Radiographic Identification of Separated Instruments Retained in the Apical Third of Root Canal–filled Teeth

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Abstract

Introduction: The aim of the study was to compare the diagnostic ability to radiographically detect separated stainless steel (SS) versus nickel-titanium (NiTi) instruments located at the apical third of filled root canals with either AH 26 (Dentsply DeTrey GmbH, Konstanz, Germany) or Roth sealer (Roth International Ltd, Chicago, IL). **Methods:** Sixty single-rooted extracted human teeth with 1 straight root canal were instrumented to a size 25 apical diameter. In 40 teeth, apical 2-mm segments of SS (n = 20) or NiTi (n = 20) files were intentionally fractured in the apical part of the root canal. The remaining 20 teeth without fractured files served as a control group. Subsequently, the root canals were filled using laterally condensed gutta-percha and either AH 26 sealer (AH) or Roth sealer (Roth). All teeth were radiographed using conventional Kodak film (Eastman Kodak Co, Rochester, NY) and a charge-coupled device digital sensor. The evaluation of the images for the presence of a fractured instrument was performed independently by 2 blinded observers. The data were statistically analyzed using McNemar and Fisher exact tests. **Results:** The kappa values were 0.76 and 0.615 for the first and second observers, respectively, and 0.584 between the observers. There were no significant differences in the diagnostic ability between digital and conventional radiography or the different root canal sealers (AH vs Roth, $P > .05$). The sensitivity to detect fractured SS was significantly higher than NiTi ($P < .05$). **Conclusions:** It may be difficult to radiographically detect a retained separated instrument. It is easier to radiographically detect fractured SS than NiTi instruments retained at the apical third of the root canal. *(J Endod 2014;40:1549–1552)*

Key Words

Complication, radiography, root canal–filled teeth, separated instrument

Endodontic instruments, manufactured from either nickel-titanium (NiTi) or stainless steel (SS), might separate during root canal treatment (1–3). The retained fragment may affect endodontic treatment prognosis if it compromises the achievement of the treatment goals by preventing adequate canal preparation, disinfection, or obturation (1).

In case of an endodontic retreatment procedure, a separated instrument retained in the canal at the initial root canal treatment also bares a medicolegal risk if not diagnosed preoperatively because its presence inside the canal might be attributed to the clinician performing the retreatment (4).

The management alternatives for separated instruments include leaving the separated instrument in the canal while endodontically treating and sealing the more coronal parts of the canal; bypassing the instrument and incorporating it into the root filling material; retrieving the instrument; or, when indicated, applying an alternative retrograde endodontic surgery to achieve the endodontic treatment goals (1, 5, 6).

When an endodontically treated tooth is scheduled for retreatment, the diagnosis of a previously retained separated instrument located at the apical third of a root canal is particularly important for the treatment plan because it might be difficult to retreat the canal while retrieving or bypassing the instrument because of the risks for the integrity of the tooth (7, 8). Thus, based on the preoperative diagnosis, other treatment alternatives should be considered, including endodontic surgery (5, 6). Furthermore, the radiographic diagnosis of a segment of a separated instrument in the apical third of a canal that was filed to the level of the instrument may be challenging because of the continuous radioopaque appearance of the instrument and the filling material within the canal (9–12). In addition, the effects of the material compositions of the separated instrument (9, 13, 14) and the root canal filling (10–12, 15) on the radiographic diagnostic ability to detect the instrument in the vicinity of the root canal filling are not fully elucidated.

The purpose of the present study was to compare the ability to radiographically detect separated SS versus NiTi instruments located at the apical third of root canals filled with either AH 26 (AH) (Dentsply DeTrey GmbH, Konstanz, Germany) or Roth (Roth International Ltd, Chicago, IL) sealers in extracted human teeth.

Materials and Methods

Single-rooted extracted human teeth were radiographed from the buccal and proximal directions using digital x-ray (GendexOralix 65S X-Ray; Gendex Medical Systems, Monza, Italy) and a direct digital intraoral charge-coupled device (CCD) sensor (Schick Technologies, Inc, Long Island City, NY). Teeth with 1 straight root canal with a curvature of less than 5° were included (16). Teeth with previous endodontic

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2014.07.005

treatment, root caries, root perforation, root resorption, or visible fractures or cracks were excluded.

The selected teeth were prepared as follows: a standard endodontic access was achieved using round burs, and the coronal third of the canal was flared with Gates Glidden drills size #2–#4 (Dentsply Maillefer, Ballaigues, Switzerland). The canal length was determined by placing a #10 K-file through the canal space until it could be visualized exiting the apical foramen at 3× magnification. The working length was determined by subtracting 1 mm from the canal length. Teeth without patency were excluded.

After inclusion and exclusion, 60 teeth were selected. The root canals were instrumented to size #25 with hand K-files (Mani Inc, Takanezawa, Japan) using a balanced-force technique (17). The canals were irrigated with 2 mL 4% sodium hypochlorite (Vetec; Sigma-Aldrich Israel Ltd, Rehovot, Israel) between all instruments, and apical patency was maintained with a size #10 file throughout the instrumentation. After instrumentation, a final irrigation was performed using 5 mL EDTA 17%, and the canals were dried with paper points.

The prepared teeth were randomly divided into 2 groups: simulation of a file separation during root canal instrumentation ($n = 40$) and a control group ($n = 20$). In order to simulate file separation, a groove was prepared using a high-speed bur on an SS K-file #30 ($n = 20$ teeth) or an NiTi K-file #30 ($n = 20$) (NiTi Flex, Dentsply Maillefer) at 2 mm from the tip of the file. Then, the files were inserted to the working length and rotated counterclockwise until the separation of the apical segment occurred. The teeth were then radiographed to ensure that the separation occurred at the working length.

The canals were obturated to the separated instrument or the working length for the teeth without a separated instrument (18). The teeth were divided into 6 subgroups of 10 teeth each as follows:

1. Separated SS + root canal filling to the separated instrument with laterally condensed gutta-percha (GP) and AH
2. Separated NiTi + root canal filling to the separated instrument with laterally condensed GP and AH
3. Separated SS + root canal filling to the separated instrument with laterally condensed GP and Roth
4. Separated NiTi + root canal filling to the separated instrument with laterally condensed GP and Roth
5. Root canal filling to the working length with laterally condensed GP and AH
6. Root canal filling to the working length with laterally condensed GP and Roth

The teeth were then radiographed using both digital and conventional radiography, each from 2 projections: buccolingually in orthoradial projection and a distoradial projection with a 15° horizontal angle shift. The images were exposed with a GendexOralix 65S X-Ray (Gendex Medical Systems, Monza, Italy) operated at 65 kVp and 7.5 mA with a focus-object distance of 20 cm. For digital radiography, a direct digital intraoral CCD sensor was used, and for conventional radiography, a conventional Kodak Insight Film (E-speed; Eastman Kodak Co, Rochester, NY) was used.

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

Two experienced endodontists (I.T. and C.F.) were initially calibrated using representative teeth (with or without a separated instrument) that were not included in the experiment. The images were encoded, and the evaluators were blinded to the presence of a fractured instrument in the canal. The evaluators separately evaluated the radiographs using images from the 2 projections simultaneously.

Each observer evaluated all the images twice with an interval of 4 weeks between each evaluation to eliminate memory bias and in order to calculate intraobserver agreement. The observation time was not restricted.

Conventional radiographs were evaluated in random order against a light box (Rinn Co, Elgin, IL). Observers used a magnifying glass (×2.5) on each occasion that the film was viewed.

The digital radiographs were evaluated in random order on a computer screen (SyncMaster 245BW 24-inch LCD Monitor; Samsung, Seoul, Korea) using image evaluation software (CDR DICOM-5; Sirona; Schick Technologies, Long Island City, NY). Observers were allowed to use the image enhancement features of the software (19).

The identification of the presence or absence of a fractured instrument as determined by the evaluators was categorized as either "true-negative" (correct identification of the absence of a fractured instrument), "true-positive" (correct identification of the presence of a fractured instrument), "false-positive" (identification of a fractured instrument in a tooth without a fractured instrument), or "false-negative" (no identification of a fractured instrument in a tooth with a fractured instrument).

The evaluation results were recorded and submitted to statistical analysis; kappa values were calculated for intra- and interobserver agreement evaluations. The diagnostic ability (specificity and sensitivity) for the detection of a separated instrument was calculated for the various settings, and the effects of the imaging modality (conventional or digital), the instrument type (SS or NiTi), and the sealer type (AH or Roth) were calculated using McNemar and Fisher exact tests. A probability of $P = .05$ was used as the level of significance.

Results

In total, 82.2% of the separated instruments were identified by the observers. The average kappa values were 0.76 and 0.615 for the first and second observers, respectively (considered as good to moderate degrees of agreement). The kappa value between the observers was 0.584 (considered as a moderate degree of agreement) (20).

There was no difference between the diagnostic abilities of conventional and digital radiographs in the detection of a separated instrument at all settings ($P > .05$). There were no significant differences in the diagnostic ability between the different root canal sealers (AH vs Roth) ($P > .05$). The sensitivity to detect fractured SS files was significantly higher than for NiTi files ($P < .05$) (Table 1).

Discussion

During case selection and treatment planning of root canal–treated teeth with apical periodontitis, it is essential to evaluate the ability to achieve effective disinfection of the root canal system and the prevention of recontamination (21). This preoperative evaluation should be based on a meticulous preoperative diagnosis supported by thorough medical history evaluation, clinical examination, and good-quality radiographs (22–27). Preoperative data collection is the basis for understanding the true condition of the tooth and for the detection of potential hazards and treatment difficulties, such as a retained separated instrument. Thus, it allows a rational decision-making process regarding the treatment alternatives and treatment plan (1, 4, 27).

The reported prevalence of separated endodontic instruments is inconsistent and variable (1, 3). A controversy also exists on whether the type of instrument (NiTi vs SS or hand vs rotary endodontic instruments) affects the risk of file separation (1, 3, 8, 28). However, it seems that in many of the cases, instrument separation results from the inappropriate use and overuse of endodontic instruments (1–3, 7, 8, 18, 28–30).