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Root resorption: Etiology, diagnosis and treatment

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Abstract
Introduction: Root resorption (RR) can cause premature loss of the affected tooth.
Objective: To analyze the literature about the different classes of RR, as well as their relationship with the specialties of orthodontics and endodontics.
Methodology: In PubMed, Science Direct, Google Schoolar searched for information with combinations of the keywords: external RR, internal RR, orthodontic treatment, endodontic treatment, epidemiology, etiology, diagnosis, manifestations and treatment.
Results: Both external and internal resorption present preference to the upper central incisor teeth. In the external reabsorption both biological and mechanical factors intervene and in the internal reabsorption the mechanical factor prevails. Cone Beam Computed Tomography (CBCT) is the most accurate diagnostic method. The treatment of external RR will depend on its etiology and the dentist's diagnostic criteria, while stopping the internal resorption process ultimately requires endodontic treatment.
Conclusion: RR has a multifactorial etiology. A correct diagnosis is essential to select the appropriate treatment plan to stop the resorption process. The CBCT is the diagnostic tool of choice for its proven effectiveness. The Calcium-enriched Mixture Cement represents a good treatment option.

Keywords: External root resorption, internal inflammatory resorption, orthodontic treatment, endodontic treatment

1. Introduction
The RR process is considered as a frequent and alarming problem in dental conservation and is one of the most undesirable results after treatment [1]. During orthodontic dental movement, apical root resorption is an unwanted side effect, difficult to predict and repair, in addition, such displacement could induce some response from the pulp tissue, so it also represents a challenge of the endodontic specialty [2, 3]. Root resorption is a condition that results in the progressive loss of hard dental tissue, which can occur both inside the root and externally [4]. Without intervention it can cause premature loss of the affected tooth [5]. Currently there is not enough information about the similarities and differences between internal and external resorption, as well as their associations with dental specialties. The objective of this review is to analyze the literature on the epidemiology, etiology, diagnosis, manifestations and treatment of different kinds of root resorption, as well as its relationship with orthodontics and endodontics.

2. Methods
The scientific literature search was carried out in databases of PubMed, Science Direct, Google (Scholar). The information search was done through the inclusion of keywords such as external root resorption, internal inflammatory resorption, orthodontic treatment, endodontic treatment. The literature that was selected from the first instance was the one reported in updated journals.

3. Results & Discussion
3.1 Epidemiology
External apical root resorption is one of the most common iatrogenic consequences of orthodontic movement [6].

According to the studies investigated, it is indicated that the teeth most susceptible to external RR were the upper central incisors, followed by the lower lateral incisors, in addition to the fact that in all patients there was some degree of external RR after orthodontic treatment [7, 8]. It is stated that the type of malocclusion, parafunctional habits and allergies do not represent a statistically significant risk of root resorption [9, 10]. On the other hand, internal RR is considered more a pathology of low incidence [11]. RR is more frequent in cases of severe trauma, especially avulsion and intrusive dislocation [12]. Most cases of internal RR are seen in anterior teeth because of their susceptibility to trauma [13]. In addition, it is common to find this condition in teeth with pulp inflammation or necrosis [13, 14]. According to the literature, there is no gender predisposition, in the case of external RR [15, 16], on the other hand, information is needed on the demographic aspect of internal RR. Both external and internal RR present preference to the upper central incisor teeth. External RR is not necessarily related to orthodontic treatments, since other factors such as patient genetics can also cause this pathological reaction. In the case of internal RR, the pulp state is strongly associated.

3.2 Etiology

As a general concept, RR is a pathological process of multifactorial origin related to permanent loss of dental structure in response to mechanical, inflammatory, autoimmune or infectious stimuli [17]. External RR can be determined by a variety of factors such as periapical pathological processes, dental eruption and periodontal pathological processes ([8]. Genetic predisposition has also been described as an etiological factor of external RR, along with mechanical factors derived from orthodontic treatment, and in turn, the reaction to orthodontic force may differ depending on the genetic origin of the individual [19, 20]. The most associated genetic factors were IL-6 SNP rs1800796 GC and the presence of specific genotypes for P2RX7 SNP rs208294 [20, 21]. It is very likely that several of the molecular pathways and the aforementioned factors interact in effector cells for resorption at the level of fusion, activation, and cell adhesion [22]. On the other hand, most cases of internal resorption are idiopathic [23]. However, like external resorption, it is usually related to dental trauma, as this can impact hard dental tissues, as well as damage the pulp and the periodontium and adjacent alveolar bone [24]. Consequently, it also becomes related to the stimulation of pulp tissue, which, when starting an inflammatory process, leads to undifferentiated pulp cells to become osteoclasts or macrophages, which results in dentin resorption [11]. The role of osteoclasts and odontoclasts is related to physiological and pathological clinical scenarios, including RR. Understanding the mechanism that controls its development and activation would provide information for its early detection and clinical management [25]. Other studies mention relationships with the presence of rheumatoid arthritis, and talk about the Herpes zoster virus, as a possible viral etiology [26, 27]. Although there is no information that confirms the exact etiology of dental resorption, we can realize that there are several patterns that can be taken as a reference to end the cause of these pathologies. In the external reabsorption both biological and mechanical factors intervene and in the internal reabsorption the mechanical factor prevails. Research on its possible relationships with systemic diseases and other factors would be of medical relevance.

3.3 Diagnosis

For the correct diagnosis, the use of radiographs and anamnesis is of vital importance, since only through them will it be possible to identify the different factors that could cause root resorption [1]. As a differential diagnosis, it can be identified that external RR is always accompanied by bone resorption, therefore, radiolucent areas can usually be seen both in the root and in the adjacent bone, while internal reabsorption is limited to affecting the root [28]. According to research, internal resorption lesions may perforate the external surfaces of the root, which may not be detectable in conventional radiographic images [29], and at the same time it is concluded that panoramic radiography is not appropriate for diagnosis of external RR [30]. The CBCT is a new technology that uses a cone-shaped beam, which rotates in 360 degrees and acquires the projected data in a single rotation, which facilitates the perception of 3D for the dentist [31]. Their arrival has greatly improved the physician's ability to diagnose internal root resorption [32] and can also be reliable in detecting the presence of external RR in clinical practice [33]. Although conventional periapical radiographs can provide acceptable diagnostic accuracy [34], CBCT is superior in the diagnosis of external and internal inflammatory RR after dental trauma and can be considered in the differential diagnosis in resorption lesions in teeth with endodontic treatment [35]. Due to its superior diagnostic accuracy, it also resulted in a greater probability of correct management of resorption lesions [36]. However, a disadvantage is that the radiation dose of a CBCT study is higher than most conventional imaging techniques [37]. Achieving an adequate diagnosis and differentiation of an external RR from an internal RR is essential, since as we both know they have different etiologies and their management must also be specific. CBCT is the most accurate diagnostic method, however, it should be used sparingly for the dose of radiation involved in its use, for this reason the use of conventional periapical radiographs should not be ruled out at least in the case of external RR.

3.4 Manifestations

Radiographs highlight that some forms of external RR are accompanied by radiolucency of the bone adjacent to the resorption lesion or may present changes in the shape of the root, in which the missing part of the root is replaced by bone tissue, without radiolucency [18]. External RR associated with orthodontic treatment causes a permanent shortening of the root, which translates into a loss of dental support [38]. Also, it is accompanied by mobility of the affected teeth [39]. On the other hand, internal RR can manifest itself in a purely destructive way (internal inflammatory reabsorption), and on the other, as resorption by internal replacement, which is in conjunction with the deposition of metaplastic bone / cement tissue adjacent to the sites of resorption [36]. It is usually asymptomatic, so an early diagnosis is necessary before the process compromises the remaining mineralized structures of the tooth [40, 41]. If a perforation of the crown and the metaplastic tissue is exteriorized, a pink coloration appears on the vestibular surface, causing pain [42]. Traditionally the pink spot was considered in the crown as a pathognomonic sign of internal resorption, but also usually indicates the presence of an invasive cervical resorption [40]. Because the process of external and internal resorption takes place in the root portion of the teeth, the manifestations of these are mostly subclinical. Thus, at the time of making radiographic diagnoses it is very important to always examine every detail to realize this type of pathologies.

3.5 Treatment

Treatment alternatives depend on the case and are intended to address the cause of resorption and help regeneration of the resorption lesion [43]. Timely management of the affected tooth can delay the resorption lesion and increase the prognosis of the tooth survival [44], Internal resorption requires the presence of vital tissue to advance, therefore, endodontic treatment stops the process [40]. The technique of choice to carry it out is thermoplastic injection of gutta-percha. In case the resorption is in an advanced stage and has produced a communication of the root interior with the periodontium, the filling material must be MTA [40]. It is not possible, through the pulp, to control the resorption process that is taking place in the external part, after all, the causes are acting in the periodontal ligament [45]. External RR for orthodontics does not require endodontic treatment, as occurs with the forces applied on the tooth, it should be treated by eliminating these forces [46]. Some studies talk about the clinical efficacy of MTA to limit the process of inflammatory resorption and promote the apexification and regeneration of the periradicular tissue [47, 48] Although it has been pointed out that its extrusion in periradicular lesions should be avoided, by a possible inflammatory reaction of the tissue due to its particles [49]. Meanwhile, new alternative materials are being introduced, such as the Calcium-enriched mixture cement that has proven to be a good candidate for sealing and filling internally reabsorbed teeth [50]. Other findings show that severe external RR can be suppressed by the administration of loxoprofen without altering dental movement [51]. It will depend on its etiology and the dentist's diagnostic criteria, while stopping the internal resorption process ultimately requires endodontic treatment. The Calcium-enriched mixture cement represents a new alternative for sealing root perforations, in addition to the conventional MTA.

4. Conclusions

External and internal resorption have a multifactorial etiology. A correct diagnosis is essential to select the appropriate treatment plan to stop the resorption process. Because its manifestations are subclinical, CBCT is the diagnostic tool of choice for its proven efficacy. Calcium-enriched mixture cement represents a good treatment option for root perforations. New questions remain open, such as its relationship with systemic diseases, demographic aspects and the development of alternative materials for the treatment of these pathologies, for future update studies.

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