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# Conventional and digital radiography in vertical root fracture diagnosis: a comparison study

## Maryam Tofangchiha<sup>1</sup>, Mahin Bakhshi<sup>2</sup>, Hoorieh Bashizadeh Fakhar<sup>3</sup>, Mehrdad Panjnoush<sup>3</sup>

<sup>1</sup>Faculty of Dentistry, Department of Oral Radiology, Qazvin University of Medical Sciences, Qazvin; <sup>2</sup>Faculty of Dentistry, Department of Oral Medicine, Shahid Beheshti University of Medical Sciences, Tehran; <sup>3</sup>Faculty of Dentistry, Department of Oral Radiology, Tehran University of Medical Sciences, Tehran, Iran

Correspondence to: Mahin Bakhshi, Department of Oral Medicine, Faculty of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran Tel.: +98 21 22403010 Fax: +98 21 22403194 e-mail: mahinbakhshi@yahoo.com

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Abstract - Background: Vertical root fractures (VRFs) can only be detected by radiography. In recent years, direct digital dental radiography (DDR) has become a substitute to film-based radiography. Purpose of this study was to compare accuracy and reliability of charge couple device (CCD)-based direct digital radiography with conventional radiography (CR) in VRF diagnosis. Methods and Materials: In this in vitro study, 230 extracted single-rooted human teeth were endodontically instrumented. VRFs were performed experimentally in half of the samples. Each tooth was imaged using the paralleling technique with E-speed film and a CCD-based digital image receptor. Two oral radiologists interpreted the images and repeated the procedure a month later with half of the samples. The accuracy, sensitivity, and specificity of each technique were determined. The reliability and degree of agreement were also determined by the means of Cohen's Kappa analysis.  $\chi^2$  test was used to compare two observers' diagnosis, considering the location of fracture line. Results: The accuracy of CR and DDR was 65% and 70% retrospectively. The sensitivity was 60% for CR, 61% for DDR and the specificity was 70% for CR, 78% for DDR, but the differences were not significant. The interobserver reliability was moderate for CR (K = 0.366, 95% CI) and fair for DDR (K = 0.538, 95% CI). Conclusion: No significant difference was seen between the two techniques. The specificity of DDR was slightly better than CR, and their accuracy and sensitivity showed small differences.

Direct digital imaging systems are popular in medical occupations because of their convenience, but many investigations showed that their image resolution is lesser than film-based radiography (1–4). Some investigators reported little or no significant differences between direct digital (DDR) and conventional radiography (CR) in caries and periapical lesions detection and bone loss estimation (5–9) while in some other reports the differences were obvious (9–16).

One of the major problems in dental clinics is vertical root fracture (VRF) diagnosis. The patient may complain of pain and tenderness during mastication but the fracture line is usually delicate and difficult to perceive in radiographs. Few studies have performed to compare DDR and CR in the diagnosis of VRF. Kositbowornchai et al. compared the CR and DDR (Sidexis) in root fracture diagnosis with in vitro studies and found no significant differences (17, 18). Youssefzadeh et al. (19) determined the sensitivity and specificity of CR in VRF diagnosis. Langen et al. (20) assessed the relative efficacy of conventional and digital storage radiographs for detection of skull fractures and found no significant differences. These authors also evaluated the effect of varying exposure parameters on the detect ability of a fracture with both techniques and stated that a reduction of approximately 35% appears to be possible without any resulting loss of image quality compared to CR (21).

The aim of this study was to determine the percent accuracy and reproducibility of a charge couple device (CCD)-based direct digital radiography and CR in VRF diagnosis.

# Materials and methods

Two hundred and thirty extracted single-rooted human teeth with closed apices were used in this experimental in vitro research study. Fractured, internal or external resorbed, and acutely curved roots were excluded. Recently extracted teeth were disinfected and preserved in 4°C-distilled water. The crowns were removed 2 mm above the CEJ with a paper disk. The roots were mounted in red compound impression material with the coronal and apical ends uncovered and the buccal surfaces marked with ink. The root canals were prepared with file numbers 15-45. The teeth were numbered and divided into two groups: a control group with no fractures of 115 teeth and a test group of 115 with fractures. VRFs were induced as described by Monagham et al. (22). A number 45 finger spreader formed conical wedge shape by a bur was driven into root canal apically until there was a sharp 'cracking' sound.

Radiographs of each tooth were obtained in the facio-lingual view using the parallel technique. All radiographic exposures were made with Planmeca dental

X-ray unit (Planmeca, Finland) at 63 kVp, 8 mA. The exposure time for CR and DDR was 0.16 s and 0.1 s, respectively. The focus-object distance was 20 cm, and the objects were positioned on the receptor with their long axis parallel to the surface of the receptor. Conventional film images were recorded on Kodak E speed No2 periapical film (Eastman-Kodak Co, Rochester, NY, USA) and processed manually for 15 s at 22°C with Teifsaz chemicals (Teifsaz, Tehran, Iran) as recommended by the manufacturer. The digital images were obtained with a fifth generation RVG CCD receptor (Trophy, France).

Conventional radiographs, mounting in a random order, were examined by two observers who had more than 10 years experience in dental radiography. They had no prior knowledge about the distribution of the fractured teeth. A view box and a magnifier glass were accessible in a dark silent room with unrestricted observation time. The presence or absence of a fracture line was recorded. The same procedure was carried out for the digital images using Trophy viewer software (Trophy, France) on a 17" SVGA monitor. The observers were allowed to magnify the digital images and adjust the density and contrast at will. Examples of typical images with both systems are shown in Figs 1 and 2. Observers repeated the evaluation one month later with half of the samples.



*Fig. 1.* Radiograph showing image of a vertical root fracture in the film–based image.



*Fig. 2.* Radiograph showing the image of a vertical root fracture in the direct digital image. The arrow indicates the fracture line.

The percent accuracy as well as reliability for each technique and each observer was calculated. The means of observers' values were accepted as technique accuracy, sensitivity, and specificity. The degree of agreement in detecting root fractures with each technique and observer was calculated using Cohen's Kappa statistics. We used  $\chi^2$  test to compare two observers' diagnosis considering location of the fracture line, buccal or lingual, and proximal.

#### Results

The sample size was 230, half intact and half vertically fractured. In 51 cases, the fracture line was buccally or lingually positioned, where in 64 cases, it was in the proximal surfaces, mesial or distal, of the root.

Tables 1 and 2 show the degree of agreement with reality for root fracture detection by CR and DDR. The average sensitivity, specificity, and percent accuracy were 60%, 70%, and 65% for CR and 61%, 78%, and 70% for DDR.

There was moderate agreement between DDR and actual condition showed by Cohen Kappa Value (K = 0.391, 95% CI) and CR and actual condition (K = 0.3, 95% CI). The level of agreement for DDR was slightly better; however, the difference was not statistically significant.

The intraobserver reliability for CR was evaluated as fair for the first observer (K = 0.515, 95% CI) and moderate for the second observer (K = 0.439 95% CI). The intraobserver reliability for DDR was excellent in both observers (K = 0.750, 95% CI). The interobserver reliability was moderate for CR (K = 0.366, 95% CI) and fair for DDR (K = 0.538, 95% CI).

*Table 1.* The number of root fractures correctly detected from conventional radiographs by two observers

	Conventional radiograph	Actual condition		
		Fractured	Intact	Total
First observer	Fractured	83	50	133
	Intact	32	65	97
	Total	115	115	230
Second observer	Fractured	55	20	75
	Intact	60	95	155
	Total	115	115	230

*Table 2.* The number of root fractures correctly detected from digital radiographs by two observers

		Actual condition		
	Digital radiograph	Fractured	Intact	Total
First observer	Fractured	75	30	105
	Intact	40	85	125
	Total	115	115	230
Second observer	Fractured	66	20	86
	Intact	49	95	144
	Total	115	115	230

*Table 3.* Percent distribution of correct diagnosis for two observers considering the location of fracture line

	Diagnosis			
	Buccal or lingual		Proximal	
	Conventional	Digital	Conventional	Digital
	%	%	%	%
First observer	82	86	64	48
Second observer	88	76	30	42

The location of fracture line seemed to have some effects on the correct diagnosis. Table 3 shows percent distribution of correct diagnosis by two observers considering the location of the fracture line. Results of  $\chi^2$  test showed that both observers diagnosed the buccal or lingual fracture lines much better than proximal ones using each technique and the difference was significant (P < 0.05).

#### Discussion

The evaluation of techniques showed that radiography is first and foremost specific method with acceptable accuracy in VRF detection.

This study compared two radiographic systems, direct digital and conventional film based for their efficacy in detecting experimental root fractures. Statistical analysis showed no significant difference between the two. The specificity of DDR was slightly better than CR, and their accuracy and sensitivity showed small differences. The interobserver and intraobserver reliability was also a little bit better for DDR.

There are a number of limitations with an *in vitro* study compared with actual clinical situation. Because there is no bone and soft tissue, the X-ray direction and angulation is fixed and the fractures were induced experimentally, the results may vary from reality. Occasionally, root fractures may elude detection immediately after injury because of hematoma and edema, which can decrease the radiographic contrast. Youssefzadeh et al., (19) after an *in vivo* study on VRF diagnosis, reported the sensitivity of CR as 23%. Because root fractures are not accessible to clinical examination in the same way as other lesions, the agreement between CR and DDR in our study was high enough to conclude that as diagnostic tools they perform equally well.

Intraoral film is capable of providing more than  $20 \text{ lp mm}^{-1}$  resolution. Current digital systems are capable of providing 7 lp mm<sup>-1</sup> of resolution. In spite of this fact, the level of agreement with the digital and film-based system was nearly the same in our study. White and Pharoah (23) stated that this is obviously because of the image magnification possibility in DDR software, which enables the observer to detect more details in the image.

Kositbowornchai et al.(17) also declared no significant differences between Sidexis CCD receptor and film-based images. This finding showed that, roughly speaking, RVG and possibly all the CCD-based products have a same capability. Kositbowornchai also stated that fractures would be missed if the X-ray beam does not pass through the fracture line and multiple radiographs may be needed (17). We experienced this in our study, when the observers were unable to detect fracture lines in the proximal surfaces of the roots.

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#### Conflict of interest

All financial and personal relationships which might bias the interpretation of the work have been fully disclosed.

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