

Risk variables of external apical root resorption during orthodontic treatment

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Introduction: External apical root resorption (EARR) is an adverse outcome of the orthodontic treatment. So far, no single or associated factor has been identified as responsible for EARR due to tooth movement.

Objective: This study investigated the association of risk variables (age, gender, extraction for orthodontic treatment and Angle classification) with EARR and orthodontic treatment.

Method: The sample (n=72) was divided into two groups according to presence (n=32) or absence (n=40) of EARR in maxillary central and lateral incisors after orthodontic treatment.

Results: There were no statistically significant differences in EARR according to age, gender, extraction or type of malocclusion ($p>0.05$).

Conclusion: The risk variables examined were not associated with EARR in the study population.

Keywords: Orthodontics. Root resorption. Tooth movement.

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INTRODUCTION

External apical root resorption (EARR) is a relevant pathological side effect^{2,10} of orthodontic treatment that leads to permanent loss of the dental root apex. According to Brezniak and Wasserstein¹¹ and Hartsfield Jr et al,¹⁶ it is a frequent iatrogenic result of orthodontic treatment, particularly in maxillary incisors.

The prevalence of EARR associated with orthodontic treatment is variable. Histological studies have reported a high prevalence, whereas clinical trials found a varied prevalence depending on the method used.⁹ EARR affects central maxillary incisors primarily; over one third of all subjects that undergo orthodontic treatment are affected by having resorptions greater than 3 mm, whereas severe resorption (greater than 5 mm) affects 2 to 5% of the orthodontic population.^{16,30} According to Capelozza Filho and Silva Filho,¹² root resorption is found in most (90.5%) permanent teeth that undergo orthodontic treatment; such areas are shallow and broad (surface resorption) and are always repaired. According to Consolaro,¹³ severe and structurally important root resorption affects 10% of the subjects that undergo orthodontic treatment.

EARR associated with orthodontic treatment is an important concern. Up to 3 mm of apical third loss results in limited damage, and root resorptions of such magnitude are assumed as a part of the biological cost of treatment. These side effects or iatrogenic events are practically unavoidable in orthodontic practice and are classified as clinically acceptable. However, they should not be seen as normal, physiological or part of the apical remodeling process.¹³

Apical resorptions that exceed 3 mm result in loss of tooth support due to a reduction of the supporting periodontium. Levander and Malmgren²² analyzed the mobility of teeth with severe EARR (resorption of 1/3 of the root or more) five to fifteen years after the active treatment phase and evaluated mobility associated with root length and supporting alveolar bone. They found a significant correlation between tooth mobility and total and intra-alveolar root length and concluded that there was risk of tooth mobility in maxillary incisors with severe root resorption during orthodontic treatment if the remaining root length was ≤ 9 mm.

Although several studies have investigated root resorption, no single or associated factor has been identified as responsible for EARR due to orthodontic treatment.³

The etiology of EARR associated with orthodontic treatment is multifactorial and involves environmental and host factors. Several variables have been described in the literature as possible risk factors for EARR: Tooth anomalies and the shape of root and alveolar bone crest,^{13,14,20,27} type and severity of malocclusion,^{5,6,14,17,27,30} amount of tooth movement,^{5,18,23,26} extractions for orthodontic treatment,^{7,24,28} cell and molecular mechanisms of osteoblast regulation,¹⁹ factors associated with the technique used, such as magnitude of force applied,^{1,25} treatment duration,^{15,21} type of orthodontic treatment,^{1,6,7,28} age and gender,^{5,6,7,14,17,20,26,27} individual variations and genetic factors.^{2,3,14}

This study investigated the association of age, gender, orthodontic extractions and Angle classification with external apical root resorptions resulting from orthodontic treatment.

MATERIAL AND METHODS

Sample

This study enrolled subjects over 18 years of age that received total fixed orthodontic treatment in the Graduate Program in Orthodontics of the School of Dentistry of Minas Gerais Federal University. The sample was divided into two groups according to presence (case group) or absence (control group) of EARR in maxillary central and lateral incisors.

Inclusion criteria

Participants were included if good quality periapical radiographs obtained before and after orthodontic treatment were available, and pretreatment radiographs showed no resorption.

Exclusion criteria

All subjects with crown fractures or restorations in the incisal edge of maxillary incisors were excluded.

Authorization of participants and parents or guardians

All participants over the age of 18 years and the parents or guardians of underage participants signed an informed term of consent after receiving explanations about the justification for radiographs

Data collection

Clinical analysis

Data about age, gender, extractions for orthodontic treatment and Angle classification of malocclusion were collected directly from patient charts.

Radiographic analysis

To evaluate the presence or absence of EARR, all periapical radiographs were digitalized using an HP Scanjet scanner 3570c at a resolution of 300 dpm. Images were analyzed directly on the computer screen using the software ARARA – An environment for image segmentation⁴ (Fig 1).

Measurements were made according to the method described by Linge and Linge,²³ modified by Brezniak et al.⁸ To determine and calculate the changes in tooth and root lengths between two

radiographs, those authors used, among other landmarks, the midpoint (M) for the cement enamel junction (CEJ), defined as the midpoint between the mesial and the distal CEJ (Fig 2).

After this landmark has been identified, the following distances were measured for all periapical radiographs: from M to root apex, as a measure of root length, and from M to incisal edge as a measure of crown length. These measurements are similar to the r1, r2, c1 and c2 distances described by Linge and Linge²³ (Fig 2).

Changes in root length due to treatment were mathematically calculated as follows: during orthodontic treatment, the length of the crown does not change, unless it is fractured or restored. Therefore, the ratio between initial (c1) and final (c2) length of the crown defines the radiographic change factor.



Figure 1 - Digitalized periapical radiographs before (A,B,C) and after (D,E,F) orthodontic treatment with maxillary incisors measurements of crowns and roots.

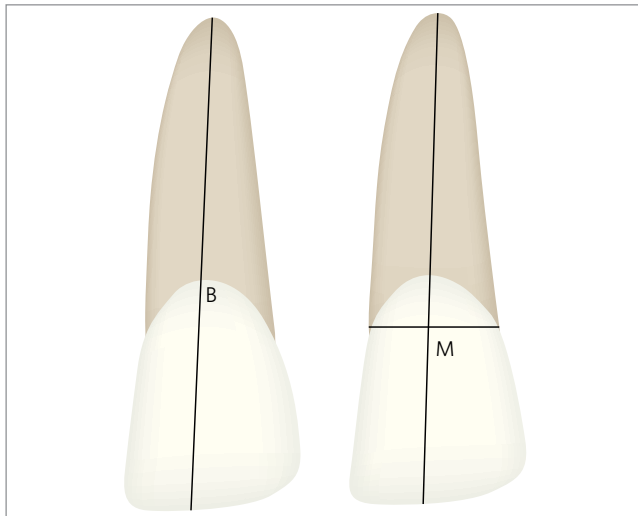


Figure 2 - Identification of midpoint (M) (Brezniak et al⁸).

If there was no change in root length during treatment, the ratio between initial and final root length ($r1/r2$) should be the same as the ratio between initial and final crown length ($c1/c2$). If the root length shortens during treatment, the amount of resorption is calculated as $r1-r2(c1/c2)$.

Therefore, subjects with less than 2 mm EARR were defined as not affected and included in the control group, and those with only one incisor with EARR ≥ 2 mm were included in the case group (Fig 3).

Examiner calibration

To observe examiner calibration, a single examiner repeated measurements of 20 radiographs at an interval of seven days between readings. Results were recorded as presence or absence of readings below 0.5 mm. Kappa statistics was used to evaluate the reproducibility of radiograph measurements.²⁹

Statistical analysis

Descriptive variables are presented as percentages, mean, and standard deviations (SD)

The Student t test, a chi-square test and the Fischer exact test were used to analyze variables below 5. The level of significance was set at 5% ($p < 0.05$).

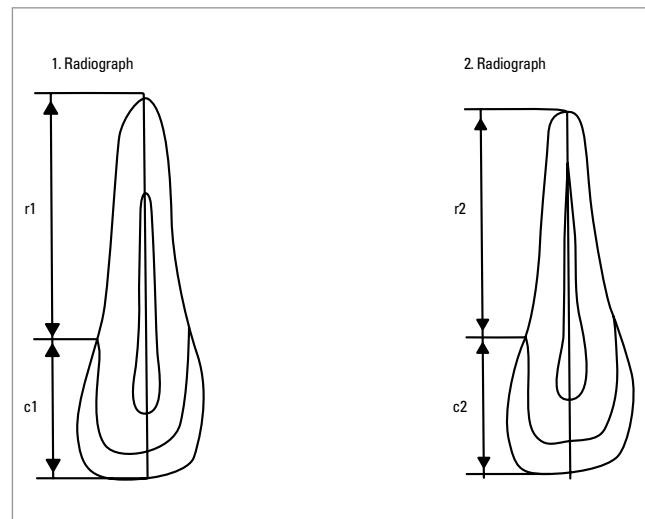


Figure 3 - Correction factor for difference in root length: $f=c1/c2$; external root resorption: $r1-r2(c1/c2)$ (Linge and Linge²³).

RESULTS

The sample included 72 subjects divided into two groups according to presence (case group, $n=32$) or absence (control group, $n=40$) of EARR in maxillary central and lateral incisors after orthodontic treatment.

Sample characteristics (age, gender, orthodontic extractions, Angle classification) and the analysis of associations between variables and EARR occurrence are presented.

Sample characteristics

Age

Age ranged from 10 to 50 years, and mean age was 15.7 years (± 7.3). In the control group, age ranged from 10 to 34 years, and mean age was 14.6 years; in the EARR group, age ranged from 10 to 50 years, and mean age was 17.2 years. There was a significant difference in age between groups (Table 1).

Gender

Figure 4 shows the classification of subjects according to gender. EARR was present in 42.1% of the women and 47% of the men. There were no significant differences in EARR regarding gender ($p=0.673$).

Extractions for orthodontic treatment

EARR was found in 43.3% of the subjects in the group that had extractions, and in 45.2% in the group without extractions. There were no significant differences between groups with or without extractions ($p=0.873$) (Fig 5).

Angle malocclusion classification

EARR was found in 41.4% of all Class I subjects, 45.4% of the Class II subjects, and 55.5% of Class III malocclusion subjects, but these differences were not statistically significant ($P=0.750$) (Fig 6).

DISCUSSION

It has been widely accepted that EARR is a frequent iatrogenic outcome of the orthodontic treatment, particularly in maxillary incisors. It is assumed that compression of the periodontal ligament, which reduces or interrupts blood supply, leads to aseptic necrosis and during removal of necrotic tissue by macrophages and osteoclasts, the root may be injured.^{10,16} Meanwhile, the etiology of EARR remains unclear and subject to the effect of innumerable risk variables. Although several studies have investigated this topic, no single or associated factor has been identified as responsible for EARR due to orthodontic treatment.³

Previous studies focused on the magnitude of the force applied,^{1,2,5} duration,^{15,21} and the type of orthodontic treatment^{1,6,7} have not established a causal relation between these factors and EARR.

Over the wide range of causal variables related to EARR, this study analyzed the effect of age, gender, extractions for orthodontic treatment and type of malocclusion. Our findings did not reveal any statistically significant differences regarding these variables. The results should be interpreted carefully because associations might have been affected by the study sample.

Difficulties in obtaining a standardized and homogeneous sample are often found in similar studies. In addition, final records from patients that have completed orthodontic treatment are not always available. When available, radiographs are not standardized and, thus, considered useless because they do not show the anatomic landmarks necessary for measurements. Therefore, limitations due to sample size are frequent.

Table 1 - EARR according to age.

Group	Descriptive statistics				
	Min.	Max.	Mean	s.d.	p
Global	10	50	15.78	7.32	
No EARR	10	34	14.60	4.13	0.162
With EARR	10	50	17.25	9.85	

Note: Statistical significance according to Student's t test.

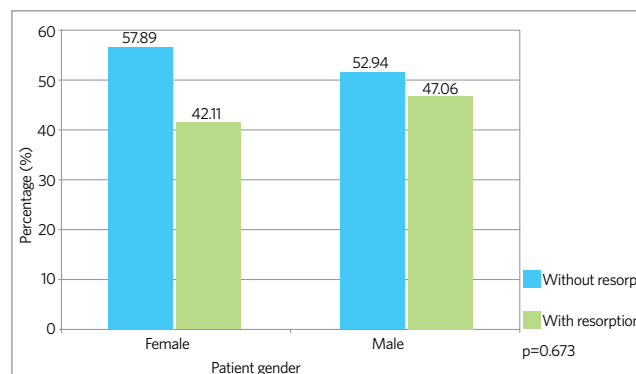


Figure 4 - Classification of subjects according to EARR and gender.

Note: Statistically significant difference according to chi-square test.

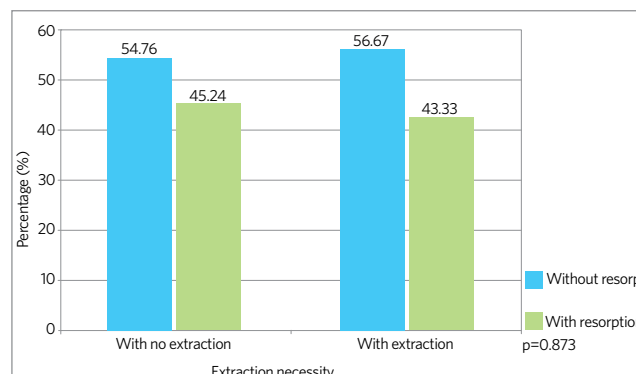


Figure 5 - Classification of subjects according to EARR and extractions.

Note: Statistically significant difference according to Fisher exact test.

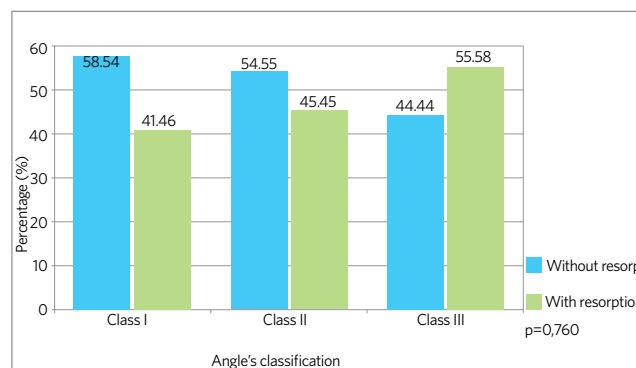


Figure 6 - Classification of subjects according to EARR and Angle malocclusion classification.

Note: Statistically significant difference according to Fisher exact test.

This study showed that age does not seem to be a significant factor in EARR, a finding similar to those reported by several authors in different studies that investigated the association of this variable with EARR.^{5,14,17}

In accordance to our study, several investigations have demonstrated that there is an association between gender and EARR.^{6,7,26,27} According Kjaer²⁰ (cited by Hartsfield Jr et al,¹⁶) a greater prevalence of EARR among women was found.

Although we did not find an association between type of malocclusion and EARR, several types of malocclusion, both dental and skeletal, have been classified as risk factors for EARR. Several factors are involved in the treatment of each type of malocclusion, which may potentialize risk variables in EARR, and the existing literature about this topic is still controversial.^{5,17,27,30}

The severity of malocclusion may be associated with the extent of orthodontic tooth movement, and the duration of orthodontic treatment may be positively associated with the extent of EARR.²⁶ According to Baumrind et al,⁵ Horiuchi et al,¹⁸ and Linge and Linge,²³ orthodontic tooth movement

has been responsible for up to one third of all EARR variation, whereas Parker and Harris²⁶ assigned 90% of all EARR variation to the extent of tooth movement. In addition, in cases of more severe overjet, a greater amount of retraction should be achieved during orthodontic treatment, and, therefore, there is, in fact, a chance of greater incisor root resorption.^{6,14}

This study did not find any association between extractions for orthodontic treatment and EARR. Extractions might affect the degree of EARR because they are associated with the amount of tooth movement required to close remaining extraction sites, differently from non-extraction cases.^{7,24} Therefore, greater EARR may be expected in cases of extraction of four premolars than in cases without extractions or with the extraction of only two maxillary premolars.

CONCLUSION

There were no statistically significant differences in EARR according to age, gender, extraction for orthodontic treatment, or Angle malocclusion classification.

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