Original Article

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EFFECT OF DIFFERENT INTRA-CANAL POST MATERIALS ON DETECTION OF ROOT FRACTURES USING CONE-BEAM COMPUTED TOMOGRAPHY

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ABSTRACT:

Aim: The aim of the present study was to test the accuracy of cone-beam computed tomography (CBCT) in detecting simulated root fractures (RF) in endodontically treated teeth with different post and cores.

Materials and Methods: Forty maxillary central incisors without any defects were randomly divided into four groups (n=10) according to type of posts; Group A (Cast), B (Fiber-reinforced composite post, FRC), C (Hybrid composite), and D (Control, without any post). Except teeth in group D, all of the samples were endodontically treated and prepared for post restoration. Using a reference FRC post and core, cast post and core and core build-up in group C were completed. In group C, hybrid composite were placed directly into post space. All of the samples were prepared for standard metal crowns considering 2mm of ferrule in their preparation. To simulate clinical situation, teeth were mounted in 135° angulation. A universal testing machine was used to fracture the teeth. Then, the CBCT scans were obtained and three oral and maxillofacial radiologists assessed the images for presence of root fractures. The data were analyzed using IBM SPSS 20.0 (IBM Corp., Armonk, NY, USA).

Results: there was no significant difference among four groups. the lowest sensitivity was for group A and B. Kappa coefficient for first and second observer was 0.972+-0.0391 and for third observer 0.876+- 0.0391 ($p>0.05$).

Conclusion: Within Limitations of this *in vitro* study, different post materials had no significant effect on diagnostic abilities of CBCT in detecting RFs.

Keywords: Cast post and core, cone-beam computed tomography, endodontically treated teeth, Fiber-reinforced composite, Intra-canal post, root fracture, upper central incisor

INTRODUCTION:

Root fractures (RFs) usually have poor prognosis that is affected by various factors such as degree of dislocation and distance between fragments.[1] One of the major causes of RF is post placement in endodontically treated teeth.[2] Post are often used in endodontically treated teeth with the extensive structural loss. Different materials have been used for post and core restorations such metallic

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and FRCs. Metallic and cast posts are traditionally used for this purpose, but they have some disadvantages such as RF due to stress concentration in roots.[2] Other post materials such as FRC posts have been introduced because of recent advancements in bonding technologies and similar rigidity to dentin. [3]Their clinical application has been recommended to reduce catastrophic RFs.[4]

In order to prevent damage to surrounding tissue, early definitive diagnosis of RF plays an important role. Their detection presents a dilemma because of lack of definitive identifying features. Detection of RFs is challenging, and clinicians use both clinical (osseous defect, pain, sinus tract) and radiographic (direct and indirect) clues for the diagnosis of RF. The presence of the radiolucent line is a direct radiographic feature that necessitates passage of x-ray beam along the fracture line. Periodontal ligament widening, periapical or periradicular rarefactions are indirect radiographic signs that help diagnosis of the RF. Conventional two-dimensional radiographic can only show one-third of these fractures.[5] Several studies confirmed the high accuracy of conventional computed tomography (CT) in diagnosing RF.[6,7] Some of its limitation such as the high radiation dose in comparison to conventional dental radiography, artifacts, and relatively low spatial resolution[8] has led to the development of CBCT.

The intra-canal metallic post can create metallic artifacts in CBCT scans. These artifacts can seriously deteriorate the diagnostic ability of these images.[9] The aim of the present study was to test the accuracy of CBCT in detecting simulated RFs (horizontal and vertical).

MATERIAL AND METHODS:

Teeth selection: Prior to conducting the study, the research protocol was approved by the Institutional Ethical Committee (Ref. No. 2744). Forty human maxillary central incisors without fracture, root resorption, or any other anomalies were collected. The teeth have not undergone any restorative or root canal treatment. The teeth were inspected under stereomicroscope (20x, SMP-200, HP, USA) to confirm the absence of vertical RF. After cleaning the teeth from tissue and calculus's using hand scaler, they were randomly divided into four groups: Group A (Cast post and core), Group B (FRC post and core), Group C (Composite post and core), Group D (Control group without any post). All of the samples were kept in distilled water at 37° C.

Endodontic treatment and post space preparation: Clinical crowns of 30 teeth were cut at 14mm using a low-speed saw (TC-3000, Vafaei Industrial CO., Tehran, Iran). Root canals treatment was performed following a standardized crown-down techniques using Protaper Universal (Apical size 30) (Dentsply Maillefer, Ballaigues, Switzerland. The root canals were filled with the gutta-percha (DiaDent, Incheon, Korea) by lateral condensation technique using eugenol-free root canal sealing material (AH 26, Dentsply DeTrey,Konstanz, Germany).

Gutta-percha was removed using heated hand plugger. The post spaces were prepared using drill size 1 from the fiber-reinforced composite post system (Exacto N°1, Angelus, Londrina, PR, Brazil), according to manufacturer's instructions. All roots were uniformly prepared 9 mm deep from the flat coronal surface to leave at least 5 mm gutta-percha apically. In group A, teeth were restored with cast post and core (Group A=10; Damcast np, damcast dentalloy corporation, Zhengzhou, China). In group B, FRC post (Group B= 10; Exacto N°1, Angelus, Londrina, PR, Brazil) were used with hybrid composite (Clearfil Photocore, Kuraray Medical, Okayama, Japan). In group C, the post space and core build-up were restored by direct hybrid composite (Clearfil photocore). In group A and B, posts were cemented using Panavia F2.0 (Kuraray Noritake Dental Inc., Kurashiki, Okayama, Japan).

Teeth were restored either with cast post and core (Group A=10; Damcast np, damcast dentalloy corporation, Zhengzhou, China), fiber-reinforced composite post (Group B= 10; Exacto N°1, Angelus, Londrina, PR, Brazil) and direct hybrid composite(Group C= 10; Clearfil Photocore, Kuraray Medical, Okayama, Japan).

All of the samples were restored with similar metal crowns (Damcast np) and were cemented using glass ionomer cement (GC Corporation, Tokyo, Japan).

Sample mountings and simulation of fracture: Teeth were placed in cylindrical auto-polymerizing acrylic (Acropars, Marlic Co, Tehran, Iran) with 135° vertical angulations. To simulate biologic width, 2mm apical to crown the margin were not covered with acrylic. To simulated clinically teeth fracture, a compressive load in a universal testing machine (K – 21046, Walter +bai, Löhningen, Switzerland) at a crosshead speed of 1 mm/min were applied. Then, Fragments were glued to each other as close as possible.

CBCT scans: Teeth were scanned using Newtom 5G (QR s.r.l., Verona, Italy) set at 110 kV. NNT viewer software version 3.0 (QR s.r.l., Verona, Italy) were used to evaluate axial and multi-planar reformation (MRP) images. The slice thickness and the interval space was 0.3 mm. Three oral and maxillofacial radiologists examined scans in axial and MPR planes in a low-light room by using a Flatron 18.5-inch monitor (LG, Seoul, Korea). All of the teeth were examined for presence or absence of RF.

Statistical analysis: Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likelihood ratio (LR+, LR-) with 95% confidence interval were analyzed based on evaluation of at least two observers for each tooth. The kappa coefficient was used to assess the agreement among all the observers. P value less than 0.05 were considered significant. All the analyzes were done using IBM SPSS ver. 20.0 statistical software (IBM Corp., Armonk, IL, USA).

RESULTS:

The Specificity was 100% in all groups of the present study. The results showed that the sensitivity of RF in group D (Control without post) and group C (composite) were higher than group A (cast) and B (FRC). The PPV in all of the groups was 100%, and the NPV in group C, and D were higher than the groups A and B (Table. 1).

The kappa coefficient for the first and second observer were 0.972+-0.0391 ($p>0.05$), and for third observer had 0.876+- 0.0391 ($p>0.05$). The diagnostic parameters for each observer are shown in Table 2. The kappa coefficient for each pair of groups has been listed in Table 1. Fracture patterns of different groups are shown in figure 1.

DISCUSSION:

The aim of this study was to assess the diagnostic ability of CBCT in detecting RF in compromised endodontically treated teeth (ETT) restored with different post and cores. Previously, CBCT has been reported as superior modality compared with periapical radiographs in detecting endodontic complications such as RF, root resorption, and fractured instruments.[10-12] Three-dimensional visualization of structures allows more rigorous analysis of region while overlapping structure in two-dimensional images obscure details necessary for definitive diagnosis.[13-15] However, one of CBCT limitation is discrepancies between the mathematical modeling and the actual imaging process that results in artifacts.[16] In case of metallic restorations, artifacts can be problematic in the visualization of RF.[17-19] In this situation, periapical radiographs with different horizontal angulations might be necessary. [20]

Beam hardening is a major source of metallic artifacts.[21] It causes the edges of the metallic object to be brighter than its center, which forms bright hyper-dense streaks in the image. Diagnostic ability of analyzed region on CBCT images are reduced to these artifacts. Although, CBCT reduces number of metallic artifacts, their total elimination is still not possible.[21,22]

Metallic posts are used commonly in ETT but their higher modulus of elasticity than tooth structure and post space preparation lowers root strength. Both of these factors predispose the tooth to more fractures. Fiber-reinforced composites were introduced more than 20 years ago.[23] Continuous advancements in adhesive technologies and similar rigidity of these posts to tooth structure have made these posts popular among clinicians. They reduce catastrophic RF by distributing loads along the root structure. These posts can appear radiolucent or radiopaque. In the present study, FRCs were radiopaque. Radiopacity can affect CBCT images. Thus, this study attempts to find any significant effect on RF identification when these posts are used. When comparing the accuracy of CBCT in detecting RF among four groups, there was no significant difference between any pair of groups. Although observers could not detect two fracture in FRC (group B) and three fractures in cast posts (group C) using CBCT images. ETT with cast post compared to other groups' accuracy of CBCT reduced which is consistent with other studies,[20,18,17,19] but it was not significant.

In our study voxel size was 0.125µm with 0.3 mm slice thickness which both can affect quality of CBCT images.[13] It is shown that the smaller the slice thickness is, the higher spatial resolution of CBCT scans which consequently affect diagnosis.[24] Conflicting results have been reported regarding the effect of voxel size on the diagnostic ability of CBCT images. While some studies found no significant difference between voxel of different thickness,[20] others reported reduction in both sensitivity and the accuracy of images with greater voxel thickness.[17,19]

Cast post resulted in lower specificity values than other groups. This is consistent with previous studies that confirm the presence of radiopaque filling materials can affect the accurate diagnosis of RF. [20,25,13] This could be the result of artifacts generation with streaking lines. An optical illusion, which is called contrast effect, produces hyperdense lines that are more dense than normal. This can be visually confusing with fracture lines. This explained the false-positive response of observers when there was no actual fracture.

The thickness of fracture line, depending on the level of fragment separation, affects its visualization in CBCT images. Fracture lines with greater thickness can be identified more accurately.[26] In our study, we repositioned fragment to their exact location in all groups, thus fracture line thickness were similar in all groups. Teeth that were fractured in more than two fragment and fragments that could not be repositioned completely were excluded from the study, [17,18,20]., and replaced with new sample following methodology explained above. We tried to simulate clinical fracture pattern in upper central incisors with different post and core restoration. In clinical situation it is critical to select an effective modality for diagnosis of RF which exposes patients to the least radiation dose.[19] Since CBCT exposes patients to higher radiation dose than periapical radiographs, it is recommended to use periapical radiographs with different horizontal angulations before CBCT in diagnosis of RF. [20]

In the present study upper central incisors were restored and angulated in 135°, simulating the clinical situation. Also, 2mm of ferrule height and biologic width has been simulated to simulate fracture commonly happens in a clinical situation with different restorations. In the clinical situation diagnosis of RF may be associated with clinical and radiographic feature such as periodontal space widening, radiolucent lesion around the root, and pain on chewing. Such features cannot be simulated *in vitro* studies which are a limitation of these studies. Although *in vivo* study would have been more realistic conducting this type of studies, it is not ethical to expose human subjects to multiple radiation exposures. Thus, conducting *in vitro* study can give an insight into the clinical situation.

The result of this study confirms CBCT as a reliable alternative in diagnosing RF. Also, this study showed that radiopaque filling materials affect the diagnosis of RF, although it was not significant. Thus clinician should take periapical radiographs with different horizontal angle primarily for diagnosis of RFs. If this method failed to give a conclusive diagnosis, CBCT offers a useful alternative.

CONCLUSIONS:

Within Limitations of this *in vitro* study, different post materials had no significant effect on diagnostic abilities of CBCT in detecting RFs.

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FIGURE:

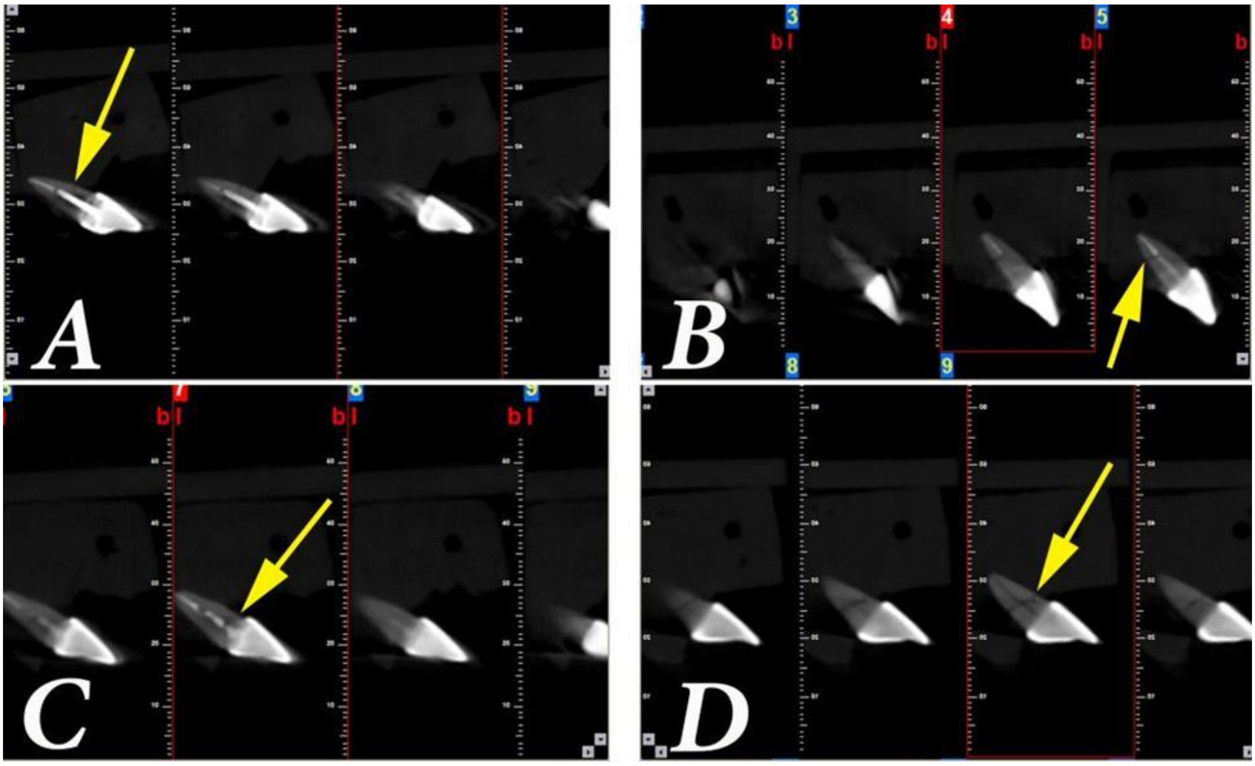

Figure 1. Root fractures detected using CBCT in Group A, B, C, and D. Yellow arrow shows the root fracture.

TABLES:

Table 1. Comparison of diagnostic parameters between different groups (n=10).

groups	Sensitivity	specificity	PPV	NPV	LR+	LR-	Kappa Coefficient
A - B	76%(61 to 100)	100% (100 to 100)	100% (100 to 100)	77% (70 to 100)	0	.24(0.12 to 0.33)	0.692±0.05
A - C	83% (72 to 100)	100% (100 to 100)	100% (100 to 100)	89% (81 to 100)	0	0.19 (0.1 to 0.28)	0.846±0.04
A - D	79% (65 to 100)	100% (100 to 100)	100% (100 to 100)	83% (76 to 100)	0	0.2 (0.12 to 35)	0.796±0.05
B - C	86% (74 to 100)	100% (100 to 100)	100% (100 to 100)	85% (79 to 100)	0	0.11 (0.06 to 0.21)	0.841±0.04
B - D	88% (80 to 100)	100% (100 to 100)	100% (100 to 100)	91% (85 to 100)	0	0.07(0.04 to 0.16)	0.901±0.03
C - D	98% (85 to 100)	100% (100 to 100)	100% (100 to 100)	99% (89 to 100)	0	0.04(0.01 to .15)	0.972±0.03

Table 2. Comparison of diagnostic parameters between different observers

Groups	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Observer 1	93 %(89 to 98)	100 %(100 to 100)	100 % (100 to 100)	95 % (90 to 98)	1.85 (0.76to3.5)	11.7(8to27)
Observer 2	81%(75to90)	100 % (100 to 100)	100% (100 to 100)	95% (90 to99)	14.37(10 to 25.7)	3.5(0.8 to 12)
Observer 3	93 %(89 to 98)	100 % (100 to 100)	100 % (100 to 100)	95 % (90 to 98)	1.85 (0.76to3.5)	11.7(8to27)