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Original Research Article

Microtomographic view of external root resorption: an observational transversal study

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Abstract

Introduction: This study investigated root resorption (RR), which can occur on the internal or external surfaces of the tooth, with difficulty in differential diagnosis using conventional radiography. **Objective:** To analyze external root resorption (ERR) through microtomography of *ex vivo* teeth. **Material and methods:** Two null hypotheses were tested: (1) the size and shape of natural root resorption are identical to those produced artificially; (2) the size and shape of natural root resorption differ from those produced artificially. **Results:** 126 teeth were scanned in high resolution, evaluated by calibrated radiologists, showing a higher incidence of RR in premolars (29.8%), followed by molars (27.7%), canines (23.4%), and incisors (19.1%), in relation to root thirds and location on the tooth surface. **Conclusion:** It was concluded that RR cavities exhibit a distinct architecture compared to those created by round burs, as observed in imaging modalities such as X-rays and cone beam computed tomography.

Introduction

Root resorption (RR) represents the loss of dental hard tissue [12] caused by inflammation initiated after dental trauma, orthodontic movement, internal bleaching, periodontal treatment and idiopathic events [4, 11, 24, 28]. It appears as a common side effect of orthodontic treatment that results in permanent loss of tooth structure at the radicular apex [32]; but it is known that between 7 to 13% of the population never underwent orthodontic movement also has some type of root resorption [4, 14, 15, 28]. RR may occur on the internal or external surface of the tooth, but differential diagnosis is difficult using conventional radiography [19].

The diagnostic efficiency of ERR is an essential aspect to the definition of the adequate therapeutic approach and eventually to success in treatment [25]. The periapical radiograph is the most widely used method to diagnose the presence of apical external root resorption (ERR) but there must be a certain degree of resorption to make it detectable. However, there are many limitations to the image acquisition of ERR using conventional radiography, since the three-dimensional (3D) structure is displayed on a two-dimensional (2D) image [25]. There may be cases where the identification of the type ERR, its degree of progress and its limits are definitely not possible to determine. In these cases you can use cone beam computed tomography (CBCT) as an alternative, for the detection of resorption, determining its extent and location will be much easier due to the various directions of the section planes, increasing the precision of diagnose [7]. CBCT is characterized by extraordinary accuracy, rapid scan time, reduced radiation dose and unmatched 3D image reconstruction capabilities [25].

Recently, micro tomography proved to be a fast and accurate method with high resolution, providing higher quality imaging [26]. It can also be used to detect and quantify the reabsorption of craters in the root surfaces of extracted teeth which have or not been submitted to orthodontic treatment [26]. When compared to the digital periapical X-rays in the evaluation of ERR, radiographic method showed a specificity of 78% and a sensitivity of 44%, that means that the radiographic method can detect less than 50% of the cases detected by micro tomography [9].

So, this work aimed to study the ERR by analyzing the micro tomography of ex vivo teeth, because it is known that even those teeth that have not undergone any orthodontic movement or trauma may present ERR lacunae. To present two null hypothesis: (1) the size and shape of nature RR is the same of those ones produced artificially; (2) the size and shape of nature RR is different of those ones produced artificially. And to find out if there is relationship among size and shape with one-third, one-face and dental group.

Material and methods

This work was carried out after the approval of the Ethics Committee under the CAAE number: 50214515.0.0000.0020, featuring an observational cross-sectional study with a sample of 126 ex vivo teeth of the lower arch, 36 incisors, 18 canines, 36 premolars and 36 molars belonging to the bank of teeth, a number which enables the assembly of nine lower dental arches, which will be part of a later study. The inclusion criteria of the teeth in the sample were not present any kind of root destruction, dental crowns that enabled its morphologic classification of the dental group, absence of carious / abrasion cavity in the cervical region.

The teeth were randomly selected from the tooth bank, using a magnifying glass (3x magnification) and natural light, until reaching the number determined for the study. After the teeth were examined by two evaluators to confirm the anatomy, which tooth group each tooth belonged and also to verify the inclusion criteria. They received a randomized number (software program) from 1 to 126, being 1 to 36 incisors, 37 to 54 canines, 55 to 90 premolars and 91 to 126 molars.

All teeth were scanned by micro-CT scanner (SkyScan 1172, Kontich, Belgium), detectability of isotropic details 9μm in medium resolution camera X-ray 11MP with total correction of distortion, 3D reconstruction by a computer cluster, which allows nondestructive viewing fine-scale objects. For scanning the crowns of the teeth were embedded in polystyrene, a material that does not interfere with image acquisition, in groups of 6 teeth, incisors, canines and premolars and three groups of teeth to the molars due to limitation of the micro-CT's working area.

After scanning, the images were evaluated in NRecon software (SkyScan NV, Belgium), which allows viewing of the teeth in the axial, sagittal and coronal planes, and the presence or absence of ERR lacunae in the apical, middle and cervical; the face where the gap occurred has also been reported, being classified as buccal, lingual and

proximal. Data were recorded in a spreadsheet and the analysis was repeated one week later, and the two moments all 126 teeth were evaluated on the same day, by two calibrated evaluators, the kappa value for inter and intra-rater agreement was greater than 0.80.

Results

The results were analyzed and tabulated using SPSS software (version 24.0: SPSS Inc., Chicago, Il, USA), by two blinded examiners and can be seen in tables I to III.

Of the 126 teeth evaluated, 41 teeth had ERR, and of these 11 teeth presented more than one RR gap per tooth: 4 incisors, 2 canines, 2 premolars and 3 molars, making a total of 139 resorption gaps.

The morphological aspect, it was observed that resorption lacunas are quite heterogeneous because there was not a definite shape, since it ranges from relatively oval cavities, but with irregular edges, to rectangular and conical cavities, and others completely shapeless. They have a variety of extensions and depths as we can see in figures 1 and 2, that is, the cavities present a heterogeneous pattern even in the same cavity and in the same tooth.

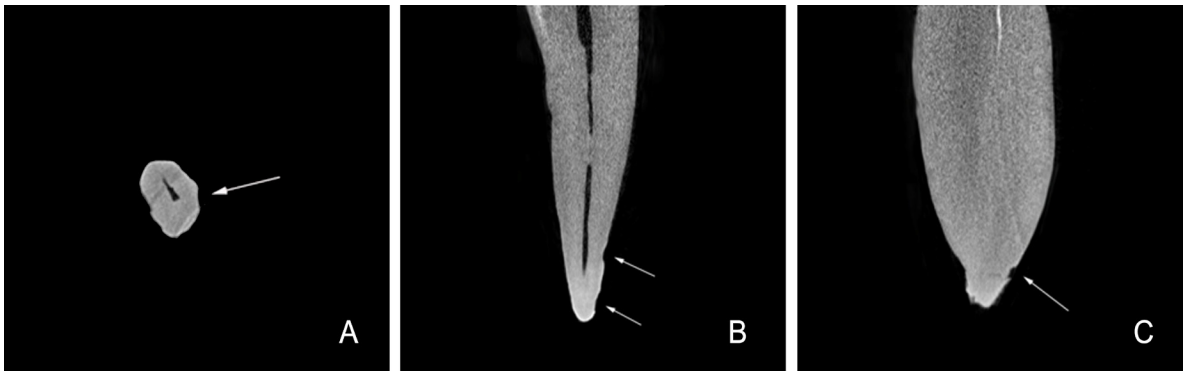

Figure 1 – Microtomographic view of a lower canine (tooth number 49) with root resorption area marking the apical third, with (A) axial (B) and coronal (C) sagittal section

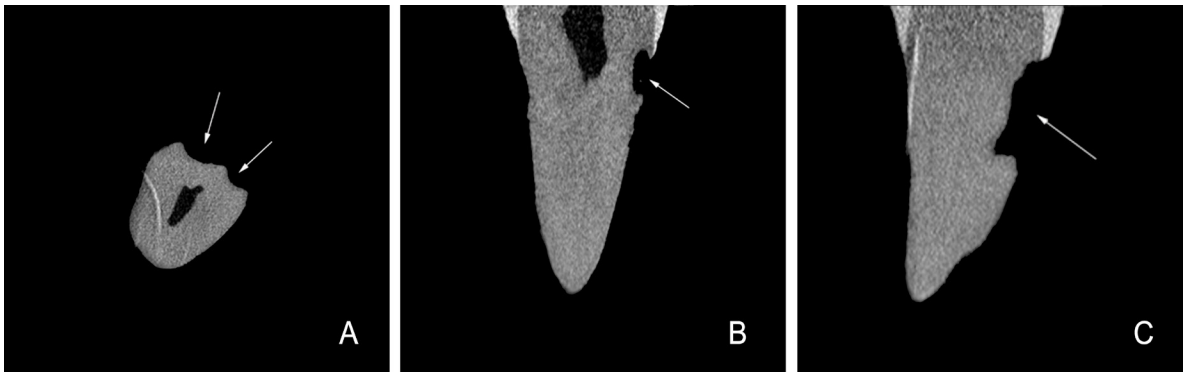

Figure 2 – Microtomographic view of a lower premolar (tooth number 71) with root resorption area marking the apical third, with (A) axial (B) and coronal (C) sagittal section

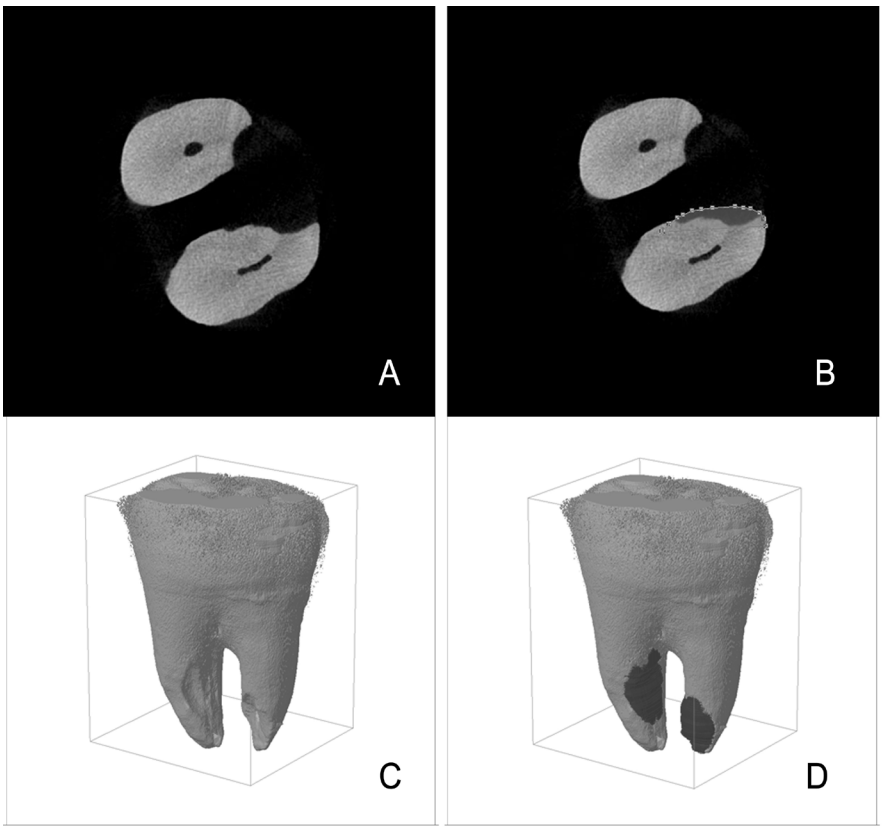

Figure 3 – Microtomographic view of a mandibular molar with reconstruction of root resorption area in an (A) axial section and (B) tridimensional viewer

The size of the cavities was calculated in relation to their volume in cubic millimeters by NRecon software (SkyScan NV, Kontich, Belgium), varying from 2.46 mm3 to 3.11 mm3, corresponding to cavities 1.67 mm and 1.81 mm in diameter, respectively. A cavity 0.3 mm in diameter would be considered small. That is, all the cavities observed in this study can be classified as large cavities, since the literature cites values from 0.3 mm to 0.5 mm for small cavities, 0.7 mm to 1mm for medium cavities and greater than 1 mm for large cavities [2, 6, 7, 9, 13, 19].

The relationship of ERR in this study was 36.7%. The premolars and molars (10.8%) was more teeth presented ERR, followed by incisors (7.9%) and canines (7.2%), but this result was not statistically significant (Chi-square= 0.445) (table I).

The presence of ERR showed statistically significant relationship with the root one-third (Chi-square=0,008) but not with root surface where it occurs (Chi-square=0,262) as can be seen in tables II and III.

Table I – Relationship of presence or absent of external root resorption in the different dental groups

			TOOTH				Total
			Incisor	Canine	Premolar	Molar	
MICRO-CT	WITHOUT RR	Score	29_a (20,9%)	11_a (7,9%)	23_a (16,5%)	25_a (18%)	88 (63,3%)
	WITH RR	Score	11_a (7,9%)	10_a (7,2%)	15_a (10,8%)	15_a (10,8%)	51 (36,7%)
Total		Score	40 (28,8%)	21 (15,1%)	38 (27,3%)	40 (28,8%)	139 (100%)

Source: raw data

Chi-square Test = 0.445

RR = root resorption

Table II – Relationship of external root resorption and one-root third according of different dental groups

			TOOTH				Total
			Incisor	Canine	Premolar	Molar	
ROOT THIRD	WITHOUT RR	Score	29_{a} (20,9%)	11_{a} (7,9%)	23_{a} (16,5%)	25_{a} (18%)	88 (63,3%)
	APICAL	Score	9_{a} (6,5%)	6_{a} (4,3%)	2_{b} (1,4%)	9_{a} (6,5%)	26 (18,7%)
	MEDIUM	Score	0_{a} (0%)	$1_{a, b}$ (7%)	7_{b} (5%)	6_{b} (4,3%)	14 (10,1%)
	CERVICAL	Score	$2_{a, b}$ (1,4%)	3_{b} (2,2%)	6_{b} (4,3%)	0_{a} (0%)	11 (7,9%)
Total		Score	40 (28,8%)	21 (15,1%)	38 (27,3%)	40 (28,8%)	139 (100%)

Source: raw data

Chi-square Test = 0,008

RR = root resorption

Table III – Relationship of external root resorption and root surface according of different dental groups

			TOOTH				Total
			Incisor	Canine	Premolar	Molar	
ROOT SURFACE	WITHOUT RR	Score	29_{a} (20,9%)	11_{a} (7,9%)	23_{a} (16,5%)	25_{a} (18%)	88 (63,3%)
	PROXIMAL	Score	9_{a} (6,5%)	6_{a} (4,3%)	9_{a} (6,5%)	13_{a} (9,4%)	37 (26,6%)
	BUCCAL	Score	2_{a} (1,4%)	2_{a} (1,4%)	5_{a} (3,6%)	2_{a} (1,4%)	11 (7,9%)
	LINGUAL	Score	0_{a} (0%)	2_{b} (1,4%)	$1_{a, b}$ (0,7%)	0_{a} (0%)	3 (2,2%)
Total		Score	40 (28,8%)	21 (15,1%)	38 (27,3%)	40 (28,8%)	139 (100%)

Source: raw data

Chi-square Test = 0.262

RR = root resorption

Discussion

All permanent teeth are subject to present clinically irrelevant ERR that it is not detectable by X-ray and as a rule does not compromise the functional capacity or longevity dente [14]. Of the 126 teeth analyzed in this study, 36.7% teeth had some ERR. An example of the configuration and architecture of these RR lacunas can be observed in figures 1 and 2. All RR occurs tridimensional, and its bidimensional radiographic evaluations is not geometrically accurate, yielding questionable extent values of the lesions [3].

The canines had the higher prevalence of ERR in this study (29.40%), and it does not agree with the literature, which states that the most likely teeth to make ERR are the upper and lower incisors, due to factors such as root configuration, periapical anatomy and bone architecture [1, 8, 9, 13]. Another study stated that central and lateral incisors are also the most prevalent teeth with ERR, especially in studies orthodontic [4, 10-12, 17] where it is called orthodontics induced external apical root resorption (OIEARR). Already in this study the canines had a higher prevalence of ERR, a justification for this finding may be the fact that we worked with micro tomography, which show the teeth at all levels, as most other studies used periapical radiographs [3, 4, 6, 8] where there is the superimposition of images; but even in studies using CT scan [1, 3, 6, 8, 9, 13-15], the values found in micro tomography were higher due to the detail of the image.

Radiographic identification of RR lacunae can be influenced by the location on the tooth [2]. In our study it was noted that RR is correlated with the root one-third (apical, middle and cervical) but not with root surface (proximal, buccal and lingual) and dental group (incisor, canine, premolar, molar).

When we tried to establish a relationship between dental group and the root one-third or root surface, we noted that there was a preference for the proximal surface as in a study where mesial and distal surfaces have considerably more resorption than the others [7]; whereas other showed that the lacunae of RR was located on all surfaces [16].

Regarding the root one-thirds, the apical one-third was the most prevalent with RR, that confirms previous studies showing that specially after applications of an orthodontic force, small areas of surface resorption always occurs, with high incidence of apical RR [5, 10].

Limitations

One limitation of this study was to have used teeth from a tooth bank, which did not allow the knowledge of the previous clinical history of the patients, what diseases they had, the treatments that the tooth was submitted to or traumas. Ideally, teeth should be used, which dental and medical history should be known to be able to correlate with possible RR.

Conclusion

The results permit accept the second null hypothesis (2) The size and shape of nature RR is different of those ones produced artificially.

It was possible observed that the arquitecture of the RR cavities is so different of that produced by round burs (artificial cavities) and seen in others image exams, like X-rays and cone beam computed tomography.

Another interesting finding was that in this study there is a relationship between RR and root one-third, but not with dental group.

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