

Diagnosis of Root Resorption – A Brief Review of Literature

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Abstract

Orthodontic treatment carries the risk of external root resorption, a feared complication leading to root shortening and compromised tooth integrity. Both cervical and apical root zones can be affected due to orthodontic forces. Patient education about this risk is crucial. Detection of orthodontic-induced root resorption is possible during and after treatment. Severity depends on various factors including environmental and individual factors. The paper discusses mechanisms, detection methods, and correlations with susceptibility, tooth structure, treatment modalities, force, and duration.

Keywords: Diagnosis, External apical root resorption, Orthodontics, Root resorption.

INTRODUCTION

Orthodontic treatment improves facial esthetics, self-esteem, mastication, phonation, and overall health by aligning teeth properly, although it poses the risk of root resorption, which involves the loss of root tissues, such as dentin and cementum.^[1,2] Root resorption is the loss of both organic and inorganic components of hard root tissues, primarily dentin, and cementum, due to the overactivity of osteoclastic cells, often surpassing cementum's ability to repair itself. It can occur as either pathological or physiological processes, with maxillary anterior teeth commonly affected.^[3] Apical root resorption is an undesirable effect, common in orthodontic treatment, that leads to the permanent loss of dental structure.^[4] Orthodontically induced external apical root resorption (EARR) (OIRR) is defined as surface resorption with loss of cementum that is irreversible when involving dentin.^[4] Clinically significant root resorption is rare despite its common occurrence. Various radiographic techniques, including periapical radiographs and micro-computed tomography scans, aid in the detection of apical root resorption.^[5] A gold standard for evaluating approaches to detecting orthodontically induced root resorption has yet to emerge, highlighting the importance of comprehending its mechanisms and association with mineralized dental tissue loss for effective orthodontic management.

HISTORICAL BACKGROUND

Pioneers in the early 1800s recognized tooth structure breakdown due to oral disease, with later contributions

such as Ottolengui in 1914 linking it to orthodontic care and Oppenheim in the mid-1930s studying the impact of orthodontic force on cementum, periodontal tissues, alveolar bone, and pulp.^[3]

INCIDENCE OF ROOT RESORPTION

Orthodontic therapy often results in root apex blunting, with severe EARR most common in maxillary incisors, followed by molars and canines.^[6] While adults, particularly in mandibular anterior teeth, are more prone to resorption than children, the clinical impact is generally minor with acellular cementum and thinner cementum layers, with fixed appliances exacerbating the prevalence and severity compared to removable appliances and aligners.^[7]

FACTORS AFFECTING ROOT RESORPTION

Root resorption during orthodontic treatment is a complex condition influenced by biological and mechanical factors.

Biological factors contributing to root resorption risk include systemic conditions, such as endocrine disorders and asthma,

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as well as immune system conditions.^[6,8] While nutritional imbalances were initially believed to impact resorption, recent research disproves this statement.^[9] Age-related changes in tissues, habits such as nail-biting and tongue thrust, pre-existing root resorption, tooth trauma history, and genetics, including genes like TNFRSF11A, are also significant factors influencing osteoclastogenesis and cytokine production.^[10-14]

Mechanical factors affecting root resorption in orthodontics encompass the type of appliance utilized, with fixed appliances generally causing more resorption compared to removable appliances.^[13] The light wire Begg technique is purported to induce less resorption than the edgewise technique.^[15] In addition, orthodontic intrusion typically results in minimal root resorption, although concentrated pressure at the tooth apex during these movements may lead to notable damage, with bodily movements distributing stress evenly along the root and higher forces correlating with increased resorption.^[10,16]

Overall, root resorption is a multifactorial phenomenon with varying degrees of severity influenced by a combination of patient-specific biological factors and treatment-related mechanical factors.

GRADING OF APICAL ROOT RESORPTION

De Shields using intraoral periapical X-rays has described the following grading system for apical root resorption:^[17]

Grade	Definition
1	Possible resorption
2	Definite resorption-the apical outline was definitely irregular but the root was not shortened or blunted
3	Mild apical blunting-the reduction in root length was <3 mm
4	Moderate apical blunting-resorption is more than 3 mm but <1/3 rd the root length
5	Severe blunting-more than 1/3 rd of the original root length was lost.

Malmgren *et al.* described the root resorption index for quantitative assessment of root resorption (Figure 1).^[18]

Grade	Definition
1	Normal root length only displays irregular root contour-mild resorption
2	Root resorption apically, amounting to <2 mm-moderate resorption
3	Root resorption apically, from 2 mm to one-third of the original root length-severe resorption
4	Root resorption exceeding one-third of the original root length-extreme resorption.

Later, zero degree was added to this index, as proposed by Levander and Malmgren^[19] to point out unaltered teeth in the root apex.

Remington *et al.* described the following grading scale for apical root resorption as^[20]

Grade	Definition
0	Normal apical contour, the same length as pretreatment
1	Apical irregularity, the same length as pretreatment
2	Apical root resorption of <2 mm
3	Apical root resorption is more than 2 mm, less than one-third of the original root length
4	Apical root resorption of more than one-third of the original root length

Alamadi *et al.*^[21] considered the “slanted root resorption” and modified the original Malmgren index and described the following grading scale (Figure 2):

Grade	Definition
1	Irregular root contour
2	Slanted root resorption <1/4 th of the root
3	Slanted root resorption 1/4 th of the root
4	Slanted root resorption of 1/2 of the root
5	Slanted root resorption of 3/4 th of the root
6	Apex of the root is maintained with middle resorption.

DIAGNOSIS OF ROOT RESORPTION

Diagnosis of root resorption involves clinical, histological, and radiographic examination, with radiological diagnosis playing a crucial role in orthodontic treatment. Early detection of root resorption is essential for effective intervention. While root resorption is often asymptomatic, extreme cases may lead to increased tooth mobility and, rarely, tooth loss.

According to Brezniak and Wasserstein^[5] radiographs are commonly used as a diagnostic aid for investigating root resorption.

BIOMARKER TO DETECT ROOT RESORPTION

One emerging diagnostic approach highlighted in the literature involves identifying particular biomarkers that are linked to root resorption. Vieira^[22] and Mona *et al.*^[23] conducted research aiming to discover potential biomarkers for root resorption associated with gingival or salivary crevicular fluid. Mah and Prasad^[24] found that additional investigations are necessary to refine assay sensitivity and establish correlations between

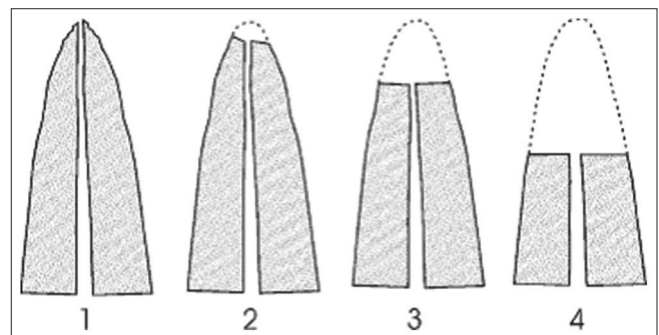


Figure 1: Quantitative assessment of root resorption by Malmgren *et al.*^[18]

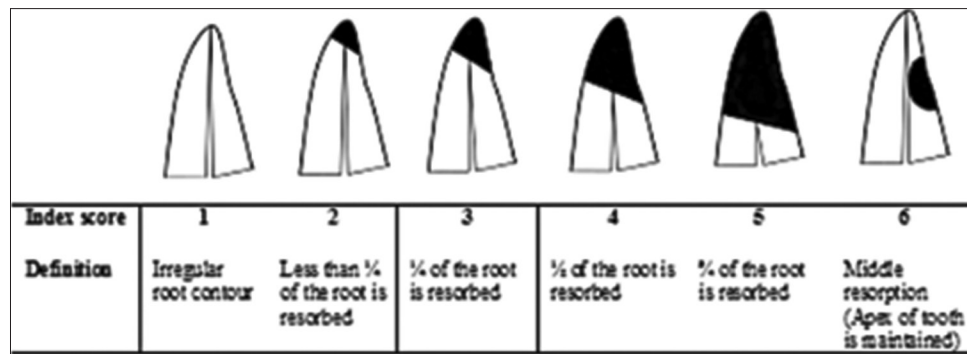


Figure 2: Modification of Malmgren index by Alamadi *et al.*^[21]

measurements and clinical observations, thereby facilitating the development of a practical clinical test. Huang *et al.*^[25] observed changes in the levels of dentin proteins in human crevicular fluid, while Mohd Nasri *et al.*^[26] identified six proteins (S100A9, IGJ, HSPA1A, IGHV4-34, TYMP, and VTN) exhibiting notable increases during the initial stages of orthodontic interventions. These findings suggest their potential as biomarkers for detecting root resorption.

Recent research highlights significant increases in interleukin-7, interleukin-10, interleukin-12p70, interferon γ , proteins, and metabolites, alongside a notable decrease in interleukin-4 in saliva when EARR is present.^[11,26] While a connection between biomarkers in gingival crevicular fluid and the onset of root resorption has been identified, further evidence regarding the clinical application of these biomarkers is warranted.^[11]

Tan *et al.*^[27] validated the use of a newly developed kit as an enzyme-linked immunosorbent assay with the incorporation of Gold nanoparticles (Figure 3) in his study for the detection of dentine sialophosphoprotein, a dentin biomarker, which is one of the most abundant non-collagenous proteins in the dentin and found that the new kit could potentially improve diagnostic accuracy and make the process easier for practitioners.

RADIOGRAPHIC METHOD TO DETECT ROOT RESORPTION

For years, periapical and panoramic radiography were the main diagnostic tools for root resorption, but newer methods like computed tomography (CT) and cone beam CT scans (CBCT) offer 3D models.

TWO-DIMENSIONAL IMAGING

Periapical X-rays, taken with the beam perpendicular to the roots, are preferred due to their availability and cost, while digital radiographs reduce ionizing radiation exposure.

Sameshima and Asgarifar^[28] found that for anterior periapical radiographs, clear visualization of the entire root is essential, with software manipulation enhancing image quality. Panoramic radiographs on digital machines are diagnostically superior to wet films, providing excellent visualization of teeth and roots, but periapicals are better for evaluating EARR, especially with minimized distortion.

Periapical radiographs offer wide availability, low cost, and relatively low radiation, especially when digitized, making them environmentally friendly. Periapical radiographs provide a two-dimensional view of a three-dimensional structure, leading to limitations in assessing root irregularities and dilacerations. Variability in image quality and susceptibility to distortion due to method and systematic errors are additional drawbacks.

Panoramic radiographs are widely available, easy to learn, and offer universal interpretation. They provide a comprehensive view of all teeth in a single image, facilitating quick assessment. Panoramic radiograph machines can be expensive and require calibration, while precise distance measurements are challenging. In addition, some patients may find it difficult due to positioning or movement constraints.

THREE-DIMENSIONAL IMAGING

CBCT have largely replaced the limitations of 2D representations in periapical and panoramic imaging, offering clearer 3D images with advanced software packages. Despite the clinical expectation that 3D images would be superior for locating impacted teeth, a significant study by Christell *et al.* (2018),^[29] demonstrated that clinicians' treatment decisions remained consistent regardless of whether they used 2D or 3D images.

Early studies by Sameshima and Sinclair,^[28] Nakajima *et al.* (2005),^[30] Walker *et al.*,^[31] Peck *et al.*,^[32] among others, highlighted the superiority of 3D root images over 2D representations. Lund *et al.*^[33] demonstrated that CBCT images consistently provided the same information regardless of the scan position. However, a study by Kumar *et al.*^[34] comparing periapical radiographs and CBCT images found no significant differences in identifying defects. Hecht's thesis (2013) conclusively demonstrated that root dilaceration perpendicular to the midsagittal plane is not detectable on 2D images but is readily visible on CBCT volumes. In addition, a systematic review by Samandara *et al.*^[29] found limited differences in the results of studies on EARR between those that used CBCT and those that used 2D imaging.

Segmentation of roots is currently time-consuming and impractical, but advancements in technology are expected

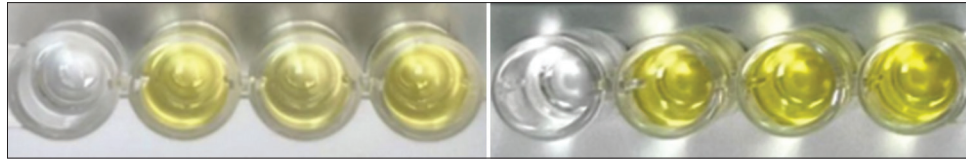


Figure 3: Difference in colour intensity formed by samples of different severity of root resorption

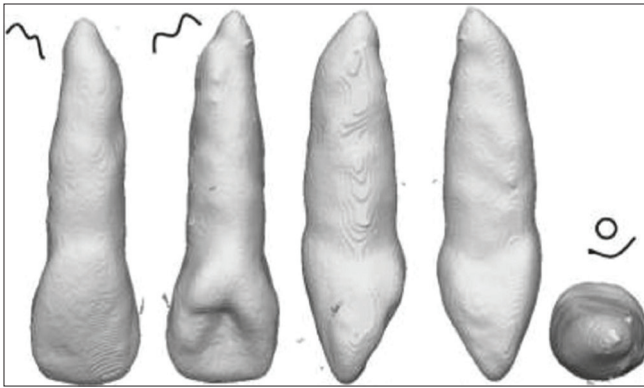


Figure 4: Segmented maxillary lateral incisor obtained from initial cone beam computed tomography scans as part of a study

to automate this process. Initial investigations into 3D root shape analysis using segmented teeth are in the early stages but hold great promise for future applications, as indicated by Ahlbrecht *et al.* (2017).^[35]

Classifying root shape in three-dimensions. In three-dimensions, a “step” at the apex is often found, which narrows the root apex. Furthermore, note the facial inclination toward the apex—it was also found that the root shape is irregular and asymmetric as it narrows from cervical to apical CBCT imaging is rapidly replacing 2D images for root visualization, offering improved clarity without subjecting patients to higher levels of ionizing radiation.

CONCLUSION

The goal of orthodontic treatment is to improve the patient’s life through enhancement of dentofacial function and esthetics. The most major hidden scars of orthodontic treatment are root resorption. Orthodontic root resorption can be predicted and prevented. Ideally, the risk factors would be strong enough to identify patients who are at risk and the necessary interventions would be done. Rapidly improved technologies, tests to identify the presence of EARR, biological markers, and advanced genetic studies of familial risk are all examples of recent scientific developments that aid in reaching the goal. EARR is relatively uncommon. Clinical management of this condition includes recognizing diagnostic and treatment risk factors, high-quality images required records for patients at risk, and the knowledge of understanding the management of EARR found either at the progress or at the end of treatment. Patient’s education and periodic dental visits are equally important.

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