Diagnosis of vertical root fractures in endodontically prepared teeth, with or without the presence of intracanal cast metallic posts using Cone Beam Computed Tomography

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ABSTRACT

Objective: To assess the diagnosis of vertical root fracture in teeth endodontically treated, with or without cast metal post (CMP), by means of CBCT, using Prexion Scanner. **Methods:** The sample consisted of 48 human premolars extracted, single-rooted, which were divided in 3 groups: Group 1, control, 16 teeth without gutta-percha and CMP, from which 8 were artificially fractured; Group 2, 16 teeth presenting gutta-percha, from which 8 were artificially fractured; Group 3, 16 teeth presenting CMP, from which 8 were artificially fractured. The teeth were fractured according to the method set out in literature. A specialist in dental radiology, with 10 years of experience in tomography, evaluated the scans. Sensibility, specificity and accuracy were calculated by means of a dichotomous evaluation (presence or absence of fracture). **Results:** By means of Fisher's test, it was not detected statistical difference between groups regarding accuracy, sensibility and specificity for the fracture diagnosis, yet there was a high percentage of false positive for the Group 3. **Conclusion:** CBCT is an excellent tool for the vertical fracture diagnosis; however, the CMP presence generates images with many artifacts, resulting in a high percentage of false positive, being of paramount importance to join the tomographic findings to the signs and clinical symptoms for the most possible accurate diagnosis of fracture.

Keywords: Image diagnosis. Endodontics. Spiral cone beam computed tomography.

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Introduction

The vertical root fractures (VRFs) are a challenge for the dentist as for its early detection and conduct to be taken. VRF may be defined as a complete or incomplete longitudinal line fracture, which has its origin in the internal portion of the root canal and extends to the periradicular tissues, until reaching the external surface of the teeth.[1] The fracture may be located in the cervical, middle or apical third of the root canal and, generally, affects endodontically treated teeth. When it occurs, being complete or incomplete, it extends to the periodontal ligament. In touch with the oral cavity by means of gingival sulcus, foreign material, food debris and bacteria have access to the fracture area. Thus, an inflammatory process is induced,[2] resulting in the rupture of the periodontal ligament, alveolar bone loss and granulation tissue formation.[3]

The main causes of VRF are physical trauma, occlusal prematurities,[4] repetitive parafunctional habits of masticatory stress,[5] pathological resorption inducing root fractures and iatrogenic dental treatment.[6] Among the iatrogenic causes, endodontic therapy is an important etiological factor for the VRF, due to the excessive force application during lateral and/or vertical condensation, due to the weakening of internal dental structure with the wedge effect caused by inadequate CMP, to dilatation of metals used in the posts for the difference of linear thermal expansion coefficient of dentin and intraradicular retention, to induction of stress during installation of prefabricated threaded posts or during cementation of rigid posts.[7,8] Once there is not always signs, symptoms and/or exact radiographic characteristics, the VRF may be taken as an endodontic treatment failure and even as a periodontal disease. However, when these fractures happen, the signs and symptoms more frequent in endodontically treated teeth are pain, edema, fistula and isolated, deep and thin periodontal pocket. Now, the radiographic characteristics are represented by the thickening of the periodontal ligament, vertical, local or deep bone losses, and periradicular local bone loss.[9]

CBCT is often used in Implantodontics, Orthodontics, Periodontics, Surgery and Endodontics. In Endodontics, CBCT proves to be very useful in diagnosis of alveolar and radicular fractures, in assessing morphology of root canal and localization, in root resorption evaluations, on endodontic-surgical planning, and in many other areas, including in endodontic researches.[10] Considering the difficulties on diagnosing VRF, the objective of the present research was to assess the accuracy of CBCT for endodontically treated teeth, with or without CMP.

Material and Methods

The work started after its approval by the Research Ethics Committee of the University of Pernambuco (UPE), (protocol CAAE n° 0251.0.097.000-11).

Forty eight single-rooted teeth with a single root canal were used. After being carefully analyzed by a radiographic and visual exam with the aid of a magnifying glass (4x), the teeth selected were those presenting no incomplete root formation, calcification, root resorption, previous endodontic treatment, root fracture or intraradicular instruments/retention. After removing the debris from the root surface with pumice and water, teeth were kept in distilled water in order to avoid dehydration. All teeth were prepared by a single operator.

The 48 teeth were then divided into 3 groups:

» Group 1 (control) (n = 16): Teeth presenting gutta-percha and without cast metal post (CMP), from which 8 were artificially fractured and 8 did not present any fracture.

» Group 2 (n = 16): Teeth with endodontic treatment and presenting gutta-percha, but with no CMP, from which 8 were artificially fractured and 8 did not present any fracture.

» Group 3 (n = 16): Teeth with endodontic treatment, and presenting gutta-percha and CMP, from which 8 were artificially fractured and 8 did not present any fracture.

Root canals were instrumented with NiTi files Protaper Universal (Dentsply-Maillefer), motor driven. The apical prepare of the teeth was carried with F3 file. The rotating instruments were used with X-Smart (Dentsply-Maillefer). The chemomechanical preparation was carried with 2.5% NaOCl, non manipulated, as irrigating substance.

Eight teeth, from each group, were artificially fractured. Dies[11] were made to adapt the teeth; then, the teeth were fractured. Roots were isolated with Vaseline and involved with lead sheets with Vaseline, obtained from the envelopes of radiographic films. Then, were included in self-polymerizing acrylic resin (Jet), and vertically adapted. After this, the roots were removed, thus opening a space similar to an alveolus. The lead sheet was then removed from each root, and inside of the artificial alveolus was inserted a molding material silicon-based to simulate the periodontal ligament. The roots were immediately placed back to the alveolus and, after condensation silicon polymerization

After the repair of all the specimens, vertical root fractures were induced.[11-16]

The specimens were adapted in a special metallic device, Kratos testing machine, positioned in the inferior part of the machine. Another metallic device was positioned in the superior part of the testing machine, and a digital spacer D (Dentsply Maillefer) was adapted to this device to pressure it and promote the fractures on the teeth. The force application point was directly on the access opening of the root canal for all teeth. Teeth underwent a progressive compression effort, at 1.0mm/mim speed. After starting the machine, the superior part moved downward, so that the spacer were introduced in the root canal. The load was increasing gradually, until the fracture occur. In this moment, occurred a sudden drop of the force and the machine was turned off to finish the test. In almost every specimen it was heard a crack in the fracture moment. The mean force used in the fracture moment was 14.3 kgf.

The root canals of Groups 2 and 3 were filled by the single-cone technique, using the gutta-percha F3 cone and Sealer #26 cement (Dentsply-Maillefer).

For the CMP, the teeth of Group 3 were used. A #4 Gates-Glidden drill was used to removing the remaining filling material, preserving only the 5 mm of gutta-percha filling the root apex, in order to let the root canal prepared to receive the CMP. For the Duracast CMP, the direct technique was used, where the acrylic resin (Duralay) produced a copy of the root canal, being then forward to the prosthetic lab to be molded. The posts were positioned in each teeth and cemented with zinc phosphate cement.

For the tomographic images, the teeth were placed in the empty alveolus of a dry human mandible. For each tomographic carried out, four teeth were randomly placed in the mandible. In order to simulate the soft tissue, the teeth were placed in the alveolus with utility wax and the mandible was immersed in a recipient with water.

The sample was scanned with a Prexion 3D (90kV, 4mA, 5 cm of FOV, 37 seconds of acquisition). The software used for image analysis was PrexViewer. The data was exported in DICOM format, 0.1 mm voxel size. The data was reconstructed with sections on sagittal, coronal and axial planes, and the obtained images were analyzed by a radiologist with 10 years of experience in CBCT. All the images were analyzed in a computer with a LED, 27" monitor, in a dark room. The observer was questioned on presence or absence of fractures in a dichotomous scale (fractured/not fractured teeth).

RESULTS

Results were evaluated by absolute and percentage distribution for obtaining percentage measures of: Sensibility, false negatives, specificity, false positives, positive predictive value, negative predictive value and accuracy. To evaluate the difference between groups regarding accuracy, sensibility and specificity, Fisher's exact test was used. The margin of error was set in 0.5% of the statistical test.

Table 1 presents the results of sensibility, false negatives, specificity, false positives, positive predictive value (PPV), negative predictive value (NPV) and accuracy. Table one emphasized the sensibility variance of 62.5 to 87.5%, in corresponding groups from 5 to 7 cases of fractured teeth, according to the answer of the evaluator. The lowest specificity occurred in teeth with CMP (37.5%), and it varied from 75.0% to 87.5% on the other two groups. Accuracy was of 56.3% in the group of teeth with CMP, and varied from 75.0 to 81.2% in the gutta-percha and control groups, respectively. It is important to emphasize the high percentage of false positives for the Group 3 (62.5%).

Table 2 is presenting the results of comparative tests between groups, regarding sensibility, specificity and accuracy, for the margin of error at 0.5%. No significant difference was observed between the 3 groups, regarding any of the analyzed measures ($p > 0.05$).

Discussion

Periapical radiographs are not reliable methods to carry out diagnosis of VRF, and CBCT allow the detection, localization and extension of fractures accurately.

Table 1. Values for sensibility, false negatives, specificity, false positives, positive predictive value, negative predictive value and accuracy. Answer of the evaluator regarding the fracture occurrence, for each group.

Group	Evaluated parameter	n	%	Basis for calculating
Control (without gutta-percha and without CMP)	Sensibility	7	87.5	8
	False negatives	1	12.5	8
	Specificity	6	75.0	8
	False positives	2	25.0	8
	PPV	7	77.8	9
	NPV	6	85.7	7
	Accuracy	13	81.2	16
Teeth with gutta-percha	Sensibility	5	62.5	8
	False negatives	3	37.5	8
	Specificity	7	87.5	8
	False positives	1	12.5	8
	PPV	5	83.3	6
	NPV	7	70.0	10
	Accuracy	12	75.0	16
Teeth with CMP	Sensibility	6	75.0	8
	False negatives	2	25.0	8
	Specificity	3	37.5	8
	False positives	5	62.5	8
	PPV	6	54.5	11
	NPV	3	60.0	5
	Accuracy	9	56.3	16

Table 2. Comparative tests results between groups, regarding Sensibility, Specificity and Accuracy.

Group	Sensibility		Specificity		Accuracy	
	n	%	n	%	n	%
Control	7	87.5	6	75.0	13	81.2
With gutta-percha	5	62.5	7	87.5	12	75.0
With CMP	6	75.0	3	37.5	9	56.3
Basis for percent by group	8		8		16	
P value	p (1) = 0.837		p (1) = 0.162		p (1) = 0.375	

Obtained results of the present study shows that CBCT is a tool with accuracy to diagnosis the VRF, corroborating with several authors.[14-20]

Through the high values obtained for sensibility, specificity and accuracy, mainly regarding the control group, this research proves the efficacy of CBCT technology in diagnosing these fractures. Despite the values for sensibility, specificity and accuracy being lower than in group 2 and 3, there was no significant difference between the values found in the 3 groups. However, the presence of radiopaque material inside the root canal, such as gutta-percha and the CMP, hindered the interpretation of the CT scans.

These results are similar to the ones observed in other studies,[14] but disagree with others, 18 in which was presented good efficacy of CBCT for detection of VRF only in Control group teeth, being verified only 75% of accurate results in the CMP teeth group. A recent work[15] have shown sensibility and specificity values regarding control and gutta-percha groups similar to the values found in this present research.

This same work showed a significant difference in sensibility and accuracy of CT scans between teeth of both groups, corroborating its results with the present ones. However, there was a significant reduction on specificity ($p = 0.016$) of images regarding the teeth filled with gutta-percha, diverging from the present results, in which the values for it was not reduced.

In clinical researches,[17,19] it was concluded that the presence of gutta-percha on root canals did not influenced significantly the sensibility, specificity and, consequently, accuracy on VRF diagnosis, thus, showing that even with this filling material, CBCT is able to precise VRF diagnosis. These *in vivo* research results corroborate with the ones found in the present *ex vivo* study.

Conclusion

1) Accuracy in diagnosing VRF by CBCT with Prexion 3D was higher in teeth without the presence of gutta-percha cones and CMP.

2) Teeth with CMP presented higher percentage of false positives.

3) There was no statistical significant difference between the 3 groups as for the accuracy, sensibility and specificity on diagnosis of VRF.

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