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A Review on Orthodontic Treatment and Root Resorption Prevention and Management

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ABSTRACT

Root resorption is a common complication of orthodontic treatment that can lead to the loss of tooth root structure. While it often occurs without significant clinical consequences, severe resorption can compromise dental health. This review explores the etiology, risk factors, diagnosis, and management of orthodontic-induced root resorption. Several factors contribute to root resorption, including patient-related characteristics, orthodontic forces, and appliance types. Early detection is crucial for effective management. Advanced imaging techniques, such as cone-beam computed tomography (CBCT), provide improved visualization of root resorption. Treatment typically involves suspending orthodontic forces to allow for natural repair. While pharmacological interventions and adjunct therapies are being investigated, the most effective approach remains early detection, careful treatment planning, and monitoring to minimize the risk of root resorption. This article gives an overview on orthodontic treatment and root resorption prevention and management.

Keywords: Root Resorption, Orthodontic Treatment, Orthodontics, Repair Process

INTRODUCTION

Root resorption is a pathological process that leads to the loss of root structure in teeth, commonly associated with orthodontic treatment. It occurs when the body's cells break down and absorb the mineralized tissues of the tooth root. This condition is of particular concern in orthodontics because the application of forces to move teeth can inadvertently trigger resorption of the tooth roots. Orthodontically induced inflammatory root resorption is a potential complication of orthodontic treatment but can also occur in patients who have never undergone such treatment. This type of resorption is distinct from other forms and is characterized as a sterile, localized inflammatory process with all the typical symptoms of inflammation. Root resorption or shortening can be triggered by various factors, including trauma, infections of the periapical tissues, and periodontal diseases. The process is usually asymptomatic until significant destruction of the dental structure occurs, making early detection possible primarily through radiological examination. Both the apex and lateral surfaces of the root can undergo resorption, though apical root resorption is the type most commonly detected on radiographs. While orthodontic treatment rarely leads to clinically significant root resorption, microscopic changes in the roots often go undetected in radiographic images. Root resorption can cause root shortening and weaken the dental arch, which is crucial for the success of orthodontic treatment. Clinically significant resorption is defined as a loss of 1-2 mm (approximately 1/4) of the root length. Severe resorption (loss of more than 1/4 of the root length or greater than 5 mm) is rare, occurring in only 1-5% of patients. Root resorption is a process closely linked to the injury and necrosis of the periodontal ligament (PDL). When heavy orthodontic forces are applied for an extended duration, necrosis or hyalinisation of the compressed PDL can quickly occur. This triggers a defensive response where leukocytes, including osteoclast progenitors, migrate from PDL capillaries and form multinucleated cells capable of resorbing mineralized tissues such as bone and tooth roots. Root resorption starts when the protective cementoblast layer adjacent to the hyalinised PDL undergoes apoptosis, allowing odontoclasts to resorb the cementum and dentine. Initially, the removal of the protective cementoid layer exposes a raw cemental surface, making it vulnerable to further resorption by odontoclasts.

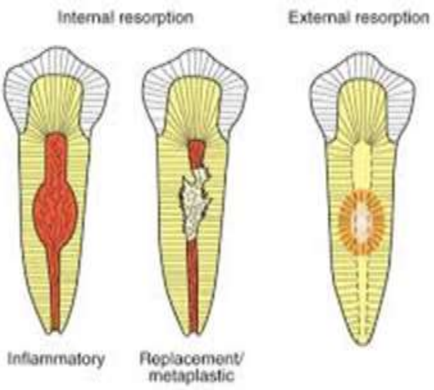

Figure 1: Root Resorption types

Radiographically, resorption is most commonly observed in the apical region of the root due to the presence of cellular cementum, which depends on active cells and vasculature. This region is particularly susceptible to trauma and injury-related reactions because the apical root third has more extensive blood vessel occupancy (47% of the PDL space) compared to the cervical end (4%). The apical region also has reduced hardness and elasticity compared to other areas of the root, increasing its susceptibility to resorption. Additionally, the tooth's centre of rotation during tipping movements is located occlusally to the apical half of the root, which, combined with variations in periodontal fibre direction, results in heightened trauma to the apical and middle thirds of the root.. Numerous studies highlight the multifactorial nature of orthodontically induced external apical root resorption (OIIRR), influenced by genetic polymorphisms, orthodontic forces, appliance types, medications, and biological factors. Evidence quality varies, ranging from low to moderate, with key findings linking medications, hormonal molecules, and aligner versus fixed appliances to root resorption risk. These studies emphasize the need for personalized orthodontic approaches to minimize the risks of OIIRR, focusing on prevention and management strategies.[9] This review discusses the etiology, risk factors, prevention, and management strategies associated with orthodontic treatment-induced root resorption.

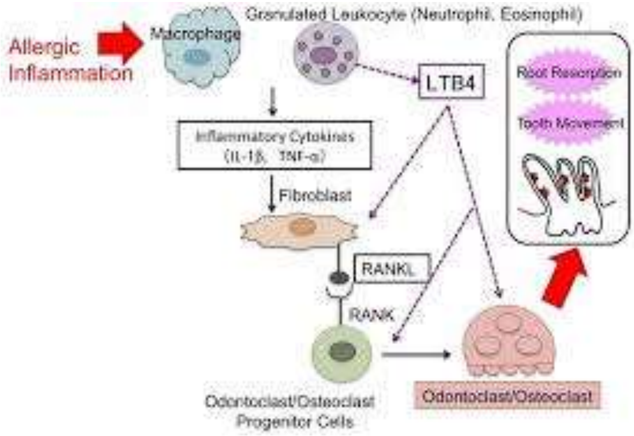

Figure 2: Pathogenesis of orthodontic associated root resorption

ETIOLOGY AND RISK FACTORS

Orthodontically induced inflammatory root resorption is influenced by various general and local risk factors that predispose patients undergoing orthodontic treatment to this complication. General factors include age, gender, ethnicity, systemic diseases, and genetics. Studies have shown an increased incidence of root resorption in adults, possibly due to decreased periodontal vascularity, inelasticity, and thicker cementum in the apical root third.[11] Gender-related differences are debated, though some studies suggest males may have altered root morphology that increases their susceptibility. Ethnicity plays a role, with Caucasians and Hispanics showing longer root lengths, which correlate with higher resorption risk compared to shorter roots found in Asians and African Americans. Systemic diseases, particularly those involving immune system imbalances like asthma and allergies, contribute to root resorption through elevated inflammatory mediators that affect periodontal tissues. Additionally, genetic predispositions, such as the presence of specific alleles in genes like IL-1b and TNFRSF11A, are linked to increased resorption risks. Local factors include tooth shape and position, with central and lateral incisors, molars, and canines being more prone to resorption. Abnormal root morphology, such as pointed, tapered, or dilacerated apices, increases vulnerability due to concentrated pressure from orthodontic forces leading to localized necrosis and resorptive damage. Previous trauma, pre-treatment root resorption, and increased dentine density in endodontically treated teeth also correlate with resorption susceptibility. Understanding these risk factors helps clinicians to better assess and monitor patients during orthodontic treatment, enabling timely intervention to minimize complications.

VISUALIZATION AND DIAGNOSIS OF ROOT RESORPTION

Root resorption during orthodontic treatment can occur unpredictably, affecting various root surfaces without necessarily reducing root length, making two-dimensional (2D) imaging methods often insufficient for accurate diagnosis. Conventional radiological evaluations, such as periapical, digital radiography, orthopantomography (OPG), and lateral cephalometric X-rays, are limited by magnification errors, superimpositions, and inconsistent positioning, leading to diagnostic inaccuracies. Advanced techniques like scanning electron microscopy (SEM) and micro-computed tomography (micro-CT) offer superior visualization of resorption craters, with micro-CT being highly regarded for its three-dimensional (3D) volumetric assessments, though its application is limited to in vitro conditions due to high radiation exposure. Cone-beam computed tomography (CBCT), developed for maxillofacial imaging, bridges the gap by providing 3D images with lower radiation doses and better image quality, enabling in vivo evaluation of root resorption. Although CBCT primarily offers linear measurements rather than volumetric, its use in detecting resorption cavities and performing reliable volumetric calculations makes it an advanced diagnostic tool for orthodontic-induced root resorption.

MANAGEMENT

Management of root resorption during orthodontic treatment involves the cessation of orthodontic forces, which halts active resorption and initiates a repair process. This repair can be partial, functional, or anatomic, with anatomic repair being the most desirable as it restores the root surface to its original contour. Studies have shown that repair progresses in stages: partial repair typically occurs within the first 4 weeks, covering exposed dentine incompletely with new cementum; functional repair follows in 5-8 weeks with complete coverage of the dentine by a thin cementum layer without restoring the original contour; and anatomic repair, which takes at least 8 weeks, fully restores the root surface. The repair process involves the deposition of cellular or acellular cementum, with acellular cementum forming slowly during initial rest periods, and cellular cementum forming more rapidly during later stages of healing as cementocytes become trapped within the mineralized tissue. Adjunct approaches to augment the repair process and reduce the rate of root resorption include the administration of drugs like bisphosphonates, which inhibit bone resorption, and anti-inflammatory agents such as tetracyclines and NSAIDs. Hormonal interventions, including corticosteroids and L-thyroxine, have also shown positive effects by altering bone remodeling dynamics. Low-intensity pulsed ultrasound has been explored as another potential treatment to enhance repair. However, the clinical applicability of these pharmacological approaches is uncertain due to potential systemic side effects, making an 8-week rest period the preferred management strategy if mid-treatment root resorption is detected.

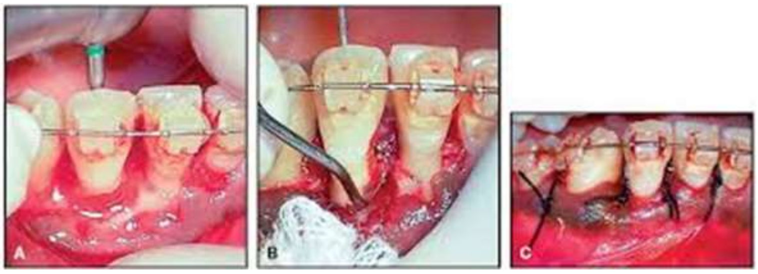

Figure 3: Management

CONCLUSION

Root resorption is a common but often unpredictable complication of orthodontic treatment, which requires careful management to minimize its impact. Despite advancements in imaging techniques, such as CBCT and micro-CT, accurately diagnosing the location, depth, and extent of root resorption remains challenging, particularly with traditional two-dimensional methods. The repair process of root resorption is influenced by the cessation of orthodontic forces, with anatomic repair taking the longest time. Although pharmacological interventions and adjunct therapies like low-intensity pulsed ultrasound may reduce resorption rates, these methods are not yet fully reliable for routine clinical use due to potential side effects. The most effective approach involves early detection, careful treatment planning, monitoring, and allowing adequate rest periods to facilitate natural repair processes, ensuring optimal outcomes in orthodontic care.

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