Correlation Between Orthodontic Forces and Root Resorption – a Systematic Review of the Literature

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ABSTRACT
Orthodontically induced external apical root resorption (OIEARR) is a major concern regarding periodontal status after nonsurgical orthodontic treatment. The aim of this study was to assess this sequel by a systematic review of published data. For assessment, we performed an electronic search of one database for comprehensive data, using keywords in different combinations: "root resorption", "periodontics" and "nonsurgical orthodontic treatment". We supplemented the results searching by hand in published journals and we cross-referenced with the accessed articles. Patients included in the results presented a good general health status, with no previous history of OIEARR and no other associated pathologies. Finally, twenty-three studies were selected and included in this review. A high prevalence (69–98%) and moderate severity of OIEARR (<5 mm and <1/3 from original root length) were reported. No difference in root resorption was found regarding the sex of the patients. A moderate positive correlation between treatment duration and root resorption was found. Also, a mild correlation regarding antero-posterior apical displacement and root resorption was found.

Keywords: root resorption, orthodontics, periodontal disease

INTRODUCTION
Orthodontic treatment ensures proper alignment of the teeth and improves the occlusal and jaw relationship. Like any other treatment modalities, orthodontic treatment, in addition to its benefits, has also associated risks and complications. The only risk factors that have been supported by previous evidence will be reviewed in this article.

Root resorption is defined as the destruction of the cementum or dentin by cementoclastic or osteoclastic activity; it may result in the shortening or blunting of the root. It is an inflammatory process resulting in an ischemic necrosis in the periodontal ligament when the orthodontic force is applied. Root resorption occurs when the pressure on the cementum exceeds its reparative capacity.
and dentin is exposed, allowing the multinucleated odon-
toclasts to degrade the root substance.\textsuperscript{3}

The etiology of root resorption still remains unclear
and is complex, including genetic predisposition and
environmental factors.\textsuperscript{4} Orthodontically induced exter-
nal apical root resorption (OIEARR) is a sterile inflam-
matory process that is extremely complex.\textsuperscript{2} The loss of
apical root structure is not predictable; when it pro-
gresses reaching the dentine, it is considered irrevers-
ible. Severe root resorption after orthodontic treatment
compromises the outcome of successful orthodontic
treatment.\textsuperscript{1}

This review aims to highlight the main coordinates of
risk issues of root resorption in orthodontics.

**MATERIALS AND METHODS**

All the protocols regarding reports for systematic reviews
of health sciences studies were respected in accordance
with the PRISMA statement.

**Data sources**

Comprehensive searches up to March 31, 2016 were used
on the PubMed electronic bibliographic database (1972
to March 2016, week 5). The keywords used for this lit-
erature search were "root resorption", "periodontics" and
"orthodontics". Only human studies were eligible, the ini-
tial search retrieved 1024 articles, and from the retrieved
articles, manual searches were subsequently performed.
No restrictions were applied regarding publication year or
journal category.

**Study design**

The articles that were selected encompass the following
inclusion-exclusion criteria:

- **Population** — individuals with large over-jets and
crowding were included, with no restrictions regarding
gender. Patients included in the results presented a good
general health status, with no previous history of OIEARR
and no other associated pathologies.

- **Treatment** — patients undergoing orthodontic treat-
ment by removable or fixed appliances.

- **Outcome** — root resorption assessed by the root lengths
of maxillary teeth using OPT x-ray, before and after treat-
ment.

In the first part of the review process, adequate abstracts
were selected and after this process only twenty-three ar-
ticles met the inclusion criteria.

**RESULTS**

The search yielded twenty-three potential studies for in-
clusion from the electronic database. Full texts of these
journal articles were retrieved for examination.

**Sex and age**

Most of the studies included both male and female pa-
tients; however, there is no evidence suggesting any dif-
fences in root resorption between genders.\textsuperscript{6} Four studies
examined young teenagers with a mean age of 13 years.\textsuperscript{6–9}

**Treatment duration**

Many studies confirmed a higher risk and severity of apical
root resorption in patients with an increased duration of
orthodontic treatment.\textsuperscript{9–16} However, other authors found
no statistical significant association between root resorp-
tion and treatment duration.\textsuperscript{17,18}

**Appliance type**

Fixed appliances have been shown to cause more root re-
sorption than removable appliances, which can be explained
by the increased range of tooth movement afforded by fixed
appliances.\textsuperscript{19} The risk of root resorption associated with dif-
ferent bracket designs has yielded inconclusive results.\textsuperscript{20,21} It
is generally agreed that the use of a rapid maxillary expander
is associated with increased levels of root resorption.\textsuperscript{22–25}

**Treatment mechanics**

L. Linge and B.O. Linge suggested that the use of intermax-
illary elastics increased the amount of root resorption, but
Sameshima and Sinclair did not find any correlation.\textsuperscript{19,26}

**Force magnitude**

More recent studies have confirmed that the higher forces
increase the amount of external root resorption, thus con-
firming the previous studies.\textsuperscript{27,28} Reitan, on the other hand,
found that external root resorption was poorly correlated
with the force magnitude.\textsuperscript{29}

**Force duration**

Debate exists as to whether more root resorption is associ-
ated with continuous or intermittent forces. Many believe
that discontinuous forces produce less root resorption be-
cause the pause in tooth movement allows the resorbed cementum to heal.\textsuperscript{30–35} Acar \textit{et al.} examined 22 human teeth. The patients were exposed to a continuous tipping force of 100 g on one side, and on the other side an intermittent force was applied through elastics for 12 hours per day over a period of 9 weeks. Their results showed that the intermittent forces resulted in less root resorption. The accuracy of these results is questionable because the intermittent forces were subject to patient compliance.\textsuperscript{34}

Weiland studied 84 premolars, which had been moved buccally with an orthodontic appliance.\textsuperscript{35} On one side of the mouth, force on the premolar was applied with a stainless steel wire (0.016 inch), while force on the contralateral premolar was applied with a superelastic wire (0.016 inch). Their results support the findings of Acar \textit{et al.} that continuous forces cause more resorption.\textsuperscript{36} They showed that the teeth activated with the super elastic wire had moved significantly more, but had 140% more resorption than the teeth with stainless steel wire. Contrary to these reports, Owman-Moll \textit{et al.} found no difference in the amount or severity of root resorption between forces applied continuously or intermittently after the application of a buccally directed force of 50 g to human premolars.\textsuperscript{36}

**Direction of tooth movement**

Intrusion has been consistently implicated as the most likely type of tooth movement to cause root resorption.\textsuperscript{16,29} Displacement of the root apex horizontally or torquing has been proven beyond doubt to produce root resorption.\textsuperscript{26,37} Reitan and Thilander \textit{et al.} suggested that the stress distribution associated with tipping movements is more likely to cause root resorption than the stress distribution associated with bodily movement.\textsuperscript{25,30}

**Amount of tooth movement**

Sameshima and Sinclair found that severe root resorption occurred in their samples when the root apex was displaced lingually, with a mean difference of 1 mm more than the control group.\textsuperscript{26} They concluded that root resorption is directly related to the distance moved by the tooth roots. Maxillary incisors tend to be moved more than other teeth in orthodontic treatment, and therefore this is a possible explanation for why maxillary incisors have a higher risk of root resorption.

**Extraction**

Sameshima and Sinclair examined the relationship of the extraction pattern in detail as a factor affecting the resorption process.\textsuperscript{26} They observed a statistically significant difference in the resorption process when extraction and non-extraction groups were compared; among the extraction groups, the extraction of all first premolars showed the greatest resorption potential. Other studies that examined this factor did not find it to be significant.\textsuperscript{38,39}

**DISCUSSIONS**

Orthodontic treatment is usually contraindicated in patients with active periodontal disease or poor periodontal health, as the chance of further periodontal deterioration is high in such cases. The current literature evidence available for orthodontically induced external root resorption is conflicting and inconclusive.

**CONFLICT OF INTERESTS**

The authors declare that there is no conflict of interests regarding the publication of this paper.

**REFERENCES**


