted teeth exhibit lesser root resorption; also the asian patients show less root resorption than white or Hispanic patients.
- iv. Adults exhibit greater root resorption than children in the mandibular anterior teeth only.
- v. Increased tooth length and over-jet show greater root resorption for maxillary dentition, while increased over-bite was weakly co-related with more root resorption in maxillary lateral incisors only.
- vi. Smaller roots suffered a greater amount of apical root shortening, hence the initial size of a root must still be considered in treatment planning.
- vii. Patients, who underwent both maxillary and mandibular 1st premolar extraction therapy had more resorption than those patients, who had no extractions or had only maxillary 1st premolar removed.
- viii. Duration of the treatment and horizontal displacement of the incisor apices are significantly associated with root resorption.

Prevention of root resorption induced by orthodontic treatment

The following statements when taken into concern, would help to reduce the severity of root resorption during orthodontic treatment. Younger, the patient at the onset of treatment, the more prolonged treatment could be without permanent loss of root-tip structure (23). Also the application of gentle forces on immature teeth has been reported to have little effect on their predestined root length.

However, there are 2 impediments to prevent root resorption during orthodontic treatment:

1. Root apex are prone to resorption, when the periodontium is compressed, so teeth cannot be moved through bone without producing some odontoclasia.
2. No exact criteria have been found, that predicts, which patients will experience overt resorption and which will exhibit little under the same treatment regimens.

However, most patients exhibit little resorption and the esthetic and functional benefits of treatment outweigh the minor iatrogenic sequela (31).

Repair of orthodontic root resorption

Repair becomes an essential factor as the root resorption is an adverse outcome of tooth movement. In addition to the iatrogenic response and compromising the crown-root ratio, root resorption has led to increased malpractice litigation against orthodontists. According to a few literatures, apical root resorption decreases the root's surface area and thereby periodontal support and the ability to resist relapse and hence the repair of root resorption is essential. The repair process starts, when the applied force is discontinued or reduced below a certain level. The repair is re-

corded as early as during the 1st week of retention (27). The process increases during the first 4 weeks of retention and after 5-6 weeks, the process slows down and reaches a steady phase. The pattern of repair of orthodontically induced root resorption regarding the location and type of tissue in adolescents after application of a well-controlled force magnitude is achieved by deposition of a reparative cementum of cellular type and always covered by the initially formed acellular cementum (28). The distinction between the two types of repair pattern, (functional rapid cellular repair and non-functional retarded acellular pattern) after rapid maxillary expansion in adolescent monkeys has been demonstrated and the latter type of repair is seen at the onset of the reparative process (28,37). It is found that the low-intensity pulsed ultrasound (LiPUS) minimizes the root resorption and accelerates healing of the resorption by reparative cementum over 4 weeks of simultaneous tooth movement and LiPUS application (9).

Conclusion

Apical root resorption is one of the most common iatrogenic problems associated with orthodontic treatment. It is becoming an increasingly more serious problem from a medicolegal standpoint. It appears that orthodontists are not able to avoid this problem completely.

The question of whether there is an optimal force to move teeth with resorption or whether root resorption may be predictable remains unanswered. Besides questions are still debated, whether the particular method of treatment used by the orthodontists influences the amount of root shortening observed. In the light of orthodontist's liability of what is basically an unpredictable phenomenon, it is necessary that the speciality define this uncertainty and establish criteria of diagnosis, records and informed consents to protect its members against unnecessary and unjustified litigation.

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