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Diagnostic Value of Cone-Beam Computed Tomography and Digital Periapical Radiography in Detection of Separated Instruments

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ABSTRACT

Introduction: File Fracture is one of the most common problems during root canal treatment which can affect treatment procedure and prognosis, so it is important to diagnose and prevent it. The aim of this study was to evaluate and compare the diagnostic value of cone-beam computed tomography (CBCT) and digital periapical radiography for detection of separated instrument retained inside the canal. **Methods and Materials:** Ninety single-rooted extracted human teeth were selected and randomly divided into 3 groups (*n*=30). Group 1, separated file #10 at the 2-mm apical third of the root canal; group 2, separated file #35 at the 2-mm apical third of the root canal; and group 3, without a broken file (control group). The teeth were instrumented to size #30 and were shaped to size #55 and then the canals were obturated up to separated instrument, or the working length for the teeth without a separated instrument, with lateral condensation technique. After that all teeth were placed in dry skull, digital radiography and CBCT was taken. After data collection, data was analyzed using SPSS software by means of sensitivity, specificity, positive and negative predictive values, and frequency tables. **Results:** Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of digital periapical radiography in detection of a fractured file #10 in the canal was 96.7% and 63.3%, 76.7%, 73.1%, 67.6%, 70%, for CBCT, respectively. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of digital periapical radiography in detection of a fracture file #35 in the canal was 93.3%, 96.7%, 96.6%, 93.5% and 95%, and 36.7%, 76.7%, 61.1%, 54.8%, 56.66%, for CBCT, respectively. **Conclusion:** Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of digital periapical radiography was better than the CBCT technique in both sizes of broken files.

Keywords: Broken File; Cone-Beam Computed Tomography; Digital Radiography; Separated Instrument

Introduction

Broken file in the root canal is among the problems that may occur during endodontic treatment and can compromise the prognosis of treatment by reducing the possibility of root canal cleaning [1-4]. In this manner, the treatment options include extracting the file, leaving the file in the canal, continuing treatment to the coronal level of the file, bypassing the file, and apical surgery [1, 2, 5, 6].

Diagnosis of a file broken in canal is an important goal in pre-treatment evaluations, because the presence of this broken instrument can reduce the ability of root canal cleaning and root strength, as well as increasing the risk of perforation [3, 7]. On the other hand, diagnosis of the remaining segment can be difficult and challenging in a canal that is filled up to the surface of the file due to the same radiographic contrast of the broken instrument and filling material [7-10]. The use of cone-beam computed tomography (CBCT) imaging is suggested in complex endodontic treatment [11-15]. However, existing studies on the use of CBCT in diagnosing the remaining broken files in the apical third of the root canal are limited and the results are inconsistent [13, 16]. The purpose of this study was the evaluation and comparison of the diagnostic value of CBCT and digital periapical radiography (DPR) in detection of separated instruments retained inside the apical third of extracted single-canal human teeth.

Materials and Methods

For this experimental study, 90 extracted single-canal human teeth were obtained. Periapical radiography was taken and teeth without internal absorption, external absorption, previous root canal treatment, fracture or perforation were selected. An access cavity was made with diamond bur #016 for each tooth. The working length was calculated by passing a #10 K-file (K-file, DiaDent, Seoul, Korea) to the apical foramen and then pulling the file back to the apical foramen. The teeth were then randomly divided into 3 groups: group 1-broken file #10, group 2-broken file #35 and group 3-control group (no broken file inside the canal).

In the first group, a groove was made on the last 2 mm of the file #10 (K-file, DiaDent, Seoul, Korea) by a diamond fissure bur #010 (Tees Kavan, Tehran, Iran). Then the file was inserted into the canal and rotated counterclockwise until the file was broken. To ensure fracture of the file during operation, periapical radiography was taken. In the next step, canal cleaning and shaping was performed by step-back method. Also, circumferential filing, with the aid of reciprocating movement up to 0.5 mm shorter than the working length was conducted. Cleaning was done up to file# 30 (K-file, DiaDent, Seoul, Korea), and flaring was performed up to file #55 (K-file, DiaDent, Seoul, Korea). In the second group, after working length determination, the canal cleaning was performed by step-back method up to file #30 (K-file, DiaDent, Seoul, Korea), a groove was made on the last 2 mm of the file #35 (K-file, DiaDent, Seoul, Korea) by a diamond fissure bur. Then the file was inserted into the canal and rotated counterclockwise until the file was broken. To ensure file fracture during operation, periapical radiography was taken. Then the canal was shaped using the step-back method up to the file #55 (K-file, DiaDent, Seoul, Korea). In the third group, after working length determination, root canal cleaning was done up to file #30 (K-file, DiaDent, Seoul, Korea) and the root canal shaping was performed up the file #55 (K-file, DiaDent, Seoul, Korea) by step-back method. In all 3 groups, the canal was rinsed by 1 mL of 5% sodium hypochlorite solution between instruments. Then, all samples were obturated with gutta-percha (Meta BioMed Co., Ltd, Cheongju city, Chungbuk, Korea) and AH-26 sealer (Dentsply DeTrey GmbH, Konstanz, Germany) by lateral condensation method. All samples were placed in dry skull, and covered with two layers of boxing wax to reconstitute soft tissue. Two digital periapical radiography and CBCT images were taken from all sample by the following details: A) Periapical digital radiography was taken using Planmeca device (Planmeca, Helsinki, Finland) with exposure conditions of 60 kVp, 8 mA and 0.100 sec. The sensor used was manufactured by DurrDental (Bietigheim-Bissingen, Germany). Radiation was perpendicular to the longitudinal axis of the tooth and from the buccolingual dimension. B) CBCT radiography image was taken using Planmeca device (Planmeca, Helsinki, Finland) with exposure conditions of 64 kVp, 6 mA, 12 sec, 320 µm voxel size and 250×250×250 image size. Volume reconstruction was done by the Romix viewer software (Planmeca, Helsinki, Finland).

Periapical and CBCT images were coded and reviewed by an endodontist and radiologist, and a coefficient of agreement was made between them. The radiologist was not aware of the results reported by the endodontist and the study was blind. The results were evaluated for sensitivity, specificity, and positive and negative predictive value. Data was analyzed using the SPSS software (Statistical Package for Social Science, SPSS, version 22.0, SPSS, Chicago, IL, USA) by means of sensitivity, specificity, positive and negative predictive values and frequency tables.

Results

In this study, 90 extracted single-rooted teeth were divided into 3 groups. Sensitivity, specificity, positive and negative predictive value and accuracy of DPR and CBCT were investigated in detecting intracanal broken files.

Table 1. Sensitivity, specificity, positive and negative predictive value and diagnostic accuracy of digital periapical radiography (DPR) and CBCT in detecting broken files #10 and #35 intra canal (%)

	K-file #35		**K-file #10**	
	CBCT	**DPR**	**CBCT**	**DPR**
Sensitivity	36.7	93.3	63.3	96.7
Specificity	76.7	96.7	76.7	96.7
Positive predictive value	61.1	96.6	73.1	96.7
Negative predictive value	54.8	93.5	67.6	96.7
Diagnostic accuracy	56.66	95	70	96.7

The coefficient of agreement between two observers for periapical digital imaging in detecting the broken files #10 and #35 was 96.7% and 95%, respectively. For CBCT, the detection of broken files #10 and #35 was 70% and 56.66% respectively, which indicates that the agreement between observers is higher in periapical digital radiography. The Kappa for DPR was 0.933 and 0.900 for detection of #10 and #35 files, and in CBCT, for the detection of #10 and #35 files was 0.400 and 0.133, respectively.

As shown in Table 1, the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of digital periapical radiography in detecting the broken file #10 in the apical third of canal for all indices were 96.7%, and for CBCT, were 63.3%, 76.7%, 73.1%, 67.6% and 70% respectively. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of digital periapical radiography in detecting the broken file #35 in the apical third of canal were 93.3%, 96.7%, 96.6%, 93.5%, and 95%, respectively, and for CBCT , were 36.7%, 76.7%, 61.1%, 54.8%, and 56.66%, respectively.

Discussion

The results of this study showed that all diagnostic values of DPR are higher than CBCT. Diagnosis of broken files in filled root canals is a clinical challenge, because in the clinical condition, anatomical features such as superimposition of soft and hard tissue and artifacts can mimic or mask a broken file and reduce the ability to detect broken files [6, 8, 17, 18]. The American Association of Endodontists and the American Academy of Radiology have endorsed the use of CBCT in non-surgical retreatment to assess the effects of endodontic treatment for *e.g.* broken file [13]. The use of CBCT in examining the broken file in the canal is not yet studied extensively.

Very limited studies are available for soft tissue simulation in CBCT. Various materials are used to reconstitute soft tissue including water, wax, acryl, self-polymerization resin, paraffin polyethylene, and plexi-glass. Wax can be considered as a reliable method for simulating the soft tissue. Because dental wax sheets are available in all dental schools and it's easy and inexpensive to work with them [12]. In this study wax was used as soft tissue simulator.

In the study by Rosen *et al.* [7], the sensitivity and specificity of CBCT in detecting broken file in the apical third of canal was lower than intra-oral radiography. Ramos Brito *et al.* [19] showed that in the absence of filling materials were no statistical differences between DPR and CBCT in terms of diagnosis of broken file; but in presence of filling materials the accuracy of DPR is significantly higher than CBCT images.

One of the main reasons for lower ability of CBCT to detect an intracanal broken file in comparison with the DPR is the higher induced radiation dose and artifacts which occur in the CBCT method [12-14, 20, 21]. It has been reported that intracanal metal materials and non-metallic fillers of the canal cause artifact in CBCT [11]. CBCT may produce significant artifacts, especially when there is a high density material in the scanned volume that may affect the diagnostic effectiveness [20]. Studies have shown that the presence of metal posts inside the canal absorb radiation and create artifacts which reduces the image clarity, as well as increasing false positive results [22]. On the other hand, the presence of gutta-percha within the canal may lead to sensitivity and specificity reduction of CBCT. The type of materials used to obturate canal and their relative radiopacity, as well as the CBCT parameters, such as the size of voxel and the FOV, sometimes affect the presence and intensity of the artifacts. The artifact of filling materials in CBCT is much wider and more significant than periapical radiography, and significantly reduces the CBCT diagnostic effectiveness [10].

Conclusion

According to the results of the present study, and considering the limitations of *in vitro* studies, it seems that all of the diagnostic indexes in periapical digital radiographic were higher than CBCT, and thus, in diagnosis of intracanal broken file, digital radiography was more efficient than CBCT.

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