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External Root Resorption (ERR) after orthodontic treatment: Review article

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Abstract

External root resorption (ERR) after orthodontic treatment represents one of its associated negative consequences. For several years, the existence of risk factors that contribute to the establishment of this alteration has been described, where we find genetic alterations related to the orthodontic treatment performed.

Keywords: Root Resorption; Orthodontic Appliances; Fixed Orthodontic Appliance; Fixed Functional Appliances.

1. Introduction

The external root resorption (ERR) represents one of the iatrogenic effects related to the treatment of orthodontics either by the use of fixed apparatus or transparent aligners, where it predisposes to the loss of the root structure as is the cement or dentin [1-4]. Due to dental movement and as a consequence of sterile inflammation of the periodontal ligament and alterations in the microcirculation that allows the presence of a large number of cytokines and molecular factors involved with the activation of osteoclasts, including the kappa-B (Rankl) /Rank nuclear factor ligand receptor activator, osteoprotegerin (OPG) pathways and interleukin (IL-1). Initial root resorption is caused by the activity of macrophage-like cells from the periodontal ligament, which causes damage to the root cement matrix, thus producing a denuded dentin root surface which is more susceptible to resorption as a result of osteoclast activity [5,6].

2. Material and methods

A comprehensive search strategy of the scientific literature was carried out using the databases of PUBMED, SCIENCEDIRECT and SCOPUS, where by means of the keywords “Orthodontic Appliances, Fixed” y “Root Resorption” by using boolean operators “AND” y “OR”, a total of 23 scientific papers were obtained, which met the following criteria:

2.1. Criteria for Inclusion

- Narrative reviews, systematic and meta-analysis of literature.
- Publications in English language.
- Scientific articles present in the database Pubmed, SicenceDirect and Scopus.

2.2. Criteria for exclusion

- Scientific articles of more than 5 years of publication.
- Studies based on case reports, protocols, opinions, letters and brief communications.

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3. Results

3.1. Diagnosis

External root resorption is usually diagnosed as a clinical finding, when a routine x-ray is analyzed. The radiographic method of choice is usually the panoramic one since this represents a diagnostic tool very useful in dentistry. However, due to the distortion that can present the image and certain shortcomings directly related to the technique of the operator and the apparatus itself, a superiority has been described by the conical beam computed tomography (CBCT) for the diagnosis of RR. However, the potential risk they pose by exposing the patient to a greater amount of radiation compared to panoramic radiographs such as high economic costs, allows us to conclude that the CBCT can be used strictly for certain specific and emergency cases, but not for routine radiographic monitoring. It is important to mention that the diagnostic capacity of the professional should, in theory, allow the identification of RR cases through the analysis and observation of the root morphology of the teeth [7].

3.1.1. Degrees

It has been possible to classify the degree of RRE thanks to the different radiographic findings described in the literature, where we have:

- **Grade 0:** No Root Resorption [8].
- **Grade 1**: Mild reabsorption, where the root has a normal length and only an irregular contour [8].
- **Grade 2**: Moderate reabsorption where there is a small root loss area and the apex has almost a straight outline [8].
- **Grade 3**: Accentuated root resorption where there is a loss of the root third [8].
- **Grade 4**: Extreme resorption with more than one missing root third [8].

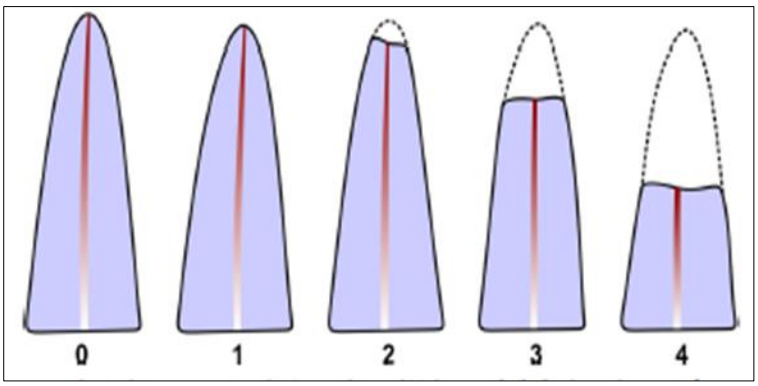

Figure 1 Classification of ERR; (Source: Handem RH et al)

3.2. Prevalence

Prevalence of 73, 90 and 100% of RR has been reported, corroborated by diagnostic tools such as radiographs, cone-beam tomography and histology, respectively. RR can affect any tooth, but there is a predilection for maxillary teeth especially the central and lateral incisors as well as mandibular incisors and first permanent molars [1,6]. Iglesias-Linares A et al., describe that more than a third of individuals who received fixed orthodontic treatment, developed a root loss of 3 mm in length and only a small percentage of between 2% and 5% of patients had a severe RR greater than 5mm [1]. In contrast, Dibiase T et al., report that only 16% of patients have manifested relevant clinical alterations that affect below a root [6]. However, the literature has described different data regarding the prevalence of orthodontic post-treatment RR, since these tend to vary from <10% to 100%. For example, Massler and Malone reported a prevalence of 86.4% and Lupi et al. Report 15 to 73% of RR at the level of the incisors [7].

3.3. Risk Factors

Among the main factors related to the etiology of ERR, it can be attributed to factors related to both the patient and the treatment. Biological factors are related to genetic susceptibility, systemic disease, age, sex, previous trauma reabsorption, habits. In contrast, treatment-related factors are based on mechanical factors such as the magnitude of force, amount of dental movement, type of force and apparatus used [5]. However, Ciurla A and Szymanska J, describe these factors as age, sex, type of malocclusion, horizontal and vertical overbite it does not represent risk factors for the

development of ERR, as it also emphasizes that the pro-inclination of the maxillary and mandibular incisors predisposes to a shortening of the roots of these teeth during the different phases of treatment [9].

Among other factors that predispose the development of ERR we find certain disorders such as: ectodermal dysplasia, tuberous sclerosis, osteogenesis imperfecta, Paget's disease. Similarly, the existence of malocclusions such as anterior open bite, type III bad occlusion and habits such as onychophagia, lip and lingual dysfunction, represent risk factors [10].

3.3.1. Genetic Factors

The presence of a genetic factor related to external root resorption has been described for several years, these genes are related to the process of bone remodeling. Some studies have described the importance of certain proteins involved in the modulation of the inflammatory response (ATP/P2RX7/IL-1b) and proteins regulating the activation of osteoclasts (RANK/RANKL/OPG). P2RX7 protein is expressed by osteoblasts and osteoclasts and allows osteoclast activation and apoptosis. Likewise, it is related to inflammatory processes through the stimulation of cytokines such as IL-1B. Inflammation mediated by the interaction of ATP/P2RX7/IL-1b activates the osteoclasts and the RANK/RANKL/OPG system during the process of resorption and bone and root remodeling. The P2RX7 gene is located on chromosome 12 in humans and the IL1RN gene is located on chromosome 2. A polymorphism in this gene may represent a risk factor that predisposes the development of a post-orthodontic ERR. However, this phenomenon is considered to have a multifactorial etiopathogenesis and it is not only possible to infer these genetic alterations as a single isolated factor [3]. Similarly, Borilova-Linhartova P et al., mention that variability in this gene (P2RX7) in combination with orthodontic treatment time acts as potentially risky factors for the development of this phenomenon [11]. Also, Iber-Diaz P et al., describe the existence of multiple genetic variants at the level of chromosomes X and Y which are directly related to the phenotype of the ERR, thus, there are certain genetic variants such as STAG2 rs151184635 and RP1-30E17.2 rs55839915, which increase the risk of developing ERR only in men [12].

3.3.2. Factors related to orthodontic treatment

Force employed

Derek-Currell S et al., describe that the RRE is directly associated with the application of orthodontic force, where he concludes that forces continue regardless of magnitude or direction (intrusive) as well as heavy forces, generate a higher ERR by purchasing them with interrupted forces; because the intermittent load allows the proper regeneration of the reabsorbed root cement [13].

Apparatuses employed

For many years, the differences between intermittent forces (transparent aligners -Invisalign System) and continuous (fixed) forces generated by the different orthodontic apparatuses were discussed. Intermittent forces were believed to allow root cement to heal in order to prevent future reabsorptions during pause periods. However, these kinds of forces have been associated and referred to as damaging agitation forces where they are likely to generate greater relevance, since current care protocols on the correct use of these aligners recommend continuous use throughout the day, therefore, they are considered as continuous forces that present an activation of short periods whose oscillation is commonly 15 days, although some clinicians recommend their change every 7 days. However, certain current protocols for the use of fixed apparatus usually involve the proper and sequential use of light forces, therefore the predisposition to develop ERR is similar to removable alienators [1]. However, Jyotirmay et al and Adeeri A et al., conclude that the rate of root resorption is lower in those patients who undergo treatment with transparent aligners compared to conventional fixed apparatus [14,15]. In a similar way, Mohamed H et al., describe that the use of transparent alienators probably does not reduce the incidence of ERR at all, but being correctly employed together with a collaborative and disciplined patient, the risk of developing this abnormality can be significantly reduced [16]. Similarly, Elhaddaoui R et al., in their review, conclude that the use of these thermoplastic splints, can generate ERR after orthodontic treatment, but to a lesser degree if compared with the results in patients with fixed apparatus [2], results comparable to those of Fang X et al., where they determine that the use of transparent splints does not act as a preventive factor of ERR, but that it can decrease the incidence and severity of root resorption in patients [17].

Functional aparatology

The use of functional aparatology is very common in orthodontics especially for the treatment of malocclusion type II, mainly related to problems in sagittal direction and jaw retrusion [18].

The Herbst apparatus is characterized as a rigid fixed functional apparatus very common in this treatment, similarly the Forsus apparatus which is a fixed and flexible apparatus that can be applied in combination with brackets. However, these devices can generate vertical and sagittal forces which represent a risk factor for the development of ERR, this is mainly associated with Herbst which tends to affect the level of the posterior roots in the teeth where anchoring is performed [18].

Coban G, relates in his research the development of statistically significant ERR in a range of 0.15 - 1.55 mm at the level of the roots of first molars and premolars treated with both Herbst and Forsus [18].

Lingual orthodontics

Lately, this modality of treatment has gained a lot of popular especially in adult patients, who present some degree of concern in relation to their aesthetics. Lingual orthodontics can develop certain factors such as uncontrolled moments, less distance between braces and much more elastic wire arches. Similarly, the brackets are located much closer to the lingual resistance centre and have different mechanics compared to conventional procedures [7].

However, Pamukçu H et al., conducted a comparative study between lingual and conventional orthodontics (vestibular) where they concluded that both developed statistically similar ERR rates, where the lingual treatment only generated mild reabsorptions, since this percentage was 7.2% compared to 9.4% of the vestibular technique [7].

Type of bracket used

For a long time, it was associated with external root resorption as a biomechanical consequence of the magnitude of the strength and distance of dental movement. However, several authors have emphasized the existence of a relationship between the ERR with the use of conventional brackets as self-ligating during treatments. The latter were introduced during the 1930s presenting certain advantages compared to their conventional counterpart, between which we find much shorter treatment times thanks to the less friction that is generated and thus allowing greater dental movement [19].

However, Qin F and Zhou Y, described that there are no significant differences when comparing the use of self-bound and conventional brackets in relation to external root resorption, despite the hypothesis that the ERR was thought to be intimately related to the rapid dental movement generated by the self-bonding brackets. It is important to emphasize that, in the present study, the self-aligning devices generated an average root resorption of 0.35 mm similar to the conventional ones whose results were 0.3 mm [19]. Likewise, Aras I et al., describe that there are no significant differences when buying the ERR in their study groups where self-bonding brackets (Damon system) and conventional brackets were placed, why it suggests that a superiority of one system over the other cannot be provided or described based on the degree of ERR generated [20]. These results are comparable to those of Yi J et al., where they conclude that there is no superiority of the self-bound system with respect to the conventional one; However, it describes the possible protection generated by the auto-linked system of the upper central incisors of the ERR [21]. Similarly, Heiffig-Handem R et al., reported that there are no significant differences between the Damon and conventional systems with respect to the development of this anomaly [8].

3.4. Dental movement

3.4.1. Torque

Torque is defined as the moment generated by twisting a rectangular wire inside the bracket groove, this is very useful to alter the inclination of the tooth. Torque is very important during treatment in patient's class II subdivision 2 to allow stability during treatment. However, a relationship between torque-generated motion and ERR has been described. For this reason, Linge described the implementation of treatments in two phases, where first there is a pretreatment with removable equipment and then the use of fixed equipment, which significantly decreases the incidence of ERR when compared with those patients who received a single-phase treatment based solely on fixed apparatus [10].

Faxen-Sepanian V and Sonnesen L., describe the existence of a much more significant ERR in patients who received a single-phase treatment compared to those with two phases at the level of the lower central incisors. Therefore, this treatment modality should be considered a valid option for treatment in patients with malocclusion II of Angle subdivision 2 [10].

3.4.2. Traction and verticalization of parts included

In contrast, orthodontic treatment used to traction and verticalize impacted maxillary canines, according to Rodríguez-Cárdenas Y et al, does not represent a risk factor for the development of RR at the level of these teeth. However, it generates appositional changes at the palatal level of the cervical portion in the axial section of the dental root [22].

The results described by Wang Y et al., where they studied the predisposing factors of ERR in the verticalization of impacted lower third molars, conclude the existence of a positive correlation between ERR and the distance of dental movement because this generates a greater load at the root apex level mainly at the torque that can be performed [23].

4. Conclusion

Based on the above, it can be said that the ERR represents one of the negative consequences of orthodontic treatment, which is due to many factors which are directly related to the patient as well as the type of treatment performed and the type of biomechanics used, therefore, it is the duty of the professional to make a timely diagnosis to be able to predict any possible complication of the treatment installed.

Compliance with ethical standards

Disclosure of conflict of interest

All the author states no conflict of interest for publishing this original manuscript.

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