REVIEW ARTICLE

ROOT RESORPTION AND ORTHODONTICS

ABSTRACT

Orthodontic treatment and apical root resorption have been associated for many years. External root resorption is a feared complication during Orthodontic procedures. It can affect both the apex, but also the cervical zone of the roots subjected to Orthodontic forces for tooth movement and can compromise the future of the involved teeth. The detection of resorptions can occur during and/or after the active phase of Orthodontic treatment. The patient must be informed about the risks of resorption as a consequence of Orthodontic treatment. However, despite the rigorous efforts of knowledgeable individuals, the exact nature of the initiation and control of apical root resorption remains essentially unknown. Although apical root resorption may occur in individuals who have never experienced Orthodontic tooth movement, the incidence among treated individuals is quite high. These facts oblige the Orthodontist to seek a better understanding of the cause and prognosis of this phenomenon.

Key words: Orthodontic treatment, root resorption

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INTRODUCTION

Root resorption is the destructive process of the cementumor dentine layers of a tooth root due to clastic cell activity which leads to a subsequent loss of root structure of a tooth. This process may be physiological or pathological. Physiological root resorption of deciduous teeth naturally occurs when the permanent teeth begin to erupt. It may also occur to a small degree in the permanent dentition associated with physiological tooth movement. Pathological root resorption has been related to Orthodontic tooth movement, trauma and ectopic eruption of adjacent teeth and in association with other pathology[1]. Bates was the first to describe root resorption of permanent teeth in 1856. The link between Orthodontics and root resorption was identified in 1914 by Ottolengui2. Rudolph observed that resorption typically attacks the root tip and travels coronally which is termed as 'Shed roof effect'.Albert Ketcham suggested that apical resorption is a common and occasionally severeiatrogenicconsequenceofOrthodontictreatment[3]. The term "Orthodontically induced inflammatory root resorption (OIIRR)" was introduced by Brezniak and Wasserstein to describe the type of root resorption experienced during orthodontic treatment[1].

External apical root resorption (EARR) is an undesirable sequela of Orthodontic treatment that results in permanent loss of tooth structure from the root apex. This root resorption differs from other kinds of resorption. This is a sterile, local inflammatory process which is complicated and has all characteristic inflammatory symptoms and occurs when pressure on the cementum exceed sits reparative capacity and dentinis exposed, allowing multinucleated odontoclasts to degrade the root substance. Orthodontically induced root resorption begins adjacent to hyalinised zones and occurs during and after elimination of hyaline tissues[3].Trauma, infectious inflammation of periapical tissues and periodontal diseases these are some of etiological factors that may induce root resorption or root shortening[4]. Root apex as well as lateral surfaces of the root can resorb however just apical root resorption can be shown by means of radiological examination. Usually Orthodontic treatment doesn't cause clinically significant root resorption however microscopic changes appear on the teeth roots, which are difficult to detect in radiological images. Root resorption induces root shortening and weakening of teeth arch and this is very important for successful Orthodontic treatment[4].

PREVALENCE

From the group of teeth examined, the majority of the published articles considers that teeth most prone to apical root resorption are the maxillary incisors especially the laterals, followed by the mandibular incisors and the maxillary premolars. Incidence on maxillary molars has also been observed.

TYPES OF ROOT RESORPTION

Root resorption can be classified into 3 categories: Surface resorption, Inflammatory resorption, and Replacement resorption. Surface resorption occurs constantly as microdefects on all roots and these normally repair themselves without notice. It is only consequential when lacunae in the cementum broaden and permit dentinoclasia. Surface resorption can occur anywhere on a root but is most common periapically. Surface resorption stops when the instigating agent (usually pressure) is removed and there is repair of the cementum. Inflammatory resorption occurs when root resorption progresses into the dentinal tubules to pulpal tissue that is infected or necrotic or into an infected leukocyte zone. Replacement resorption produces ankylosis of a tooth because bone replaces the resorbed tooth substance[5].Root resorption occurring from Orthodontic treatment is either a surface resorption or transient inflammatory resorption. Replacement resorption is not normally seen after Orthodontic treatment.

Brezniak and Wasserstein suggested the term Orthodontically induced inflammatory root resorption (OIIR) to distinguish this type of resorption from others such as those caused by trauma, periapical lesions of periodontal disease. They then described three degrees of severity:

1. Cemental or surface resorption with remod-

eling - only the cemental layers are resorbed and then fully regenerated.

2. Dentinal resorption with repair - cemental and the outer layers of dentine are resorbed and usually repaired with cementum material. This process may alter the shape of the root from its original form.

3. Circumferential apical root resorption - full resorption of all hard tissues of the root apex occurs. This leads to irreversible root shortening. External surface repair and remodeling of sharp edges occurs in the cemental layer[1].

MEASUREMENT METHODS

A system of classification for the various types of resorption makes it possible to make a precise diagnosis regarding their degree of severity.

Levander and Malmgren presented a classification system for root resorption which is widely accepted in the orthodontic literature [1988]. According to this index, severity of root resorption increases from grade 1, defined as presence of irregular root contour, to grade 4, where root resorption is greater than 1/3 of the original root length[7,8].

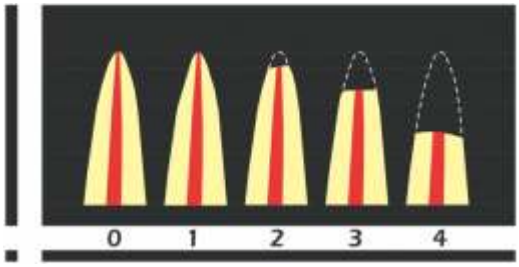

FIGURE: 1

Degree 1 – irregularity in the apical root contour, maintaining the original root length

Degree 2 – resorption of up to two millimeter of the root length

Degree 3 – resorption from 2 mm up to 1/3 of the root length

Degree 4 – severe root resorptions, above 1/3 of the root length.

For external cervical resorption, the Heither say system of classification distinguishes four levels of cervical lesion.

Level 1- the resorption is a small invasive cervical lesion that presents a shallow dentinal erosion.

Level 2- the resorption lesion is very limited and penetrates the dentin close to the pulp chamber but does not extend as far as or only slightly onto the root dentin.

Level 3- the resorption lesion presents a deep penetration into the dentin up to the first third of the root.

Level 4- the resorption lesion is widely invasive and spreads apically beyond the first third of the coronal root.

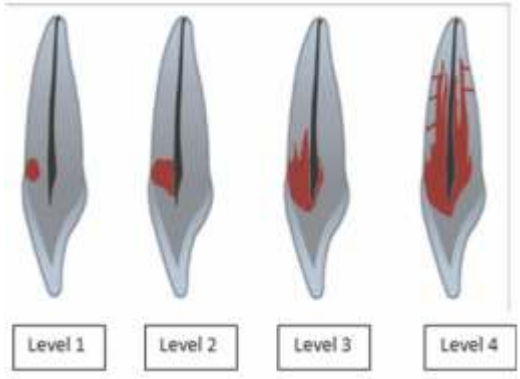

FIGURE: 2

ETIOLOGY

The etiology of apical root resorption is multifactorial. These factors consist of individual biologic characteristics, genetic predisposition and the effect of orthodontic forces. Risk factors for ARR can be categorized as patient-related and treatment-related. Patient-related factors include; genetics, systemic factors, asthma and allergies, chronic alcoholism, the severity of malocclusion, tooth-root morphology, a previous history of root resorption, alveolar bone density, root proximity to cortical bone, endodontic treatment and patient age and sex. Orthodontic treatment-related risk factors include; the treatment duration, magnitude of applied force, direction of tooth movement, amount of apical displacement, and method of force application[6].

Genetic Factors

Predisposition to root resorption may be autosomal dominant, autosomal recessive, or hereditary determined by a few genes. Genetic factors account for at least 50% of the variation in root resorption[4]. From various studies it is clear that susceptibility does not depend on segregation of a simple Mendelian gene, either dominant or recessive. Instead, inheritance is multifactorial (polygenic), although no one has yet tested for a major gene effect. This means that about two thirds of the total variance in root resorption was accounted for by the siblings in each family sharing half of their genes in common by descent. It is then primarily biochemically based risk factors that modulate a given patient's resorption potential during treatment. This finding also absolves the Orthodontist of the bulk of responsibility for the extent of resorption. On the other hand, the clinician still bears responsibility for monitoring the teeth during the course of treatment[5]. The TNFRSF11A gene encodes the receptor activator of nuclear factor-kappa B (RANK), an essential signalling molecule in osteoclast formation and activation as a potential mechanism in pathogenesis of root resorption[7].

Race

Sameshima et al reported that Asian patients were found to experience significantly less root resorption than white or Hispanic patients. In contrast, Smale et al recruited patients from 3 different centres in 3 countries and found no differences in resorption among the subsamples. They reported that this justified their decision to combine all patients into one group for analysis[4].

Chronological age

The risk of root resorption increases with age because of a decrease in periodontal membrane vascularity and an increase bone density[2]. On the other hand some authors stated that There is no significant relationship between the chronological age and root resorption[9]. Periodontal membrane becomes narrower and less vascularized, aplastic, alveolarb bone becomes denser less vascularized and cementum becomes wider with age. Through these changes adults show higher susceptibility to root resorption. When a patient is older than years, risk for root resorption increases[4].

Dental age

Teeth with incomplete root formation undergo less root resorption than those with completely formed roots. It is stated that incompletely formed roots reach their normal root length. Some studies stated that if tooth root are not completely formed in the beginning of Orthodontic treatment, they are further developing during treatment, however remain shorter. Linge and Linge have established that Ortodontically treated teeth lose averagely 0, 5 mm of the root length[4].

Sex

No significant relationship between sex and root resorption was found by performed studies.

Nutrition

Root resorption occurred in the animals lacking calcium and vitamin D in their foods.

Habits

Habits such as bruxism, nail biting, tongue thrust associated with open bite and increased tongue pressure are related to increased root resorption.

Anomalies of position and the number of teeth Hypodontia increases risk of root resorption. Impacted teeth may also induce occurrence of root resorption. Third molars are the most commonly Impacted teeth, which may cause Root resorption of the second molar through the cutting of the third molar, which lacks the place in the tooth arch. Maxillary Canines are the second most commonly impacted teeth. They can induce root resorption of the incisors and first premolars it is recommended annual palpation of the canine regions, Dental radiographs before 10 years of age and early extraction of deciduous canines.

Tooth structure

Root resorption most often occurs in the apical part of the root, because forces are concentrated at the root apex because Orthodontic tooth movement is never entirely translator and the fulcrum is usually occlusal to the apical part of the root, periodontal ligaments are situated in different directions in the apical part of the tooth root, the apical third of the root is covered with cellular cementum, whereas the coronary third is covered by noncellular cementum. Active cellular cementum depends on blood circulation, thus periapical cementum is more friable and easily injured in the case of trauma. Levander and Malmgren divide root forms to normal, short, blunt, dilacerated and pipette- shaped .Most authors have shown that roots with abnormal shape have a higher susceptibility to root resorption. According to the data of Sameshima and Sinclaire, normal and blunt tooth roots are resorbing the least. Pipette-shaped roots are the most susceptible root form to root resorption. Short roots have a greater risk for root resorption than average length roots. It was found that small roots resorbe almost twice more than other root forms. There are controversial data about initial length of the tooth root and the amount of tooth root resorption. There is an opinion that longer roots are more likely to be resorbed than shorter ones because longer roots are displaced farther for equal torque. Tooth With longer roots need stronger forces to be moved and that the actual displacement of the root apex is greater during tipping or torquing movements. It was established that a normal root form of central incisors and wid roots are preventive factors of these teeth roots, decreasing risk of root resorption. Slightly increased root resorption is characteristic for the tooth with narrower roots[4].

Mechanical factors

Orthodontic treatment and apical resorption have been associated for many years. Treatment-related factors that have been associated with apical root resorption include the magnitude of Orthodontic force, treatment mechanics, direction of tooth movement, appliance type and treatment duration. These are considered as a mechanical factors associated with root resorption[10]. Mechanical risk factors which may possibly be preventable such as the magnitude of force used or the duration of force have been investigated[1].

Orthodontic appliances

Comparing root resorption resulting from removable and fixed appliances, it was established that root resorption more often is induced by treating it with fixed appliances. Studies of IlanaBrin showed that root resorption was diagnosed more rarely in children who have undergone 2-phase Orthodontic treatment than in children, who have undergone Orthodontic treatment with fixed Orthodontic appliances only. While assessing the influence of metal and aesthetic brackets on root resorption, it was diagnosed more often in patients treated with aesthetic brackets. This is because treatment with aesthetic brackets lasts longer. Application of an additional upper utility arch for intrusion of maxillary incisors induces root resorption of maxillary central incisors more often than by treating with straight arch. With Intermaxillary elastics greater root resorption is found on the side of tooth arch where elastics were used. Use of Class III Elastics increases root resorption of first mandibular molars distal root. Some researchers have established that use of intermaxillary Class II Elastics and type of Orthodontic arch does not have any influence on occurrence of root resorption.

Type of orthodontic tooth movement

All types of Orthodontic tooth movement induced some form of root resorption . Tipping, torque and bodily movement of teeth have been implicated as mechanical risk factors. Most Often root resorption was established after Orthodontic intrusion (anchoring of a tooth into an alveolar bone). According To Reitan, The force that distributes along the root during bodily movement is less than the one, which concentrates at the root apex resulting from tipping. Bodily Movement induces less risk for root resorption than tooth tipping.

Other Researchers state that tooth tipping induces less root resorption than bodily movement. Root Resorption occurs in cervical and apical part of the root during tipping movement. Middle Part of the root is resorbing during bodily tooth movement. This happens because of the shape of periodontal space, which is the thinnest in the middle part of the root. Comparing root resorption after application of the same magnitude continuous intrusion and extrusion forces it was established that teeth intrusion causes four times more root resorption than extrusion. Deep and extensive resorption areas, situated near the root apex foramen can be observed in the apical part of the intruded tooth root. Superficial and limited resorption cavities around the root apex foramen is characteristic for extruded teeth Teeth rotation causes only minor injuries of periodontal tissues especially in single-root teeth. Resorption areas during the tooth rotation appear in the medial root third. Horizontal section of the root shows how prominent root zones might generate pressure areas when single-root tooth rotation is performing. The resorbed areas are consistently located at the boundaries between the buccal and distal surfaces as well as lingual and mezial root surfaces[4]. In some of the recent studies Expansion with RME has also been identified to cause root resorption[1].

Orthodontic force

Orthodontic force leads to micro trauma of periodontal ligaments and activation of inflammation related cells. According to some researches there was no root resorption difference detected while using low and high forces (50 G and 200 g). Some studies established that distribution of resorbed lacunae is directly related to the force magnitude, resorbed lacunae develops more quickly in case of higher forces. According to Schwartz, Forces increasing 20-26 g/cm, cause periodontal is chemia, Which may lead to root resorption. When Orthodontic force decreases to less than 20-26 g/cm tooth root resorption stops . Optimal force for Orthodontic tooth movement but not causing root resorption should be 7-26 g/cm on root surface area. It was established that intermittent force causes root resorption more rarely than the continuous force because the intermittent force protects from formation of hyalinized areas or it allows reorganization of hyalinized periodontal ligaments and restoration of blood circulation at the time, when forces are not active. Continuous Force leaves no time to repair of damaged blood vessels and other periodontal tissues and this may lead to higher level of root resorption[4].

Duration of orthodontic treatment

Duration of Orthodontic treatment is considered an important factor that may cause root resorption. Many studies show that severity of root resorption is related to duration of Orthodontic treatment. Results of other studies have shown that root resorption may begin in the early stage of Orthodontic treatment, it is especially characteristic to teeth with long, narrow and deviated roots. It was established that duration of treatment with fixed Orthodontic appliances was found to contribute to the degree of root resorption. Patients, whose Orthodontic treatment with fixed appliances lasts longer, experience significantly more grade 2 Root resorption. Average Treatment length for patients without root resorption is 1.5 years and for the patients with severe root resorption 2.3 years. Several contemporary studies have found no relation between the length of Orthodontic treatment and root resorption[4]. Since more en-masse anterior retraction is needed with miniscrew anchorage cases, treatment time increases which might increase the risk of OIIRR[1].

Influence of tooth extraction

Influence of tooth extraction on root resorption is valued controversially. Higher Root resorption rates were established in patients with several extracted teeth than in those, who haven't undergone tooth extraction. Root resorption develops more often after extraction of four first premolars if compared to the patients with non-extracted teeth or with extracted of just maxillary first premolars.

Self ligation

With the introduction of self ligating brackets, many claims have been made about the increased efficiency of tooth alignment compared to conventional brackets. This is most likely due to lower friction levels reported with the use of self ligating brackets. The use of elastics such as in the case of class II correction may be a risk factor for the teeth that support the elastics. It is due to the jiggling movements that occur on these anchor teeth[1].

MANAGEMENT

Patients must be informed of the risk of root resorption prior to starting Orthodontic treatment as a part of informed consent. In most cases, clinically significant shortening of a tooth root is rare. However, each patient must be made aware that, at present, we cannot predict which individuals will be susceptible to severe root resorption. Significant loss of tooth root structure can lead to an unfavourable crown to root ratio. Many clinicians fear that the potential consequence is an adverse effect on the long term prognosis of the affected tooth. Various methods are there to minimise OIIRR. These include the use of light intermittent forces, reduction of treatment duration, habit control and prior assessment of family and medical history. Minimizing the use of inter maxillary elastics and high risk tooth movements such as intrusion and root torquing have also been recommended[1].

It is thought that active Orthodontic forces have an important role in the continuity of root resorption, therefore, the repair process begins after the release of the Orthodontic force or decrease in the magnitude of the force at a certain level. The repair is first observed around the resorption lacunae. This process shows similarity to the early cemento genesis during the development of the teeth. Resorption lacunae are recovered with the accumulation of new cementum and formation of a new periodontal ligament. Owmann-Moll et al. Stated that the possible repair level in resorption cavities that can be histologically observed can be summarized as follows:

I- Partial Repair: Part of the surface of the resorption cavity is covered with reparative cementum (cellular or acellular cementum).

II- Functional Repair: The total surface of the resorption cavity is covered with reparative cementum without the re-establishment of the original root contour (cellular cementum).

III- Anatomic Repair: The total surface of the resorption cavity is covered with reparative cementum to an extent such that the original root contour is re-established.

Studies found that resorption continued for 4 weeks after the stop of the Orthodontic force. After four-week light force application which was followed by 4-week retention, there was continuous and regular repair, while most of the repair occurred where the heavy force was applied in 4 weeks, which was followed by the 4-week retention[9].

CONCLUSION

External apical root resorption (EARR) can be a significant sequel of Orthodontic treatment and in the most severe cases may threaten the longevity of the teeth. Identification of the factors contributing to EARR during Orthodontic treatment is therefore essential in order to minimise the incidence and severity of root resorption. The key point to take from this review is that, whilst Orthodontic treatment is associated with an increased incidence and severity of EARR, it is not currently possible to determine which patients are at particular risk. Until better evidence becomes available, all prospective Orthodontic patients should be warned of the possibility of root resorption as part of the consent process. Additionally, pretreatment radiographs should be taken for all patients, to act as a baseline against which any future resorption can be measured.

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