



Original research

A clinical risk prediction model of orthodontic-induced external apical root resorption



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ABSTRACT

Purpose: This paper aims to study the role of nine variables in the susceptibility to External apical root resorption (EARR), in order to obtain an integrative model to predict the occurrence of this orthodontic-induced complication.

Materials and methods: 212 patients treated with multi-bracket appliances were studied. Root resorption was measured in the four maxillary incisors and maxillary canines using before and after treatment radiographs (2544 measured teeth). A design-to-purpose software was developed to optimize image processing and data collection. For each patient, the tooth with maximum percentage of root resorption (%EARR_{max}) was evaluated. A multiple linear regression model was used to assess the role of nine clinical and treatment variables to the susceptibility of EARR.

Results: The analysis of intra-observer mean error confirmed the reliability of the method (Student's t test for paired samples and Dahlberg test). Five clinical and treatment variables explained 28% of the %EARR_{max} variance: gender, treatment duration, anterior open bite, premolar extractions and Hyrax appliance. Other variables, such as age, tongue thrust, overjet and skeletal pattern, had less significant effect on %EARR_{max}.

Conclusion: Among the clinical and treatment variables studied that are potential contributors for EARR, five variables associated with root resorption were identified.

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Modelo de previsão de risco de Reabsorção Radicular Apical Externa induzida pelo tratamento ortodôntico

R E S U M O

Palavras-chave:

Reabsorção radicular
Ortodontia
Etiologia
Diagnóstico assistido por computador

Objetivos: Estudar a influência de nove variáveis na suscetibilidade à reabsorção radicular apical externa (RRAE), com o propósito de obter um modelo integrado que preveja a ocorrência desta complicação induzida pelo tratamento ortodôntico.

Métodos: Foram estudados 212 pacientes tratados com aparelhos ortodônticos multi-bracket. A RRAE foi avaliada através de radiografias realizadas antes e após o tratamento ortodôntico, tendo-se analisado os 4 incisivos e os 2 caninos do maxilar superior. Para tal, foi desenvolvido um protótipo de software que permite otimizar o processamento de imagem e registrar de forma automática a percentagem de reabsorção radicular (%RRAE_{max}). Usando um modelo de regressão linear múltipla, a contribuição das nove variáveis clínicas e relacionadas com o tratamento foi analisada.

Resultados: A análise do erro médio intra-observador confirmou a fiabilidade do método (teste t de Student para amostras emparelhadas e fórmula de Dahlberg). Verificou-se que 28% da variância da %RRAE_{max} era explicada por cinco variáveis: sexo, duração do tratamento, aparelho Hyrax, mordida aberta anterior e extração de pré-molares. Outras variáveis, como idade, interposição lingual, overjet e padrão esquelético, não tiveram uma contribuição significativa.

Conclusões: Das variáveis clínicas e relacionadas com o tratamento estudadas, que podem contribuir potencialmente para a RRAE, cinco foram associadas ao fenómeno de reabsorção radicular.

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Introduction

External apical root resorption (EARR) is a complex, multifactorial phenotype, determined by host and environmental factors, which are still not clearly identified.¹⁻⁴ Biological or host-related risk factors that have been described include genetic susceptibility,^{2,5-7} gender,^{3,8-10} age,^{9,11-14} tongue thrust, existence of anterior open bite, type of malocclusion¹⁴ and systemic diseases.^{3,4} Environmental factors mainly concern mechanical or orthodontic treatment variables like treatment duration,^{9,14} type of orthodontic appliance,¹ tooth extraction,^{8,9} intrusive movement, root torque and force magnitude. Polymorphisms in interleukin 1 gene and a few other loci have also been implicated, but results remain controversial.^{7,9,10,15} Lessons from other well-studied complex phenotypes like diabetes have shown that genotyping hardly contributes to improve clinical evaluation of disease susceptibility.¹⁶

There are no strict criteria for the diagnosis of this phenotype. Levander and Malmgren have proposed the evaluation of root resorption using ordinal scales,¹⁷ whereas others have assessed it by measuring root lengths,^{11,13,18} and arbitrary cut-offs, with no prognostic correlation, that have been frequently used. In clinical orthodontics, panoramic and cephalometric X-rays/radiographs are routinely ordered as the primary diagnostic tool. Although less accurate than periapical films, panoramic radiographs have advantages like less radiation exposure and visualization of the complete dentition, besides being less time-consuming for the operator

and even more patient-friendly. Panoramic films may overestimate by approximately 20% the amount of root loss¹⁹ but this magnification factor is relatively constant in the vertical axis,^{20,21} which is clinically the most important aspect in analyzing EARR.²² This overestimation can be overcome using the percentage of root/tooth length variation instead of direct measurement of root length. In addition, mainly due to image distortion, comparison of panoramic with periapical films has revealed maximum differences in the lower incisors, but minimum in the maxillary incisors,¹⁹ precisely the most frequently affected teeth.¹ Recent advances in digital image processing and artificial intelligence techniques offer more precise computer-assisted methods for dental X-ray analysis. Three-dimensional imaging systems are known to be the best way to evaluate EARR, though not easy to apply in clinical practice.

In order to individualize orthodontic treatment choices, it would be particularly important to predict each patient's risk of developing EARR.

The aim of this work was to evaluate the contribution of several clinical and treatment factors to orthodontic-induced EARR, in order to create a multifactorial integrative model that would predict the risk of developing this common orthodontic complication.

Materials and methods

For this retrospective study, 212 patients who had been submitted to orthodontic treatment were selected from the

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