Original Article

Comparative study of root resorption of maxillary incisors in patients treated with lingual and buccal orthodontics

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ABSTRACT

Objective: To compare the magnitude of external apical root resorption (EARR) of maxillary incisors in patients with mild to moderate anterior crowding, treated with lingual and conventional (labial) orthodontics.

Materials and Methods: The sample comprised 40 patients divided into two groups: lingual (20 patients) and conventional buccal brackets (20 patients). Patient ages ranged from 11 to 45 years, and the study included 12 men and 28 women. Apical root resorption was measured from periapical radiographs obtained at the beginning of treatment (T1) and at the end of the leveling phase (T2). Periapical radiographs were scanned and transferred to the CorelDraw X7 image-processing program, in which measurements of root lengths were performed. For intragroup and intergroup comparisons between the T1 and T2 phases, paired and independent *t*-tests, respectively, were used at 5% significance.

Results: There was significant apical root resorption for all teeth evaluated; the magnitude of the EARR (T2–T1) ranged from –0.35 mm to –0.63 mm in the lingual group, and from –0.66 mm to –0.85 mm in the conventional group. Although there was an intergroup variation in the magnitude of EARR observed, no statistically significant differences were found. Neither group presented any teeth with resorption $\geq$1 mm.

Conclusions: The magnitude of apical root resorption in maxillary incisors in patients with anterior crowding was similar regardless of orthodontic technique, lingual or conventional. Both techniques resulting in an apical rounding considered clinically insignificant. (*Angle Orthod.* 2017;87:795–800.)

KEY WORDS: Orthodontics; Dental radiography; Root resorption

INTRODUCTION

External apical root resorption (EARR) is an undesirable treatment-induced sequela of dental braces.[1] Root shortening can result in irreversible consequences to the support of orthodontically treated teeth, and is therefore of great interest to orthodontists.[2] The EARR etiology, although widely discussed in the literature, remains somewhat obscure and controversial. Several factors contributing to EARR have been analyzed: individual susceptibility, genetic predisposition, anatomical characteristics, malocclusion severity, periapical inflammation, systemic factors (including allergies, asthma, arthritis, diabetes, and hormonal deficiencies), and mechanotherapy and orthodontic techniques.[1–3]

Attending the esthetic need for most adult patients, lingual orthodontics, together with ceramic, sapphire, and polycarbonate buccal braces, were designed to improve the appearance of orthodontic devices.[4,5] The EARR caused by conventional buccal orthodontics is well-known but, when new techniques are available, one might question the consequences on the root apex of a different force system.

In lingual orthodontics, the bracket is closer to the center of resistance of the tooth and the interbracket distance is smaller compared with conventional buccal orthodontics.[4] These differences may give rise to

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greater forces in the alignment and leveling phase.[5] Another peculiarity of the lingual technique is the tendency of the mandibular incisors to touch the brackets of the maxillary incisors. The effects of this contact are frequently observed by researchers who have already found intrusion of both maxillary and mandibular incisors.[6] Opening of the bite occurs frequently in dolichofacial patients.[6–8] Therefore, it is often necessary to place resin planes on the occlusal surfaces of the posterior teeth to make it easier for patients to chew and to avoid dental extrusion.

There is a lack of studies evaluating the EARR magnitude in patients treated with lingual orthodontics so there is a need for new investigations in this area.[4] Owing to the concerns related to induced root resorption and the differences in biomechanics between buccal and lingual orthodontics, this study aimed to compare the amount of EARR in maxillary incisors at the end of the alignment and leveling phase in patients treated by either method.

MATERIALS AND METHODS

This retrospective study was approved by the research ethics committee of the Sagrado Coração University, under protocol No. 1.249.814.

Subjects

The study participants consisted of 40 patients aged between 11 and 45 years of both sexes (12 males, 28 females) who had undergone orthodontic treatment using conventional buccal ($n = 20$) or lingual ($n = 20$) techniques. The total number of teeth analyzed was 160 (4 per patient). Patients were treated in two private clinics. All patients had a similar amount of initial crowding (1 to 4 mm). For inclusion in the study, patients needed to present with Angle Class I or II malocclusion. Patients already had available periapical radiographs of the incisors obtained before the beginning of treatment (T1) and at the end of the leveling phase (T2). Patients having endodontically treated teeth, teeth that had undergone previous orthodontic treatment or trauma, those that already had resorption, and syndromic patients or those with dentoskeletal deformation were excluded from the study. The treatment protocol did not include any extraction or interproximal reduction.

The sample was divided into two groups according to orthodontic technique, and subjects were matched according to age and sex. The lingual group consisted of 20 patients: 16 female (80%) and 4 male (20%). The mean age of this group was 24.02 years. The brackets of the lingual technique were selected under the trademarks GAC, Eurodonto, and Ormco, all with an .018-inch slot. The archwires used in the leveling phase had the following sequence: .012-inch NiTi, .014-inch NiTi, .016-inch NiTi, .018-inch NiTi, and .018-inch stainless steel.

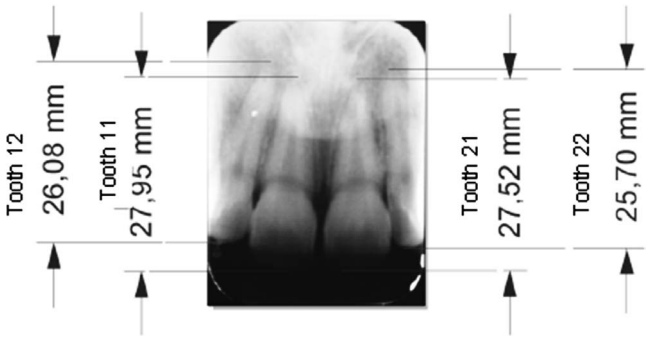

Figure 1. Scanned periapical radiograph showing dimensions used for measuring root length in CorelDRAW X7.

The conventional group consisted of 20 patients: 12 female (60%) and 8 male (40%). The mean age of this group was 23.43 years. The brackets used were from Morelli and 3M, with Roth prescription and a .022-inch slot. The archwires used in the leveling phase were identical with those used in the conventional group, except that the last wire was .020-inch stainless steel.

In both groups, the alignment and leveling phase had an average duration of 8 months (5 to 10 months).

Radiography, Image Acquisition, and EARR Measurement

Periapical radiographs of phases T1 and T2 were obtained in private clinics, using the parallelism technique with a universal positioner. The same operator then photographed the radiographs using the same camera for each. The camera was stabilized using a tripod at a distance of 9 cm from the radiograph, which was placed on a negatoscope. A plumb was used to maintain the plane of the machine, to avoid possible distortions in the final image. Images were transferred to the computer and saved in JPEG format, then imported into CorelDRAW X7 to obtain measurements of root length, according to the diagram in Figure 1. Following calibration, the same operator performed the measurements on the periapical radiographs at T1 and T2. Measurements were performed on the maxillary incisors of both groups.

Images were standardized for measurement and processed to avoid distortion using the following protocol: creation of a blank file in CorelDRAW X7 with a width of 31 mm and a height of 41 mm to match radiographic film dimensions, and a resolution of 300 dpi. The scanned radiographic image was then imported into this file. Measurement of EARR was performed using linear delimitations generated by the program, tangent to the root apex and the incisal edge

Table 1. Comparison of Mean Patient Age for Lingual and Buccal Groups[a]

	Lingual		Buccal			
	Mean	SD	Mean	SD	Diff	*P*[a]
Age (y)	24.02	6.36	23.43	10.83	−0.59	.835

[a] Indicates statistically not significant.

of the referred teeth. After having defined the traces, another tool called the "parallel dimension" was used in which the mouse cursor was placed on one of the traces and dragged to the other, generating a linear measure corresponding to the length of the tooth. This line was created perpendicular to the horizontal planes of the radiographic film. The differences in tooth length of the maxillary central and lateral incisors between T2 and T1 were calculated to evaluate the degree of resorption that occurred during the leveling phase. To confirm the calibration of the examiner and ensure data reproducibility, an intraexaminer method error assessment was performed. Thirty percent of the total sample was randomly selected and, after 30 days, the measurements were repeated. The systematic error was calculated by the *t*-test at the 5% significance level ($P < .05$). The casual error was calculated using the Dahlberg formula.

Statistical Analysis

Data are presented in the tables as means. All groups used for comparisons passed the Kolmogorov-Smirnov normality test. An independent *t*-test was used to compare lingual and buccal groups. The chi-square test and the proportions test were used for comparing gender composition in each group. In all tests, a significance level of 5% ($P < .05$) was adopted. All tests were carried out with the Statistica version 12 software (StatSoft Inc, Tulsa, Okla).

RESULTS

Power Analysis

Power analysis was undertaken using the mean standard deviation of the variation between T1 and T2 of 0.51 as the desired effect size. Adopting a significance level of 5%, we used a sample of size 20 with 85% power to detect a minimum difference of 0.50 between the two groups.

Study Group Characteristics

Comparisons between the mean age and sex composition of the lingual and conventional groups are presented in Tables 1 and 2, respectively. There were no significant differences in either of these variables between the two groups.

Table 2. Comparison of Gender Composition of Lingual and Buccal Groups

	Gender		
Group	F	M	Total
Lingual	16 (80%)	4 (20%)	20 (100.0%)
Buccal	12 (60%)	8 (40%)	20 (100.0%)
Total	28 (70%)	12 (30%)	40 (100.0%)

[a] $P = .168$: statistically not significant.

Effect of Orthodontic Treatment on EARR

After we determined the accuracy of the EARR measurement procedure, we analyzed the systematic intraexaminer error using a paired *t*-test. No statistically significant differences were observed between measurements (*P* value range = 0.32–0.78). Furthermore, no significant casual error was observed (variation = 0.017–0.018).

There was a statistically significant intragroup difference in T1 and T2 root length for all teeth evaluated. On analyzing the lingual group, we found a smaller average change in tooth length for tooth 11 (–0.35 mm), compared with the change observed for tooth 12 (–0.63 mm). For the buccal group, the variation in root length ranged from tooth 11 (–0.66 mm) to tooth 21 (–0.85 mm; Table 3). When the EARR was compared between lingual and buccal techniques, no significant differences were found (Table 4).

DISCUSSION

The EARR often found in teeth that undergo orthodontic treatment is considered iatrogenic, owing to the effect of decreasing the size of the roots of the teeth involved.[9] In most cases, EARR is not severe, making its consequences clinically insignificant. In cases wherein EARR occurs with greater severity, orthodontic treatment must be modified, or even interrupted, to preserve the long-term support of the teeth. Currently, it is known that severe EARR can have multifactorial origins, such as individual predisposition, higher intensity of orthodontic force,[10] and increased duration of orthodontic treatment.[11,12]

Periapical radiography is the most widely used test for detecting EARR, owing to the convenience of compact radiographic devices that can be located in offices, which are also usually more affordable than other forms of imaging diagnostics.[13] In this study, the technique of parallelism was adopted using an acrylic device, which enables the radiographic film to be placed absolutely perpendicular to the x-ray beam. The reliability of this technique has been proven from previous studies, such as that of Gegler and Fontanella (2008),[13] who used teeth inserted in resin blocks and varied their inclinations by up to 20°. Their results

Table 3. Intragroup Variation of T1 and T2 Root Length Measurements

		T1		T2		Variation		
Group	Tooth	Mean	SD	Mean	SD	mm	%	*P*
Lingual	12	23.31	2.69	22.68	2.64	−0.63	−2.71%	<.001*
	11	25.26	2.29	24.91	2.34	−0.35	−1.39%	.025*
	21	25.52	2.41	24.94	2.44	−0.59	−2.31%	<.001*
	22	23.59	2.68	23.04	2.71	−0.55	−2.33%	<.001*
Buccal	12	25.09	2.24	24.33	2.11	−0.77	−3.05%	<.001*
	11	26.47	2.15	25.81	1.99	−0.66	−2.50%	<.001*
	21	26.75	2.38	25.90	2.27	−0.85	−3.19%	<.001*
	22	25.36	1.92	24.53	1.73	−0.83	−3.27%	<.001*

* Indicates statistically significant variation ($P = .05$).

showed that this positioning was efficient in maintaining the length of the teeth in the radiographic image using the different simulated slopes.

Maxillary incisors are among the teeth most susceptible to EARR; hence, the length of these teeth was evaluated in this study.[11,14,15] The measurement period included the duration of the leveling phase, commonly used to observe the first evidence of resorption. The choice of this study period was supported by a study by Artun et al. (2005),[16] which showed that at the end of the first 6 months of orthodontic treatment, it is possible to predict whether there will be a significant increase in EARR in the subsequent treatment periods.

For the intragroup results, there was a statistically significant difference in the root length of the teeth evaluated. The extent of EARR (T2–T1) varied from –0.35 mm in tooth 11 (smaller change) to –0.63 mm in tooth 12 (greater change) in the lingual group.

The amount of resorption was obtained from alignment and leveling mechanics, wherein crowding ranged from mild to moderate in all cases. The mean EARR observed was 2.71% of the mean root length at the start of the leveling phase, meaning that 97.29% of the original root length was maintained over the duration of the study. To our knowledge, the only previous study to investigate EARR in patients treated with the lingual technique was conducted by Fritz et al. (2003),[4] in which the authors evaluated the magnitude of resorption in the anterior and canine teeth (maxillary and mandibular). The treatment protocol involved, in addition to alignment and leveling, premolar extractions and consequent anterior tooth retraction. They evaluated the whole treatment duration and found a mean EARR of 3.7% of the pretreatment root length; however, the increased amount of EARR compared with our study can likely be attributed to methodological differences. For example, the Fritz et al. study [4] had a longer period between T1 and T2, owing to more complex mechanics involving space closure and torque control. Furthermore, in contrast to the periapical radiographs used for root length measurements in the present study, Fritz et al.[4] used panoramic and cephalometric radiographs. According to some authors, periapical radiography and parallelism results in fewer image distortions, thereby preventing the need of subsequent corrections.[13,17]

For the intragroup results in the buccal group, statistically significant differences were observed in the root length of the teeth evaluated. The extent of EARR (T2–T1) varied from –0.66 mm in tooth 11 (smaller change) to –0.85 mm in tooth 21 (greater change). In accordance with these results, other studies have reported variations in dental length resulting from treatment with conventional orthodontics.[14,18–21] The amounts of EARR between groups treated with different techniques or prescriptions reported in the literature are minimal, as they were in the current study. It has been reported that less EARR associated with a specific prescription might be related to the type of wires used (superelastic, for example), the use of smaller wires in larger slots (0.018 × 0.025-inch in 0.022-inch slots),[14] or even to the extent of bends made.[18] Conversely, some studies have reported higher EARR (resorptions of 1.5 mm up to one-third of the root),[15,22] in contrast to the results of the current study. In those studies, it was suggested that a long period of orthodontic treatment,[11] a high intensity of force during movement,[23] carelessness following orthodontic therapy, the presence of EARR at the end of leveling,[16] or atypical root morphology[15] may have contributed to the greater degree of EARR.

When analyzing differences in biomechanics, it should be remembered that the interbracket distance is decreased in the lingual technique compared with

Table 4. Change in Root Length Between T1 and T2 for Lingual and Labial Groups

	Lingual		Buccal			
Tooth	Mean	SD	Mean	SD	Difference	*P*
12	−0.63	0.26	−0.77	0.62	−0.13	ns
11	−0.35	0.64	−0.66	0.65	−0.31	ns
21	−0.59	0.28	−0.85	0.60	−0.26	ns
22	−0.55	0.23	−0.83	0.82	−0.28	ns

ns indicates statistically not significant.

labial.[4] Occlusal contact between the mandibular incisors and the maxillary incisor brackets is also observed in most lingual cases.[5,24] These considerations raise questions about possible differences between EARR levels in conventional and lingual orthodontics.[4]

In concordance with the literature, in which variation in EARR between different techniques or prescriptions was found to be minimal, the present study found no significant difference in EARR between patients treated either with lingual or buccal orthodontics. Neither group displayed any tooth resorbed 1 mm or more. Thus, the values obtained can be considered clinically insignificant because the EARR manifested as a simple rounding at the apex, which is not expected to compromise long-term stability.

To date, there are no previous studies comparing the EARR induced by conventional buccal or lingual techniques. However, several studies have compared different techniques, systems, and prescriptions, all performed with conventional brackets.[14,18–21] Thus, the present study contributes the additional finding that these two techniques did not differ significantly in the magnitude of EARR observed after the leveling period.

The current study presented important information to show that, regarding root resorption, either buccal or lingual orthodontics could be safely performed. Other factors such as individual predisposition, intensity of force, duration of treatment, and amount of orthodontic movement are still relevant to influence the magnitude of EARR.[10] Consideration of biological limits, observation of predisposing factors, and radiographic follow-up, at least at the end of the leveling phase, make these techniques absolutely feasible.

A noteworthy limitation of this study was that the two-dimensional method used to obtain radiographic images may have influenced the degree of EARR estimated, which could have occurred to different extents in other planes. However, there is general agreement that the use of cone-beam computed tomography scans, for cases in which conventional radiographs do not provide all the necessary information, should be limited to protect the patient from excessive radiation. Computed tomography can be used in cases in which there is, for instance, the need to observe the bone area for implants and mini-implant installation, and also to better evaluate impacted teeth and their surrounding structures.[9,25,26]

CONCLUSIONS

- Based on the results of the present study, the magnitude of apical root resorption in the maxillary incisors was similar regardless of the orthodontic technique used, lingual or conventional.
- Both techniques resulted in apical rounding; however, this effect was clinically insignificant.

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