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Original research

Evaluation of Biological and Orthodontic Factors in the External Root Resorption Induced by Orthodontics

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ABSTRACT

Introduction: Orthodontists need to know that External Root Resorption (ERR) is not only related to orthodontic forces but also to other biological factors because of its multifactorial origin. **Objective:** To assess the biological and orthodontic factors of external root resorption induced by orthodontic treatment. **Materials and methods:** Longitudinal study with a prospective design in 19 patients (11 men and 8 women) with an initial average age of 22±7.5 years, with complete root formation of the upper and lower incisor teeth and without external root resorption. The biological and orthodontic factors evaluated were: Age, sex, crowding, overjet, overbite, incisor inclination, dental malocclusion, skeletal sagittal classification, ERR degree, root morphology, and treatment technique (conventional and self-ligating). The Levander and Malmgren index was applied at six months of treatment, using periapical digital radiographs. **Results:** After 6 months of orthodontic treatment, 56.6% of the teeth did not present ERR and 43.4% presented ERR grade 1, with tooth 31 having the lowest ERR 26.3%; there was no statistically significant association between biological and orthodontic factors with the ERR. **Conclusions:** None of the biological and orthodontic factors studied was associated with the ERR induced by orthodontic treatment during the first six months.

Keywords: Root resorption, orthodontics, biological factors.

INTRODUCTION

External Root Resorption (ERR) is defined as the loss of the organic and inorganic components of root hard tissues, such as dentin and cementum[1]. Its origin is multifactorial and is categorized into biological and external factors; the biological factors are related to genetics, age, sex, nutrition, root morphology, alveolar bone density, type of malocclusion, and systemic factors, among others[2]. On the other hand, external factors correspond to those derived from orthodontic treatment, such as the type of appliance, treatment technique, type, magnitude, and direction of forces, presence or absence of tooth extractions, and type of dental movement[3].

Biomechanics deployed during orthodontic treatment can directly influence the severity of err[4]. The use of low friction techniques such as self-ligation and conventional ligation techniques is related to the magnitude of forces in orthodontic treatment[5]. Studies have shown that after orthodontic treatment with moderate forces, root resorption is usually superficial and mild, but these lesions on the root surface are irreversible[6]. It is important to identify protective and risk factors to prevent ERR, which is one of the most serious adverse effects of orthodontic treatment. Another adverse effect that occurs is tooth mobility due to the shortening of the root length, which can lead to tooth loss[7].

Professionals need to be aware that ERR is not only associated with orthodontic forces but also with other internal constraints such as biological factors[2]. Therefore, the present study aimed to evaluate the biological and orthodontic factors on external root resorption induced by orthodontic treatment in patients of the Orthodontic Postgraduate Clinics of the Universidad Cooperativa de Colombia (UCC) in Bogota, Colombia, during the first six months of treatment.

MATERIALS AND METHODS

A six-month prospective longitudinal study with a sample of 76 upper and lower incisor teeth of 19 patients who received orthodontic treatment (conventional appliances n=11 and self-ligation n=8) in the orthodontic postgraduate clinics of the UCC.

The subjects were selected non-probabilistically by convenience, in patients who started orthodontic treatment and met the following inclusion criteria: complete root formation of the upper and lower incisors, without root resorption and minimum crown-root ratio of 1:1.5. Criteria for exclusion were: patients who did not want to participate in the study, patients with fixed prosthesis and/or individual crowns in incisors, with endodontic treatment, with root resorption in the index teeth and pregnant patients. A written informed consent form was used to confirm inclusion in the study. The study was approved by the Institutional Bioethics Committee (Ethical Concept No.004-2019), with a minimal risk classification.

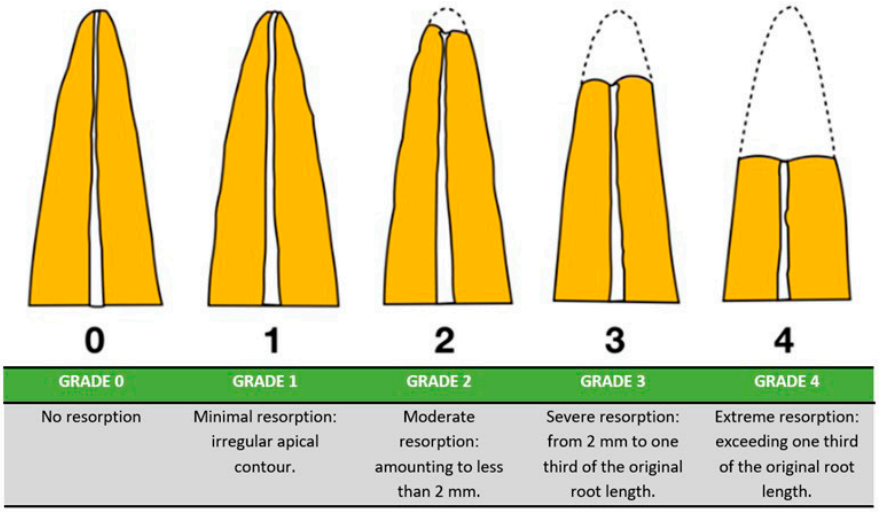
The following variables were considered: age, sex, crowding, overjet, overbite, incisor inclination (Incisor-Mandibular Plane (IMP), Incisor-Palatal Plane (IPP)), type of malocclusion (according to Angle), skeletal sagittal classification (Wits and ANB measurement), degree of ERR, root morphology and treatment technique (conventional ligation and self-ligation). To store the information, a format was designed as an individual collection instrument and then a database was designed in Microsoft® Excel for Mac version 16.75.

Root length measurements on dentoalveolar radiographs were performed by a single investigator (LPDP), using a pilot test with a sample of five radiographs, which were measured three times with an interval of two weeks; the Student's t-test for repeated measures with a significance level of 0.05 was applied. To corroborate the internal consistency of the operator, a Pearson correlation was performed and finally, the Dalberg test was performed, with an average error no greater than 0.2 mm. The measurements of the clinical crowns were taken from the incisal edge to the gingival margin of the index teeth, in the study models of each patient.

Then the measurement in mm of the clinical crowns was transferred onto the image of the digital dentoalveolar radiograph, using MicrosoftÒ PowerPoint for Mac version 16.76, locating the incisal edge and a reference line at the amelo-cemental junction. To determine the length of the root, it was measured from this reference line to the apex, following the trajectory over the root canal. The initial measurement at T0 (before starting treatment) was compared with the final measurement at T1 (6 months after starting treatment), thus observing the difference, a value corresponding to the degree of err[8,9]. The degree of root resorption was classified according to the Malmgren Quantitative Root Resorption Index (Figure 1). Root morphology was determined by direct observation of the patients' dentoalveolar radiographs, considering the Levander and Malmgren classification as normal, short, rhomboidal, dilacerated, and pipette.

For the cephalometric measurements, the Dolphin version 11.95 Premium software was used and they were performed by an expert (LPDP) on the tracings of the patients' lateral head films. The intraclass correlation coefficient and the Dahlberg formula were used for each of the measurements, which showed a high reliability (between 0.92 and 1.0) and an average error that did not exceed 0.6°. For the type of malocclusion, crowding, *overjet,* and *overbite* variables, an exhaustive and detailed visual analysis was performed on the study models of each patient.

For the association, a multivariate correspondence analysis was performed, with a logistic regression without the combination of variables to assess the relationship of biological factors with the occurrence of external root resorption for each of the studied teeth 11, 21, 31, and 41. For the fulfillment of the hypothesis, the Z probability value was reviewed, being the accepted value of 0.05.



GRADE 0	GRADE 1	GRADE 2	GRADE 3	GRADE 4
No resorption	Minimal resorption: irregular apical contour.	Moderate resorption: amounting to less than 2 mm.	Severe resorption: from 2 mm to one third of the original root length.	Extreme resorption: exceeding one third of the original root length.

Figure 1. Grades of external root resorption according to Levander and Malmgren.

RESULTS

A total of 19 patients were evaluated in this study, 57.9% were men and 42.1% were women, with an average age of 22 ± 7.5 years; the minimum age was 13 years, and maximum, 35 years. Regarding the root morphology of the assessed teeth, it was found that 31.6% presented pipette shape, 25% were dilacerated, 18.4% were rhomboidal, 14.5% had normal morphology and 10.5% presented short roots (Figure 2).

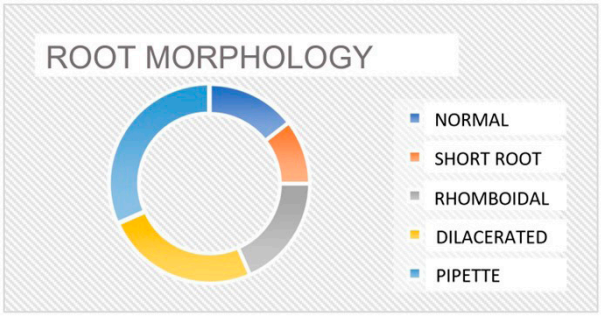


Figure 2. Root morphology.

Of the 76 studied teeth, 56.6% (n=43) did not present ERR and 43.4% (n=33) did present ERR at six months of orthodontic treatment. About the degree of ERR per tooth, in teeth 11 and 41 there was no evidence of ERR in 52.6% and 47.4% did present it; for tooth 21 there was no evidence of ERR in 47.4% while 52.6% did present it and finally tooth 31 had no evidence of ERR in 73.7% and 26.3% did present it. The ERR grade for all teeth was 1 and there was no ERR in grades 2, 3, and 4 (Figure 3).

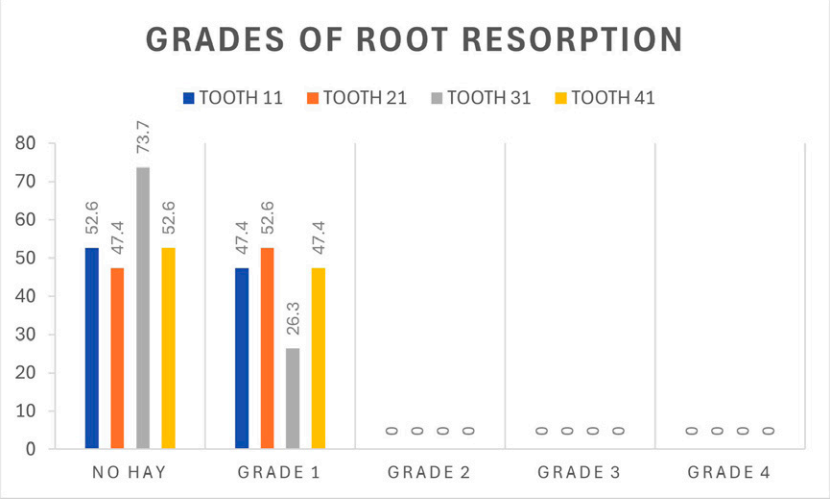


Figure 3. Grades of external root resorption.

A multivariate correspondence analysis was performed in which the closest variables are related to each other and the distant ones are not. Thus, the morphology of tooth 41 was directly related to the IPP and IMP measures; the morphology of tooth 31 was related to the Wits measurement and the type of malocclusion; the treatment technique was related to the degree of ERR of tooth 21. Variables such as the degree of ERR of tooth 31, gender, and ANB were not related to ERR (Figure 4).

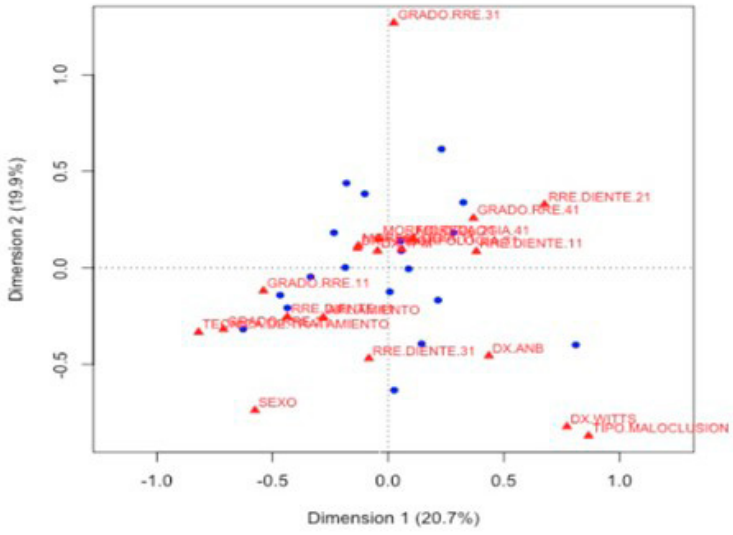


Figure 4. Relationship between orthodontic treatment characteristics and ERR in the sample.

The association of the morphological and orthodontic variables with the ERR was evaluated for each of the index teeth using a logistic regression, where the response variable is the ERR and the explanatory variables are the biological factors. As a result, no association was found between the evaluated variables and the ERR since all the Z probabilities were less than alpha (0.05).

DISCUSSION

In this study, the association between biological and orthodontic factors and the resorption induced by orthodontic treatment was studied in the upper and lower incisor teeth of 19 patients, 6 months after the start of treatment. The results showed that resorption was more frequent in teeth 11, 21, 41 and less frequent for tooth 31; these results are similar to those of the study by González *et al.* carried out in 2012 in the population of Cartagena, Colombia where the most frequent ERR occurred in the upper left lateral, followed by the upper central teeth[10].

It was determined that for the study population, the orthodontic treatment technique is not a representative variable. Regardless of whether it was conventional or self-ligating, no association was found with ERR. These results are similar to those of the systematic review by Currell *et al*. who concluded that the association between ERR and orthodontic mechanotherapies is low to very low[11].

Concerning the degrees of ERR, 56.6% of the patients had no resorption, followed by grade 1 resorption (43.4%) and the absence of grades 2, 3, and 4, according to the Levander and Malmgren index[8]. When comparing the situation of ERR of the incisors at the beginning and 6 months of orthodontic treatment, the difference was significant for teeth 11, 21, and 41, which presented grade 1 resorption. The results regarding the degree of resorption are similar to those reported by Artun *et al.*[12] who found a mild degree of ERR between 6 and 12 months after the beginning of orthodontic treatment.

When the incidence of ERR was related to gender and age, no association was found. This result is similar to that of Owman-Moll *et al.*[13], Sameshima and Iglesias-Linares[14], and contrary to the conclusions of Echabe-Krutwig and Argote-Ilardia[15], who reported that ERR increases with age, attributing this situation to the greater predisposition to present periodontal disease in adult patients.

In this study, a minimal ERR was observed at six months, coinciding with Pastro *et al*. who reported that patients with severe ERR have a longer average treatment time than patients with mild err[16]. The absence of moderate and high ERR is associated with the low magnitude of forces applied to the teeth during the alignment and leveling phase, inherent to the characteristics of the archwires used, which correspond to thin and flexible archwires made of alloys such as nickel-titanium. In more advanced stages of treatment, such as the working phase, the contrary is observed since thicker and stiffer archwires made of alloys such as stainless steel are used, which offer forces of greater magnitude. Aras *et al*.[5] and Casa *et al*.[17] conclude that large magnitude moments applied to teeth produce higher degrees of ERR, even causing exposure of root dentin[17].

Despite being a well-studied topic, there is still not enough evidence to confirm the association between biological and orthodontic factors with err[18,19]. However, the future in this area is promising due to the existence of 3D technologies with high-resolution images and low radiation for patients, which allow early detection, quantification and characterization of ERR as one of the most frequently reported adverse effects of orthodontic treatment[14].

CONCLUSIONS

1. No association was found between ERR induced by orthodontic treatment and any of the biological and orthodontic factors studied.

2. In the first 6 months of orthodontic treatment, ERR does not occur with a high frequency and when it does occur, it corresponds to grade 1.
3. Of the four incisors, tooth 31 presented the lowest ERR, which was not significant in comparison with the other evaluated teeth.

RECOMMENDATIONS

The results hereby presented are only applicable to the selected sample, therefore, an approximation was made of the relationship between ERR and the biological and orthodontic factors, but they should not be extrapolated to the general population; therefore, they should be taken with caution. It is recommended to continue the study with a probabilistic sample and with a follow-up period longer than six months of orthodontic treatment.

BIBLIOGRAPHIC REFERENCES

1. Blake M, Woodside DG, Pharoah MJ. A radiographic comparison of apical root resorption after orthodontic treatment with the edgewise and Speed appliances. *Am J Orthod Dentofacial Orthop*. 1995; 108(1): 76-84. DOI: 10.1016/s0889-5406(95)70069-2
2. Deng Y, Sun Y, Xu T. Evaluation of root resorption after comprehensive orthodontic treatment using cone beam computed tomography (CBCT): A meta-analysis. *BMC Oral Health*. 2018; 18: 116. DOI: 10.1186/s12903-018-0579-2
3. Weltman B, Vig KWL, Fields HW, Shanker S, Kaizar EE. Root resorption associated with orthodontic tooth movement: A systematic review. *Am J Orthod Dentofacial Orthop*. 2010; 137(4): 462-476. DOI: 10.1016/j.ajodo.2009.06.021
4. Remington DN, Joondeph DR, Artun J, Riedel RA, Chapko MK. Long-term evaluation of root resorption occurring during orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 1989; 96(1): 43-46. DOI: 10.1016/0889-5406(89)90227-8
5. Aras I, Unal I, Huniler G, Aras A. Root resorption due to orthodontic treatment using self-ligating and conventional brackets: A cone-beam computed tomography study. *J Orofac Orthop*. 2018; 79(3): 181-190. DOI: 10.1007/s00056-018-0133-5
6. Malmgren O, Goldson L, Hill C, Orwin A, Petrini L, Lundberg M. Root resorption after orthodontic treatment of traumatized teeth. *Am J Orthod*. 1982; 82(6): 487-491. DOI: 10.1016/0002-9416(82)90317-7
7. Qin F, Zhou Y. The influence of bracket type on the external apical root resorption in class I extraction patients - A retrospective study. *BMC Oral Health*. 2019; 19: 53. DOI: 10.1186/s12903-019-0743-3
8. Levander E, Malmgren O. Evaluation of the risk of root resorption during orthodontic treatment: A study of upper incisors. *Eur J Orthod*. 1988; 10(1): 30-38. DOI: 10.1093/ejo/10.1.30
9. de Castilhos BB, de Souza CM, Fontana MLSSN, Pereira FA, Tanaka OM, Trevilatto PC. Association of clinical variables and polymorphisms in RANKL, RANK, and OPG genes with external apical root resorption. *Am J Orthod Dentofacial Orthop*. 2019; 155(4): 529-542. DOI: 10.1016/j.ajodo.2018.05.016
10. González FD, Robles Guiza V, Rivero Fuentes L, Pilas Martelo MM, Pulido Ramos J. Reabsorción radicular inflamatoria en sujetos con tratamiento ortodóntico. Cartagena (Colombia). *Salud Uninorte*. 2012; 28(3):382-90. https://rcientificas.uninorte.edu.co/index.php/salud/article/view/1475
11. Currell SD, Liaw A, Grant PDB, Esterman A, Nimmo A. Orthodontic mechanotherapies and their influence on external root resorption: A systematic review. *Am J Orthod Dentofacial Orthop*. 2019; 155(3): 313-329. DOI: 10.1016/j.ajodo.2018.10.015

12. Artun J, Van 't Hullenaar R, Doppel D, Kuijpers-Jagtman AM. Identification of orthodontic patients at risk of severe apical root resorption. *Am J Orthod Dentofacial Orthop*. 2009; 135(4): 448-55. DOI: 10.1016/j.ajodo.2007.06.012
13. Owman-Moll P, Kurol J, Lundgren D. The effects of a four-fold increased orthodontic force magnitude on tooth movement and root resorptions. An intra-individual study in adolescents. *Eur J Orthod*. 1996; 18(3): 287-294. DOI: 10.1093/ejo/18.3.287
14. Sameshima GT, Iglesias-Linares A. Orthodontic root resorption. *J World Fed Orthod*. 2021; 10(4): 135-143. DOI: 10.1016/j.ejwf.2021.09.003
15. Echabe-Krutwig MA de, Argote-Ilardia I. El tratamiento ortodóncico y la reabsorción radicular. Revisión bibliográfica. *Rev Esp Ortod*. 2002; 32(4): 325-331.
16. Pastro JDV, Nogueira ACA, de Freitas KMS, Valarelli FP, Cançado RH, de Oliveira RCG *et al*. Factors associated to apical root resorption after orthodontic treatment. *Open Dent J*. 2018; 12: 331-39. DOI: 10.2174/1874210601812010331
17. Casa MA, Faltin RM, Faltin K, Sander FG, Arana-Chavez VE. Root resorptions in upper first premolars after application of continuous torque moment. Intra-individual study. *J Orofac Orthop*. 2001; 62(4): 285-295. DOI: 10.1007/pl00001936
18. Yassir YA, Mclntyre GT, Bearn DR. Orthodontic treatment and root resorption: An overview of systematic reviews. *Eur J Orthod*. 2021; 43(4): 442-456. DOI: 10.1093/ejo/cjaa058
19. Villaman-Santacruz H, Torres-Rosas R, Acevedo-Mascarúa AE, Argueta-Figueroa L. Root resorption factors associated with orthodontic treatment with fixed appliances: A systematic review and meta-analysis. *Dent Med Probl*. 2022; 59(3): 437-50. DOI: 10.17219/dmp/145369