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ORIGINAL RESEARCH

Is there Correlation between the Root Apex Anatomy with External Root Resorption?

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ABSTRACT

The aim of this study was to correlate the root apex anatomies with external root resorption in patients orthodontically treated through panoramic radiography and cone beam computed tomography (CBCT) methods. Two hundred and forty dental roots were evaluated by tomographic and radiograph images from thirty patients submitted to orthodontic treatment. Orthodontic treatment with fixed appliances was developed based on the technique of straight arc (Straightwire) with Roth prescription. Dental roots anatomy were classified based on shape as: Score 0 – normal root; Score 2 – short root; Score 2 – blunt; Score 3 – bent; and Score 4 – pipette shape. Measurements of external root resorption (ERR) were performed before and after orthodontic treatment by means of CBCT and panoramic radiograph. All patients and 72% of the 173 roots presented with ERR. The frequency of root type, the normal root (score 0) was 88.75% in panoramic radiography and only 18.75% for CBCT. The frequency of ERR was high in maxillary central incisors (73%), maxillary lateral incisors (73%), mandibular central incisors (72%), mandibular lateral incisors (70%). Statistical analysis showed no correlation between the methods, type root and tooth type ($p < 0.05$). The CBCT had better results for identifying apical roots resorption than panoramic radiograph, but the correlation between the type of root and ERR was not confirmed.

Keywords: Orthodontic treatment, Apical root resorption, Cone beam computed tomography, Panoramic radiograph.

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INTRODUCTION

Orthodontic treatment allows improvement of the patient's facial and dental by obtaining ideal positional relationship among teeth, within and between the arches.[1] The orthodontic tooth movement occurs through the teeth micromotion that stimulate bone resorption and tooth roots around the bone apposition.[2] However, various studies have been reported that orthodontic mechanics may affect the supporting tissues by modifying the balance between tooth and alveolar bone.[3-5] The imbalance in local homeostasis may cause in external root resorption (ERR).[3]

The ERR is a dental disorder characterized by the loss of the surface layer of root protection cell and action of osteoclasts on the occurrence of hyaline zone.[6] The ERR incidence is significantly higher in orthodontically treated individuals, however it also occurs in individuals who have never submitted to orthodontic treatment.[7] The factors to ERR can be divided into mechanical and biological factors. For mechanical factors, type of orthodontic appliance, the movement type, orthodontic force magnitude, duration and type of force are involved.[8] For biological factors, a gender, age, genetic susceptibility, and systemic factors have been demonstrated influence in root resorption.[5]

Among the different methods to diagnose the ERR, the panoramic and periapical radiographs are most commonly employed due to the reduced cost. Panoramic radiography has limitations when there is need for viewing images as well defined, due to the limitation of fit between the direction of the X-ray source and the specific areas where overlaps of anatomical structures occur.[9,10] The panoramic radiography shows a 20% reduction in image quality compared to periapical radiograph.[11]

Recently, the cone-beam volumetric tomography or cone beam computed tomography (CBCT) has become a viable option for dental office.[12] This feature provides three-dimensional (3D) evaluation of teeth with the highest level of accuracy when compared with conventional radiographs, allowing the visualization of minimum details, such as the root size, presence of periodontal ligament, root anatomical

alterations, among other details.[12-14] Different aspects associated with ERR have been studied from conventional radiographs as prevalence, etiology, classification and pathologic mechanisms, including ERR.[13,14] The ERR occurs a 3D change and requires careful investigation in order to obtain more precise data on its frequency and location.[13,14]

Considering the known limitations of panoramic radiographic and the few clinical studies evaluating ERR with CBCT, the aim of this study was to correlate the root apex anatomy with ERR in patients orthodontically treated through panoramic radiography and CBCT methods.

METHODOLOGY

Selection of Samples

Tomographic and panoramic radiographs of 240 teeth roots were evaluated from 30 patients who underwent nonextraction orthodontic treatment. Mean patient age was 13 years (11 to 16 years) at the beginning of the orthodontic treatment. The inclusion criteria were healthy patient with Angle class I malocclusion with permanent dentition, crowding, and absence of caries and periodontitis. The exclusion criteria were previous orthodontic treatment, presence of bruxism, previous traumatic dental injuries, metallic restorations and continuous medication intake. Patients that accepted to participate in this study signed an informed consent term. The study was approved by the Ethics in Research Committee of Federal University of Goiás (Brazil, No. 235/2010).

Orthodontic Technique

The straight wire roth prescription was used following the sequence of wires: 0.012", 0.014", 0.018", and 0.016" × 0.022" nickel-titanium and 0.019" × 0.025" stainless steel wire on a 0.022" slot. The patients were reviewed at 4-week intervals and the same orthodontist conducted orthodontic treatments.

Characteristics of the Device

The CBCT images were obtained from an I-CAT Cone-Beam tomography unit (Imaging Sciences International, Hatfield, Pa), following the specifications: volume of 0.25 mm isometric voxel; tube voltage was 120 kVp; current measured 3.8 mA; and exposure time was 40 seconds (field of view: 13 cm); gray scale (14 bit); 0.5 mm focal distance; and image acquisition with single 360° rotation.

Analysis of Radiographs

Images were made before and after orthodontic treatment from all patients. The dental root form was adapted from Levander and Malmgren (1998).[15] In this study, the dental root form was classified into: (0) normal, (1) short, (2) blunt, (3) bent and (4) pipette shape at root apices (Fig. 1).

At first it was used in light box dark room for better viewing of images and CBCT roots were evaluated towards the distal and mesial lingual/palatal vestibule. The data were immediately numbered in worksheet Microsoft Office Excel ® 2007 version.

Analysis of External Root Resorption

The linear length between the root apex and incisal edges was measured by one examiner. The reference points for the measurements were as follows (Fig. 2): AB, from incisal edge to apex of the central and lateral incisors (sagittal section).

RESULTS

All patients and 72% of the 173 roots presented with ERR. The frequency of root type, the normal root (score 0) was 88.75% in panoramic radiography and only 18.75% for CBCT. For other types of roots (scores 1 to 4), a significant increase (18.83%) in the frequency occurred during the examination by CBCT compared to panoramic radiography (Table 1).

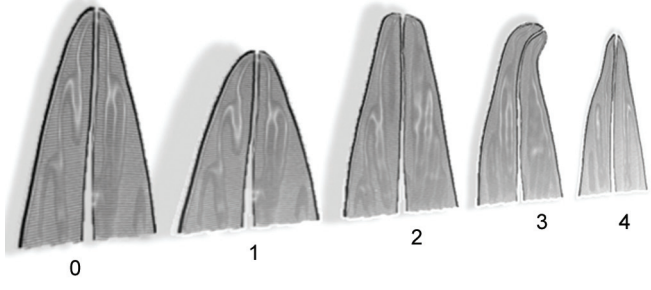


Fig. 1: The five models based on the classification of root shape adapted from Levander and Malmgren (1988)[15]

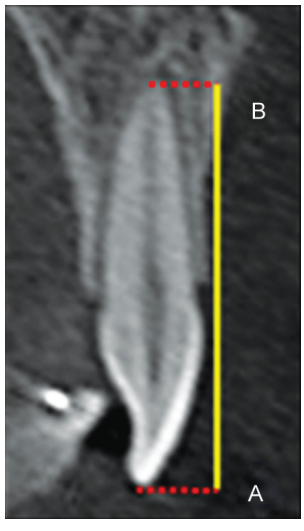


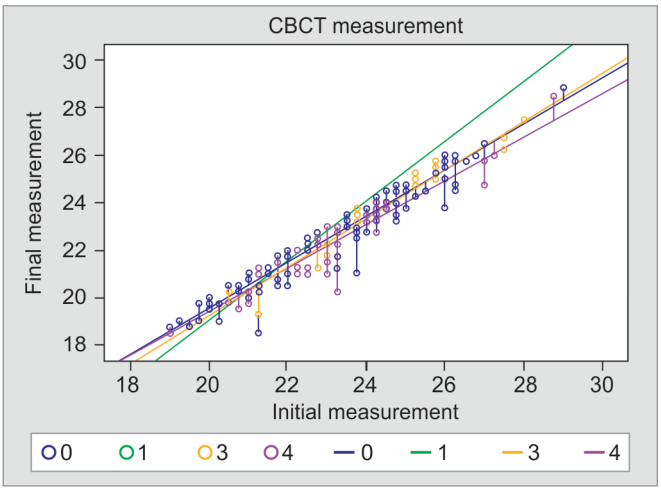
Fig. 2: Reference points for obtaining maximum linear length of incisors: (A) Incisal edge; (B) apex

Table 1: Frequency of root type found in CBCT scans and panoramic radiography

	Normal (score 0)	*Short (score 1)*	*Blunt (score 2)*	*Bent (score 3)*	*Pipette (score 4)*	*Total*
Panoramic radiography						
Root type	213 (88.75%)	20 (8.33%)	0%	2 (0.8%)	5 (2%)	240 (100%)
CBCT						
Root type	168 (70%)	2 (0.8%)	0%	32 (13.33%)	38 (15.83%)	240 (100%)

Table 2: Absolute frequency and percentage frequency (%) of external root resorption

Tooth	*N*	*Absolute frequency*	*Frequency (%)*
Maxillary central incisors	60	44	73
Maxillary lateral incisors	60	44	73
Mandibular central incisors	60	43	72
Mandibular lateral incisors	60	42	70
Total	240		



Graph 1: The initial measurements were correlated with final measurements

The frequency of ERR was high in maxillary central incisors (73%), maxillary lateral incisors (73%), mandibular central incisors (72%), mandibular lateral incisors (70%) (Table 2).

The ERR was found more frequently in panoramic radiography in the roots of the score '0' and '1' (186 and 15 roots, respectively) compared CBCT (143 roots and 2, respectively). A significant increase in the frequency of RRA at the root of the score '3' and '4' (27 and 34 roots, respectively) was found in the examination of CBCT compared to radiographic examination panoramic type (roots 1 and 4, respectively) (Table 3).

The initial and final measurements were correlated for CBCT (Graph 1). For all scores, the mensuarements were high correlation that confirm the analyses made by examinator.

The Chi-square test was applied to assess the correlation between the methods (panoramic radiography × cone bean CT), type root (scores 0 × 1 × 2 × 3 × 4) and tooth type (maxillary central incisors × maxillary lateral incisors × mandibular central incisors × mandibular lateral incisors) at a significance level of 5%. Statistical analysis showed no correlation between the methods, type root and tooth type ($p < 0.05$).

DISCUSSION

Conventional radiographs have been commonly used for the frequency of ERR after orthodontic treatment that found high results of ERR.[14] However, the CBCT has shown better efficiency to improve the diagnostic of ERR after orthodontic treatment.[14] In this study, the frequency of ERR were carried out by measurements of root before and after orthodontic treatment. The difference in the measurements of root length indicated that there was presence of ERR. Two hundred and forty roots were performed and there was presence of ERR in 72%. This high frequency of ERR is confirm with others studies.[16,17]

This study evaluated the type of tooth and root in two methods of diagnostic imaging. A higher frequency was observed for the normal root (score '0') when observed in panoramic radiography. However, the normal root decreased by 18.75% when evaluated in the CBCT, and a considerable increase to the roots with score '3' (12.53%) and score '4' (13.83%) compared to panoramic radiography. These results confirm with others studies that the CBCT is more accuracy than panoramic radiograph for ERR detection.[11,18,19] Furthermore, the software of the CBCT offers values in millimeters, which was used for the measurements in this study, in order to obtain a linear measure accurately.

Table 3: Frequency of RRA according to the type of exam and type of root

	Normal (score 0)	*Short (score 1)*	*Blunt (score 2)*	*Bent (score 3)*	*Pipette (score 4)*	*Total*
Panoramic radiography						
Root type	156 (90.29%)	12 (7.28%)	—	01 (0.49%)	04 (1.94%)	173 (100%)
CBCT						
Root type	116 (69.42%)	01 (0.98%)	—	24 (13.10%)	32 (16.50%)	173 (100%)

A method for quantifying the ERR has been described with the aid of periapical radiographs pre- and post-treatment.[20,21] The reference points used by the authors included the distance between the cementoenamel junction and root apex.[20,21] The magnification correction of the radiographic technique was based on the ratio between the length of the crown obtained radiographically before and after treatment.[20,21] The evaluation of ERR was technically complex and new measurements were reported in the literature, including the use of CBCT.[20,21] In this study, the image acquisition through CBCT, the strategy of NAG and the use of the software, allowed the accurate determination of ERR, eliminating the limiting factors of two-dimensional (2D) radiographs.

The high frequency of ERR was for maxillary central incisors (73%), maxillary lateral incisors (73%), mandibular central incisors (72%), mandibular lateral incisors (70%). Studies have reported that ERR occurs more frequently in incisors after orthodontic treatment, ranging from 47 to 95%.[16,22,23]

Prevalence studies have been used heterogeneous samples of the type of malocclusion, applying different orthodontic techniques and devices.[16,22,23] The patients selected for this study had Angle class I malocclusion with low crowding, and they were treated with fixed appliances for a mean time of 22 months, and anyone were submitted for extraction. These factors may have contributed to the low severity of root resorption observed.

The correlation between orthodontic treatment and root resorption has been widely studied, however the different treatment techniques, many types of radiographic evaluation criteria and the various diagnostic methods employed image has impaired the comparison of the results.[16,18,19,22,23]

CONCLUSION

The CBCT had better results for identifying apical roots resorption than panoramic radiograph, but the correlation between the type of root and ERR was not confirmed.

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