Comparison of digital with conventional radiography in detection of vertical root fractures in endodontically treated maxillary premolars: an ex vivo study

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Objective. The purpose of the present study was to compare the diagnostic ability of conventional intraoral film radiography and a charged-coupled device (CCD) sensor in detecting vertical root fractures (VRF) in endodontically treated single-rooted extracted human maxillary premolars.
Study design. The study consisted of 60 extracted single-rooted endodontically treated maxillary premolars: 30 with clinically confirmed VRF (experimental group) and 30 with no VRF (control group). An intraoral CCD sensor and conventional Kodak Insight Film were used. Two observers evaluated the digital and conventional radiographs twice with an interval of 4 weeks. Specificity and sensitivity for each radiographic technique were calculated and subjected to statistical analysis. Kappa values were calculated for intra- and interobserver agreement. Fisher's exact test was used to evaluate detection of VRF. The overall differences in sensitivity and specificity between radiographic techniques were evaluated by McNemar test.
Results. The specificity of the digital system was significantly better ($P = .016$) for the second observer at the first reading. There were no significant differences in sensitivity and specificity for both observers between the 2 systems for other readings ($P > .05$).
Conclusions. No difference was found between the intraoral CCD sensor and conventional radiography in detecting vertical root fractures for single rooted maxillary premolars ex vivo. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:124-8)**

Maxillary premolars and mesial roots of mandibular molars are the most often endodontically treated vertically fractured teeth and roots.[1-7] A vertical root fracture (VRF) is mostly a bucco-lingual–oriented fracture, which is difficult for the clinician to detect on conventional periapical radiographs. Occasionally, a hairlike fracture line can be seen as a radiolucent line separating the root segments when oriented parallel to the x-ray beam or at a 4-degree angle to either side.[8] In the early stages in which subtle cracks are present with no separation of the adjacent segments and segments of the fractured root superimpose one another, fractures are usually undetectable in routine conventional radiography.[9] Radiographic detection usually depends on either the actual separation of the 2 segments, or on the more typical bony radiolucencies around these teeth. The bony lesions can be seen as a "halo" lesion, perilateral radiolucency, and angular resorption of the crestal bone, combined with diffuse or defined, but not corticated borders.[4] Early detection of fractured teeth is vital to prevent extensive damage to the supporting tissues.[4,5,8] One of the most important factors in radiographic detection of VRF is image quality. Today, various digital imaging modalities are available.[10] It is possible to digitally acquire, enhance, store, retrieve, and transfer radiographic information with a reduced radiation dose compared to conventional film.[11,12] Digital radiographic systems often use sensors containing a charge-coupled device (CCD) or complementary metal oxide semiconductor (CMOS)

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chips[12] that produce an image as an array of pixels displayed instantly on a computer monitor.[13]

The purpose of the present study was to compare the diagnostic ability of conventional intraoral film radiography and a digital CCD sensor in detecting VRF in endodontically treated single-rooted extracted human maxillary premolars.

MATERIALS AND METHODS

The study consisted of 60 extracted endodontically treated single-rooted human maxillary premolars: 30 with VRF without separation of the segments that were clinically confirmed with dental operating microscope after extraction (experimental group) and 30 with no vertical root fractures (control group). The reasons for the extraction of maxillary premolars with vertical root fractures were the typical signs of VRF, when at least 2 of the following clinical symptoms were present: coronally located sinus tract, deep osseous defect, and typical peri-radicular radiolucency.[3] Each tooth was coated with a layer of wax and mounted in a plaster box. All images were exposed with a Gendex Oralix 65S X-Ray (Gendex Medical Systems, Monza, Italy) operated at 65 kVp and 7.5 mA with a focus-object distance of 20 cm. A direct digital intraoral CCD sensor (Sopix, Sopro Imaging, Acteon Group, La Ciotat Cedex, France) size 1 offering 1.25 million pixels, pixel size 22 μm × 22 μm with a resolution of 20 lp/mm (line pairs per millimeter), and conventional Kodak Insight Film (Eastman Kodak Co, Rochester, NY), E/F sensitivity, size 2 were used. Both were exposed buccolingually in ortho-radial, mesio-radial, and disto-radial projections with a 15-degree horizontal angle shift (Fig. 1).

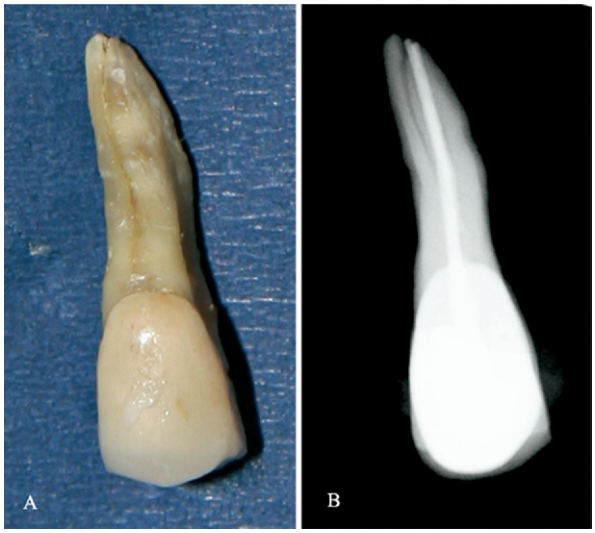

Fig. 1. Extracted maxillary premolar with vertical root fracture: clinical (**A**) and radiographic (**B**) images.

Exposure time was 0.4 seconds for conventional radiographs and 0.25 seconds for the CCD system. Films were processed automatically by PerioMAT Plus machine (Dürr Dental, Bietigheim-Bissinger, Germany) according to the manufacturer's instructions.

Two observers separately evaluated the digital and conventional radiographs to detect the presence of the fracture lines simultaneously from the 3 projections. If a fracture line was clearly discernable in any of the projections, the observer classified the tooth as having VRF. Each observer evaluated the images twice with an interval of 4 weeks to eliminate memory bias and to calculate intraobserver agreement. Observation time was not restricted. Conventional radiographs were evaluated at random against a light box (Rinn Co, Elgin, IL). Observers used a magnifying glass (×2.5) on each occasion that the film was viewed.

In another session, digital radiographs were evaluated randomly on a computer screen (IBM 15-inch high-quality monitor) with screen resolution set at 1024 × 768 pixels and color set to a 16-bit depth using image evaluation software (Sopropix). Observers were allowed to use image-enhancement features of the software such as zoom, brightness, contrast, density, and color inversion.

Fracture assessments were categorized as true-negative (correct identification of a nonfractured root), true-positive (correct identification of fracture site in a fractured root), false-positive (identification of a fracture in a nonfractured root), and false negative (no identification of a fracture in a fractured root). Specificity and sensitivity for each radiographic technique were calculated.

Kappa values were calculated for intra- and interobserver agreement. Fisher's exact test was used to evaluate detection of VRF with conventional film and digital images according to the gold standard. The overall differences in sensitivity and specificity between the radiographic techniques were evaluated by McNemar test.

RESULTS

For the first and second readings, the first observer identified 16 and 15 VRF, respectively, out of 30 VRF cases with intraoral CCD, and 9 and 11 VRF, respectively, out of 30 with conventional x-ray film. The second observer detected 12 and 15 VRF with intraoral CCD and 11 and 14 with conventional film.

Kappa values for the first observer were 0.571 (digital) and 0.625 (film), and for the second, 0.799 (digital) and 0.543 (film). Kappa values between the observers