Biological and orthodontic treatment risk factors associated to external root resorption: a case-control study

Factores de riesgo biológicos y relacionados con el tratamiento de ortodoncia asociados a reabsorción radicular externa: estudio de casos y controles

Sonia Patricia. Plaza-Ruíz[1], *Andreina Reimpell-Vivas*[2], *María Camila Santana-Suárez*[3], *Fernando Zárate-Cadena*[4]

[1] DDS. MSc. Associate Professor, Orthodontic Department, Fundaci n Universitaria CIEO-UniCIEO, Bogot , Colombia. ORCID: 0000-0002-6419-0478
[2] DDS. Assistant Professor, Orthodontic Department, Fundaci n Universitaria CIEO-UniCIEO, Bogot , Colombia. ORCID: 0000-0002-6419-0478
[3] DDS. Orthodontics Department, Fundaci n Universitaria CIEO-UniCIEO, Bogot , Colombia. ORCID: 0000-0001-5954-5791
[4] DDS. Orthodontics Department, Fundaci n Universitaria CIEO-UniCIEO, Bogot , Colombia. ORCID: 0000-0002-2120-2520

ABSTRACT

Introduction: external apical root resorption (EARR) is considered an adverse effect related to orthodontic treatment, but its specific risk factors remain controversial. The aim of this study was to identify the biological and orthodontic treatment risk factors associated with EARR in the incisors of patients who completed orthodontic treatment. ***Method:*** case-control study. 126 subjects (27.81 + 11.02 years old; 56 men, 70 women) selected for convenience; 63 cases and 63 controls, matched with cases in age and sex. EARR was measured on panoramic radiographs using the Levander and Malmgren classification. Demographic, biological, and orthodontic treatment-related variables were taken from clinical records. The cephalometric variables before and after treatment were measured with the Dolphin software. Statistical analysis included: Chi^2, U Mann Whitney, t-test, and logistic regression models. Statistical significance was established at $p<0.05$. ***Results:*** there was evidence of association between EARR and previous root resorption ($p=0.028$; OR=24.925; 95% CI 1.427; 435.344); horizontal skeletal pattern ($p=0.008$, OR=0.914, 95% CI:0.854;0.977); pre-treatment upper incisor position ($p=0.023$; OR=0.850; 95% CI:0.738;0.978) and pre-treatment lower incisor position ($p=0.019$; OR=0.838; 95% CI:0.724;0.971). Previous root resorption and vertical skeletal pattern were significantly associated with EARR in the final multiple regression model. ***Conclusions:*** radiographic control and adaptation of orthodontic treatment is recommended in subjects who have previous root resorption and a horizontal skeletal pattern, since they are more likely to present EARR.

Keywords: root resorption, radiography, panoramic, etiology, risk factors, orthodontics

RESUMEN

Introducci n: la reabsorci n radicular externa apical (RREA) es considerada un efecto adverso relacionado con el tratamiento de ortodoncia, pero sus factores de riesgo espec ficos siguen siendo controversiales. El objetivo del presente estudio consisti en identificar los factores de riesgo biol gicos y relacionados con el tratamiento de ortodoncia asociados a la RREA en incisivos de pacientes que finalizaron tratamiento de ortodoncia. ***M todo:*** estudio de casos y controles. 126 sujetos (27,81 + 11,02 a os; 56 hombres, 70 mujeres) tomados por conveniencia; 63 casos y 63 controles, emparejados con los casos en edad y sexo. La RREA se midi sobre radiograf as panor micas con la clasificaci n de Levander y Malmgren. Las variables demogr ficas, biol gicas y relacionadas con el tratamiento de ortodoncia fueron tomadas de los registros cl nicos. Las variables cefalom tricas antes y despu s del tratamiento fueron medidas con el software Dolphin. El an lisis estad stico incluy : Chi^2, U Mann Whitney, prueba t y modelos de regresi n log stica. La significancia estad stica fue establecida en $p<0,05$. ***Resultados:*** se encontr evidencia de asociaci n entre RREA y reabsorci n radicular previa ($p=0,028$; OR=24,925; IC 95% 1,427; 435,344); patr n esquel tico horizontal ($p=0.008$, OR=0.914, 95% CI:0.854;0.977); posici n de incisivo superior pretratamiento ($p=0.023$; OR=0.850; 95% CI:0.738;0.978) y posici n de incisivo inferior pretratamiento ($p=0.019$; OR=0.838; 95% CI:0.724;0.971). La reabsorci n radicular previa y el patr n esquel tico vertical estuvieron asociados significativamente con la RREA en el modelo final de regresi n m ltiple. ***Conclusiones:*** se recomienda control radiogr fico y adaptaci n del tratamiento de ortodoncia en los sujetos que presenten reabsorci n radicular previa y patr n esquel tico horizanotal, ya que son m s propensos a presentar RREA.

Palabras claves: reabsorci n radicular, radiograf a panor mica, etiolog a, factores de riesgo, ortodoncia.

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INTRODUCTION

External apical root resorption (EARR) is an inflammatory pathology in which the periodontal ligament remains inflamed, acting on the mediating cells of bone surface. It is produced by continuous and increased stimulation of osteoclasts that reabsorb root mineralized tissues.[1] EARR has been one of the side effects reported during orthodontic treatment and its prevalence is between 1 and 15%.[2-4] Loss of affected teeth's root structure may change the prognosis and cause a reassessment of the therapeutic objectives initially planned in orthodontic treatment.[2,5] Various x-ray images are of help in diagnosing, comparing analysis and identifying possible risk factors for EARR.[3]

EARR's etiology is multifactorial; however, identifying the main risk factors remains a controversial issue. Several authors[3,6] claim that treatment involving extraction of the first four premolars, the triangular shape of the root, and the presence of prior root resorption are important factors for its onset. Other authors[5] have linked EARR to male gender and to treatments without extractions. Genetic factors have also been studied, with some specific genes identified as risk factors in the onset of EARR.[5,7] As for the teeth most prone to EARR, the highest prevalence has been reported in the upper and lower incisors.[5,6]

Although the risk factors for EARR have been extensively studied,[2-4] most studies are cross-sectional, so they are subjected to biases, including limitations to establish causality, and measurement and selection biases that could invalidate the results.[8] Information on the strength of association through odds ratio (OR) to assess patients' predisposition to EARR is scarce. This knowledge on the factors associated with EARR is necessary for clinicians to closely monitor the orthodontic treatment and to inform patients of the risk of this condition.[3] The objective of this study was to identify the biological and orthodontic risk factors associated with moderate and severe EARR in upper and lower incisors in patients who completed orthodontic treatment.

METHODS

This was a case-control observational study. The sample was gathered from the clinical records of patients who completed orthodontic treatment during the years 2012-2018 at the CIEO-UniCIEO University Foundation. The study was approved by the institution's Ethics Committee on June 10, 2016.

Of a population of 1,062 subjects during the studied period, 575 had completed orthodontic treatment. Of the 223 subjects who met the inclusion criteria, 63 cases of EARR were identified in incisors. 63 convenience control cases were also selected and paired by sex and age. Sample size calculation was performed using the Epidat software (Xeral Directorate of Public Sa de de la Xunta, Galicia), with data from a previous study[2] with an OR of 6.38 (95% IC: 4.2; 9.7) for the exodontia treatment of four premolars as a variable. The calculation was based on a 95% confidence level and a power of 90%, resulting in a minimum sample size of 62 pairs. The total sample consisted of 126 subjects (27.81 +/– 11.02 years). The inclusion criteria were: patients over 12 years of age, with pre-treatment periapical radiographs of upper and lower incisors, pre- and post-treatment radiographs and good condition (panoramic cephalometric) obtained within three months of the end of orthodontic treatment. Patients with active periodontal disease during treatment, dentoalveolar trauma in the incisor area, agenesis of more than three incisors, open apexes, endodontic treatment, and prior orthodontic treatment were excluded.

The following patients were considered as cases: patients with moderate and/or severe EARR in at least one upper and/or lower incisor, diagnosed on a panoramic radiograph with degrees 3 and 4 on the Levander and Malmgren scale[9] by at least two of three observers. Patients without visible EARR or with mild EARR were considered as controls. All the study's radiographs were taken on the same equipment (ORTHOPHOS XG 3D Ready by Dentsply Sirona) and under the same conditions according to Sirona's protocol.

The classification of root apex morphology was performed on pre-treatment periapical x-rays according to Goldberg et al[10] (oval, rounded, flat, beveled, sharp). The analysis of cephalometric variables was performed on patients' initial and final profile x-rays using the Dolphin software (Imaging Premium 11.8 by Dolphin Imaging & Management Solutions, Chatsworth, USA). These measurements were performed by a previously calibrated operator (CS) on 30 periapical and cephalometric x-rays. For root morphology, the percentage of intra-operator agreement was measured, and for cephalometric variables the error method was calculated by evaluating random error with the Dahlberg formula, and systematic error using a paired *t* test. In addition, the Bland-Altman plot was used to evaluate agreement.

The cephalometric variables were plotted and measured using the definitions of the initial authors as reference:[11-13] Maxillary Position (SNA), Mandibular Position (SNB), Sagittal Skeletal Classification (ANB and Wits), Vertical Skeletal Pattern (SN-GoGn), Upper Incisor Position (UI/A-Pg), lower incisor Position (Ll/A-Pg), upper incisor inclination (IMAX), pre- and post-treatment lower incisor inclination (IMPA), and the respective differences between these two measures were calculated to evaluate changes during orthodontic treatment and relate it to EARR (Table 1).

Table 1. Cephalometric variables

VARIABLE NAME	CONCEPTUAL DEFINITION	OPERATIONAL DEFINITION
(SNA) Upper maxillary position	Anteroposterior position of the maxilla relative to cranial base	Posteroinferior angle formed between planes (S-N) (N-A)
(SNB) Mandibular position	Anteroposterior position of the mandible relative to cranial base	Posteroinferior angle formed between planes (S-N) (N-B)
(ANB) Sagittal skeletal classification	Anteroposterior ratio of maxilla and mandible	Difference in degrees between (SNA) (SNB)
(Wits) Sagittal skeletal classification	Anteroposterior ratio of maxilla and mandible	Difference in mm on the occlusal plane between the perpendicular of the occlusal plane to A and the perpendicular of the occlusal plane to B
(SN-Gogn) Pre-treatment vertical skeletal pattern	Inclination of mandibular plane relative to cranial base	Posteroinferior angle formed between planes (S-N) and (Go-Gn) moving this at the S level
(ENP-ENA) U1: imax	Inclination of upper incisor relative to palatal plane	Posteroinferior angle formed between planes (ENP-ENA) (Iua-Iu)
(Go-M) l1 IMPA	Inclination of lower incisor relative to the mandibular plane	Posterosuperior angle formed between planes (Iia-Ii) (Go-M)
(UI/A-Pg) Upper incisor position	Position of upper incisor relative to (A-Pg)	Distance from Point Iu to Plane (A-Pg)

VARIABLE NAME	CONCEPTUAL DEFINITION	OPERATIONAL DEFINITION
(Li/A-Pg) Lower incisor position	Position of lower incisor relative to (A-Pg)	Distance from point Ii to plane (A-Pg)
SNA Difference	Change in maxillary position during orthodontic treatment	Difference between SNA measured pre-treatment and post-treatment
SNB Difference	Change in mandibular position during orthodontic treatment	Difference between SNB measured pre-treatment and post-treatment
ANB Difference	Change in skeletal classification during orthodontic treatment	Difference between ANB measured pre-treatment and post-treatment
Wits Difference	Change in skeletal classification during orthodontic treatment	Difference between Wits measured pre-treatment and post-treatment
IMAX/IMPA Difference	Change in incisors inclination incisors during orthodontic treatment	Difference between IMAX measured pre-treatment and post-treatment Difference between IMPA measured pre-treatment and post-treatment
UI/A-Pg Difference	Change in upper incisors position during orthodontic treatment	Difference between the upper dental position measured pre-treatment and post-treatment
Li/A-Pg Difference	Change in lower incisors position during orthodontic treatment	Difference between the lower dental position measured pre-treatment and post-treatment
Difference sn-gogn	Change in skeletal pattern during orthodontic treatment	Difference between SN-GoGn measured pre-treatment and post-treatment

Source: by the authors

Demographic (sex, age) and biological data (systemic history, root apex morphology, pre-treatment overjet, prior root resorption, skeletal classification), as well as those related to orthodontic treatment (premolar extractions, orthodontic technique, bracket type, duration of treatment, greater caliber arch used) were taken from medical records. An extraction case was considered if at least two premolar extractions were performed on one of the arches.

Statistical analysis

Statistical analysis was performed with Stata 14 software (version 14 for MacBook, StataCorp, College Station, Tex). The qualitative variables were expressed in relative and absolute frequencies, and the quantitative variables were presented as central tendency (mean and median) and dispersion (standard deviation), with their respective confidence intervals (CI). The statistical analysis included Chi^2 test, Mann-Whitney U test, and *t* test. A multiple logistic regression model was used to explore the association force of exposure to the studied risk factors and the presence of external root resorption, taking variables with the $p<0.20$ value in the full model and deleting non-significant variables ($p>0.05$) of the backward stepwise regression model, until finding the model with the best fit and fewest variables. The model's goodness of fit was measured with the Akaike Information Criterion (AIC), considering the model with the lowest AIC value as the best model. In all tests, statistical significance was set at $p<0.05$.

RESULTS

The percentage of agreement of the three operators in diagnosing the presence of EARR was high (>96%), as well as the inter- and intra-operator concordance in root shape (>90%), and the concordance of the cephalometric measurements with the Bland Altman plot, where the mean error was (–0. 0033; –0.0339) with standard deviation (SD) (0.041; 0.073), and 95% CI (0.007; 0.0121). The method error showed low random errors (0.064-0.090) and no systematic error ($p>0.05$).

The sample's descriptive analysis is shown in Table 2. The highest prevalence of EARR was in the upper central incisors (19.04%), the most frequent being the right central incisor (20.63%), while in the lower arch the most common were the lower central incisors (11.11%), with the lower left central incisor (12.7%) being the most affected tooth (Table 3).

Table 2. Descriptive analysis of variables

Demographic Variables	n	%		
Sex				
Male	56	44.4		
Female	70	55.6		
Age	M	SD		
	27.62	11.03		
Biological Variables	n	%		
Systemic history				
Respiratory diseases	13	10.31		
Cardiovascular diseases	2	1.58		
Articular diseases	3	2.38		
Thyroid diseases	4	3.17		
Allergies	5	3.96		
Immune diseases	1	0.79		
Hepatitis	5	3.79		
Overjet pre-treatment				
Inverted< 0mm	5	3.97		
Edge-edge 0-1mm	29	30.9		
Normal 2-3mm	68	53.9		
Increased >3mm	14	11.11		
Prior EARR				
No	116	92.06		
Yes	10	7.93		
Skeletal classification				
Class I	74	58.27		
Class II	40	31.50		
Class III	13	10.24		
Variables Related to orthodontic treatment	**n**	**%**		
Premolar Extractions				
No	108	85.72		
4 premolars	11	8.73		
Upper premolars	6	4.76		
Lower premolars	1	0.79		
Technique				
Standard	27	21.43		
Self-ligating	47	37.30		
MBT	52	41.27		
Bracket type				
Conventional	78	61.90		
Self-ligating	48	38.09		
Highest caliber arch used				
Round	19	15.08		
Rectangular	107	84.92		
Duration of treatment	***m***	***SD***	***Range***	***CI 95%***
	18.25	8.34	6-49	17.90–20.79

Source: by the authors

Table 3. Descriptive analysis of EARR

EARR	12	11	21	22	32	31	41	42	Upper lateral	Upper central	Lower lateral	Lower central
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
No	114 (90.48)	100 (79.37)	104 (82.54)	111 (88.10)	117 (92.86)	110 (7.30)	114 (90.48)	122 (96.83)	225 (89.28)	204 (80.95)	239 (94.84)	224 (96.82)
Yes	12 (9.52)	26 (20.63)	22 (17.46)	15 (11.90)	9 (7.14)	16 (12.70)	12 (9.52)	4 (3.117)	27 (10.71)	48 (19.04)	13 (5.15)	28 (11.11)

Source: by the authors

Table 4 shows the association between EARR and the different categorical independent variables, where evidence of association was only observed (p=0.001) between prior root resorption and EARR. As for association between EARR and continuous variables, there was evidence of association between pre-treatment vertical skeletal pattern (SN-GoGn) (p=0.0215), pre-treatment position of the lower incisor (Li/A-Pg) (p=0.0157) and pre-treatment position of the upper incisor (UI/A-Pg) (p=0.020) (Table 5).

Table 4. Bivariate analysis of the relationship between moderate/severe root resorption and independent variables

Variables	Case		Control		P
	n	(%)	n	(%)	
Systemic history					
No	44	(68.84)	49	(77.78)	0.417
Yes	19	(30.16)	14	(22.22)	
Overjet pre-treatment					
0-2 m	52	(82.54)	55	(87.30)	0.752
<0 mm	3	(4.76)	2	(3.17)	
>2 mm	8	(12.70)	6	(9.52)	
Prior RR					
No	53	(84.13)	63	(100)	0.001*
Yes	10	(15.87)	0	(0)	
Skeletal classification					
Class I	41	(65.07)	33	(52.38)	0.333
Class II	16	(25.39)	23	(36.50)	
Class III	6	(9.52)	7	(11.11)	
Extractions					
No	51	(80.95)	57	(90.48)	0.127
Yes	12	(19.05)	6	(9.52)	
MBT technique					
No	38	(60.32)	36	(57.14)	0.717
Yes	25	(39.68)	27	(42.86)	
Standard Technique					
No	49	(77.78)	50	(79.37)	0.828
Yes	14	(22.22)	13	(20.63)	
Self-ligating technique					
No	39	(61.90)	40	(63.49)	0.854
Yes	24	(38.10)	23	(36.51)	
Bracket Type					
Conventional	38	(60.32)	40	(63.49)	0.714
Self-ligating	25	(39.68)	23	(36.51)	
Higher arc caliber					
Round	9	(14.29)	10	(15.87)	0.803
Rectangular	54	(85.71)	53	(84.13)	
Treatment duration					
18 months	30	(46.88)	34	(53.12)	0.476
>18 months	33	(53.23)	29	(46.77)	

Chi^2 test. Statistically significant at *p<0.05; **p<0.01; ***p<0.001; ****p<0.0001
Source: by the authors

Table 5. Bivariate analysis of the relationship between moderate/severe root resorption and continuous variables

Variables	Case		Control		p
	Average	SD	Average	SD	
Age	27.626	11.034	27.595	11.100	0.949
Treatment duration	20.428	9.053	18.269	7.198	0.232
Pre-treatment SNA	83.966	3.969	83.888	3.674	0.9093^{Ł}
SNA Difference	0.022	0.72	0.065	0.58	0.8279$^{¥}$
Pre-treatment SNB	80.633	3.934	80.431	3.849	0.7718^{Ł}
SNB Difference	–0.288	1.182	–0.190	1.133	0.8624
Pre-treatment ANB	2.926	2.3	3.180	2.6	0.4747$^{¥}$
ANB Difference	0.347	1.2	0.219	1.6	0.4207
Pre-treatment Wits	–0.937	2.498	–0.703	2.825	0.6341^{Ł}
Pre-treatment IMAX	109.898	7.184	110.866	8.171	0.4813^{Ł}
IMAX Difference	0.501	4.437	–0.306	4.452	0.3352
Pre-treatment IMPA	93.382	6.909	92.523	6.677	0.4794^{Ł}
IMPA Difference	2.444	4.843	1.026	4.496	0.912^{Ł}
SN-GoGn pre-treatment	32.215	5.1	34.933	5	0.0215*
Difference (SN-GoGn)	0.020	0.48	0.619	0.61	0.7123$^{¥}$
Ii/A-Pg pre-treatment	2.407	2.443	3.514	2.621	*0.0157^{*Ł}
Difference Ii/A-Pg	0.819	1.425	0.690	1.633	0.6387^{Ł}
Iu/A-Pg pre-treatment	5.476	2.621	6.584	2.657	0.020^{**Ł}
Difference Iu/A-Pg	0.603	1.8	0.144	1.8	0.0942$^{¥}$
Overjet pre-treatment	3.127	0.97	3.236	1.3	0.1959$^{¥}$
Overjet Difference	–0.256	1.2	–0.423	1.4	0.1647$^{¥}$

^{Ł} Student t; $^{¥}$ U Mann-Whitney. Statistically significant at *p<0.05; **p<0.01; ***p<0.001; **** p<0.0001.
Difference = pretreatment measure - post-treatment measure
Source: by the authors

Table 6 shows the variables introduced in the logistic regression model, as well as the crude OR, the full model and the final model, showing that prior root resorption (p=0.039; OR=20,528; 95% CI: 1,157; 364,034) and horizontal skeletal pattern p=0.037; OR=0.927; CI95%: 0.865;0.995were the only variables that maintained their statistical significance.

Table 6. Multivariate analysis of association of EARR and variables

Variable	Crude OR			Full model adjusted OR			Final model OR		
	OR	p	95% CI	OR	p	IC 95%	OR	p	95% CI
Prior EARR	24.925	0.028*	1.427;435.344	18.599	0.048*	1.029;336.164	20.528	0.039*	1.157;364.034
SN- GoGn	0.914	0.008*	0.854;0.977	0.941	0.097	0.876;1.011	0.927	0.037*	0.865;0.995
IMPA Difference	1.068	0.094	0.988;1.155	1.058	0.221	0.966;1.159	-------	-------	--------
LI/A-Pg	0.838	0.019*	0.724;0.971	1.062	0.720	0.763;1.478	-------	-------	--------
UI/A-Pg	0.850	0.023*	0.738;0.978	0.868	0.427	0.612;1.229	-------	-------	--------
Difference UI/A-Pg	1.154	0.163	0.943;1.411	0.947	0.702	0.718;1.249	--------	-------	---------

Logistic regression with Firth's correction. Statistically significant at *p<0.05; **p< 0.01; ***p<0.001; ****p<0.0001

Source: by the authors

DISCUSSION

EARR is one of the most deleterious adverse side effects of fixed orthodontic treatment.[2,3] It is highly important for clinicians to identify possible risk factors for EARR in order to control or avoid them during orthodontic treatment. The present study found that the upper and lower central incisors followed by the upper lateral were the ones with the highest prevalence of EARR (19.04%, 11.11%, and 10.71%, respectively), which is in agreement with the findings by other authors.[3,6]

Regarding the biological and orthodontic treatment-related variables that were analyzed in this study, there was evidence associated only with prior root resorption (p=0.028; OR=24.925; CI 95% 1.427; 435,344); pre-treatment vertical skeletal pattern (p=0.008, OR=0.914, 95% CI:0.854;0.977); pre-treatment upper incisor position (p=0.023; OR=0.850; 95% CI:0.738;0.978) and pre-treatment lower incisor position (p=0.019; OR=0.838; 95% CI:0.724;0.971).

However, in the final logistic regression model, only prior root resorption p=0.037; OR=0.927; CI95%: 0.865;0.995 and the SN-GoGn angle (p=0.031; OR=1.079; CI 95% 1.007; 1.157) remained statistically significant, showing that having prior root resorption increases the chance of EARR by 20.52 times and having low SN-GoGn angle pre-treatment increases the chance of EARR by 1.079 times compared to having a high angle. Similar results were found by Marques et al,[2] who reported association between root resorption prior to treatment start and development of EARR during orthodontic treatment (OR=6.91; 95% CI: 4.4;10.9). Similarly, several authors[7,14] have found statistically significant association between prior EARR and increased risk of EARR during orthodontic treatment. Subjects with prior root resorption are expected to have a greater susceptibility to developing more severe resorption during orthodontic treatment, so these patients should have more radiographic checkups during orthodontic treatment and consider using lower force systems in teeth with this pre-treatment abnormality. As for vertical skeletal pattern, although some authors[15,16] have also found this variable as a risk factor for EARR, the results have been contradictory. Harris et al[15] also found a high correlation between patients with low angles and the onset of EARR at the distal root of the first lower molar during orthodontic treatment. On the other hand, Handelman[16] highlights the importance of limiting the apical movement of incisors during orthodontic treatment within vestibular and lingual corticals to avoid iatrogenic sequelae such as EARR, as thin alveoli such as those found in high-angle facial patterns may be more prone to EARR. On the contrary, other authors such as Parker et al[17] and Picano et al[7] found no association between the vertical pattern and EARR. These differences among studies may be because the last two authors evaluated the vertical skeletal pattern using the Frankfurt mandibular angle (FMA) or because of differences in methodology and sample population.

The present study also found that having lower values of UI/A-Pg and LI/A-Pg pre-treatment increases the chance of being a case in 1.17 and 1.18 times respectively. However, it should be noted that the CIs are very close to 1 (no association). Parker et al[17] and Picano et al[7] found no association between the incisors position and EARR. While the present study found no relationship between changing the incisor position post-treatment, other authors[17,18] state that the increase in the incisor's angle with the palatal plane has a strong correlation with the increase in EARR.

While several authors link EARR to other variables such as allergies,[19] apical root morphology,[2,19] initial overjet,[3,6,19] skeletal classification, extractions treatment,[2,3,6,7,19-21] orthodontic technique used,[20] and duration of treatment,[3,6,7,14,18,19,22] the present study could not establish a significant relationship between these variables and EARR as well as other authors,[2,3,7,14,19,20,22-24] with results similar to that of our study. Currell et al[25] conducted a systematic literature review (SLR) in search for evidence to support the association between orthodontic movement and EARR. However, they found low to very low evidence of a positive association between EARR and high force levels, continuous forces, intrusive forces, and duration of treatment. Theodorou et al,[26] in an SLR on the optimum force magnitude for dental movement with fixed devices evaluating EARR as a secondary result, conclude that forces between 50 cN and 100 cN are optimal for orthodontic tooth movement with lower adverse effects such as EARR. For their part, Yi et al[27] assessed the association between bracket type and EARR by means of an SLR in which they included studies comparing self-ligation and conventional brackets in the occurrence of EARR during orthodontic treatment. They found evidence suggesting that self-ligation brackets do not reduce the onset of EARR compared to conventional brackets on upper lateral incisors and lower incisors. However, self-ligation brackets appear to have some advantage in higher central incisors in terms of protecting them against EARR.

One of the strengths of our study was the case-control design, which is indicated in the identification of risk factors in diseases with long latency periods such as moderate/severe EARR, allowing comparison between subjects within the same population.[28,29] Most studies on risk factors in the literature are cross-sectional studies, which main disadvantage is the lack of a time sequence, which creates difficulties in assessing cause-effect relationships, and information on exposure is very vulnerable to measurement errors.[29] In addition, this study conducted matching by sex and age, which are considered possible confounding variables in the studied effect.

Among the limitations of the study is the fact that this is a retrospective study, and some data entered in the medical records may have information biases (patient remembrance bias and/or pollster bias in data collection). This could be one of the reasons why no significant associations were found with many of the variables under study. Also, there is no information on the actions taken to slow down or stop the progress of EARR when it was detected during the course of treatment. In addition, the use of panoramic radiographs as a diagnostic means to assess the presence of EARR may be a limitation of this study as this x-ray type has lower sensitivity and specificity in the diagnosis of EARR. Samandra et al[30] conducted an SLR to evaluate evidence on EARR measurement associated with orthodontic treatment using cone beam computed tomography (CBCT), finding out that tomography is a reliable means for diagnosing EARR and can even diagnose very small EARR in early stages. However, using CBCT as a routine orthodontic analysis is not recommended due to increased risks associated with exposure to ionizing radiation, especially in growing patients.[31] Another limitation of the present study was that the EARR evaluation method used[9] was reported and validated on periapical x-rays, and although this method has already been used by other authors,[24] this could potentially affect the results.

Clinicians are advised to consider the variables found in this study as possible risk factors for EARR in their diagnosis, and to adapt or modify the treatment plan by means of soft forces and routine radiographic control in these patients, in order to avoid or to control the occurrence of moderate/severe EARR during orthodontic treatment.

CONCLUSION

We found evidence of association between prior EARR, pre-treatment position of upper and lower incisor, horizontal skeletal pattern, and risk of moderate to severe EARR during orthodontic treatment.

CONFLICTS OF INTEREST

The authors state that they have no conflict of interest.

CORRESPONDING AUTHOR

Sonia Patricia Plaza Ru z
Fundaci n Universitaria CIEO-UniCIEO
(+57) 3183373032
sp.plaza@unicieo.edu.co
Carrera 23 # 124-70 Cons 201
Bogot , Colombia

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