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Evaluation of an Ultrasonic Technique to Remove Fractured Rotary Nickel-Titanium Endodontic Instruments from Root Canals: Clinical Cases

Jeff R. Ward, BDS, Peter Parashos, MDSc, and Harold H. Messer, MDSc, PhD

The removal of fractured rotary nickel-titanium instruments from small, curved root canals is one of the most complex operative procedures in endodontics. There have been many different devices and techniques developed to remove fractured instruments, but none are consistently successful and all show a high incidence of canal damage such as perforation. A technique using a staging platform and the use of modern ultrasonic tips with direct visualization through a dental operating microscope has recently been evaluated. The use of this technique in clinical practice is described in 24 cases and illustrated by 3 cases.

The removal of broken instruments from the root canal in most cases is difficult and often hopeless (1). No standardized procedure for successful instrument removal exists. Many techniques and devices have been tried—predominantly with fractured hand instruments (1–4). These techniques are time-consuming, have limited success, and impart considerable risk to narrow and curved canals.

The success of nonsurgical fractured instrument removal from root canals depends on several factors. Among them are the length and site of the fragment, the diameter and curvature of the root canal, and the friction and impaction of the instrument fragment into the canal wall (1). Rotary nickel-titanium instruments tend to be more difficult to remove than hand instruments. This is because they generally fracture at a smaller length, further apically, at or around the curve of narrow canals than hand instruments. Because of their rotational motion, they tend to be wound in and impacted in the canal walls, occluding the entire canal lumen.

Instruments located in the straight portion of the canal can usually be removed (5). When a fractured instrument lies partially around the canal curvature, but the coronal aspect can still be visualized and accessed, then removal may or may not be possible. If the entire segment of the broken instrument is apical to the curvature and safe access with visualization is not possible, then nonsurgical removal usually cannot be accomplished (5).

CPR® ultrasonic tips (Obtura-Spartan Corp., Fenton, MO) have been developed recently for use in the Spartan® piezoelectric ultrasonic device (Obtura-Spartan Corp.) to assist in the removal of fractured instruments, among many other uses. Five zirconium-nitride–coated and three titanium CPR tips, in various lengths and configurations, are available. The manufacturers state that these tips are uniquely designed to operate at a specific amplitude and frequency to maximize the safe removal of fractured instruments from root canals. A technique is described that uses modified Gates Glidden burs to platform to the coronal aspect of the fractured instrument, then dry ultrasonic troughing around the fragment to expose it, followed by the ultrasonic vibration of the fractured instrument segment with irrigating solution. A dental operating microscope is used for direct visualization of the fractured instrument at all times during the use of this technique.

Instrument Removal Procedure

The technique used to attempt removal of the fractured instrument segment in each of these cases is an adaptation of the ultrasonic technique described by Ruddle (6) and reported in our previous study (7). This technique is recommended by the instructional video accompanying the Spartan piezoelectric ultrasonic unit.

Success of Instrument Removal

Twenty-four clinical cases involving fractured rotary nickel-titanium instruments were treated. As with our experimental study (7), the location of the fractured instrument segment and the success of the instrument removal procedure were recorded. All fractured instruments that were located before or at the curve were successfully removed in less than 45 min, with only one of nine fractured instruments removed beyond the curve (Table 1). In all of the successfully removed cases, the canal could be negotiated beyond the "staging platform," and preparation and obturation to the radiographic terminus was completed. No perforations occurred with the successful or the unsuccessful removal cases. If the coronal portion of the fractured instrument was not visible using a dental operating microscope after coronal and radicular enlargement, fractured instrument removal procedures were not attempted and the canal was prepared to the instrument segment and dressed

TABLE 1. Success of fractured instrument removal with respect to the position of the instrument fragment around the curve

Location	Clinical Cases	
	Removed	Not Removed
Before the curve	6	0
At the curve	9	0
Beyond the curve	1	8
Total	16	8

with calcium hydroxide for 4 weeks and then obturated. This applied to eight cases (Table 1).

CASE REPORTS

Case 1

A 44-yr-old female was referred to the Endodontic Unit, Royal Dental Hospital of Melbourne, for the orthograde endodontic retreatment of her maxillary right first molar and endodontic assessment of the second premolar in the same quadrant. The first molar was asymptomatic with the radiograph showing root-filling material in only the distobuccal canal (Fig. 1A). On examination, the second premolar had a deficient distal restoration with recurrent caries. Extraction of the premolar was recommended because of the hopeless restorative prognosis. Hence, the restorative treatment plan involved the retreatment of the first molar and the extraction of the second premolar with the provision of a three-unit bridge replacing the second premolar.

Orthograde retreatment of the first molar was commenced with removal of the gutta-percha root filling from the distobuccal canal with rotary nickel-titanium instrumentation without solvent. Greater Taper™ (Dentsply/Tulsa Dental, Tulsa, OK), rotary nickel-titanium instruments were used to prepare the coronal and middle portions of each canal. ProFile® .04 taper instruments (Dentsply Maillefer, Ballaigues, Switzerland) were then used to enlarge the apical third of each canal. ProFile instruments were used sequentially from 15/.04 to 25/.04 to working length in the mesiobuccal canal, but 2.5 mm of the ProFile 25/.04 fractured at the curve in the apical third of the mesiobuccal canal during the apical enlargement. A check radiograph and 8× magnification with the dental operating microscope showed the instrument segment was at the curve (Fig. 1B).

Because the instrument segment could be visualized and the coronal aspect was in the straight portion of the canal, removal of the fractured instrument was attempted. The fractured instrument segment in this case was successfully removed (Fig. 1C). The removal procedure took approximately 30 min from the beginning of platforming until the instrument segment was removed. The mesiobuccal canal was then negotiated to the radiographic terminus with small precurved stainless-steel hand files and was prepared to an apical size 35/.04 ProFile to the working length. Root canal preparation and obturation of all canals was completed using .04 taper gutta-percha (Dentsply Maillefer) and AH 26® sealer (Dentsply DeTrey GmbH., D-78467 Konstanz, Germany), and a cuspal coverage amalgam overlay was placed (Fig. 1D). The extent of the mesiobuccal canal enlargement from the platforming was evident in the final parallel radiograph. The canal was enlarged toward the mesial wall where space was created to lift the fractured instrument segment off the mesial wall.

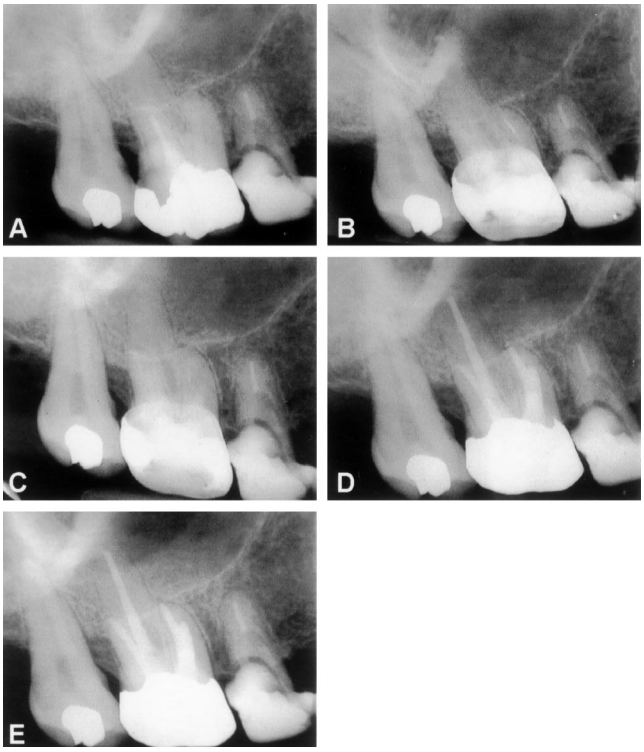

FIG 1. (*A*) Preoperative radiograph of maxillary right second premolar and first molar. The second premolar was not restorable and extraction was recommended. The first molar appears to be previously endodontically treated with root-filling material evident in the distobuccal canal only. (*B*) 2.5-mm segment of fractured ProFile size 25/.04 at the curve in the apical third of the mesiobuccal canal of the maxillary first molar. (*C*) Complete removal of the fractured instrument segment from the mesiobuccal canal and removal of the root-filling material from the distobuccal canal. (*D*) Completed endodontic treatment. Full cuspal coverage amalgam overlay placed. The enlargement of the mesial aspect of the mesiobuccal canal by the instrument removal procedure. (*E*) 12-month review. Patient awaiting a specialist prosthodontic appointment for provision of a bridge to replace the maxillary right second premolar.

At 12-month recall, the maxillary first molar was asymptomatic with a review radiograph showing no evidence of periapical pathosis (Fig. 1E). This patient is still on the waiting list with the specialist prosthodontic department for the provision of the bridge replacing the second premolar. This premolar is asymptomatic and will be extracted nearer to the time of bridge preparation.

Case 2

A 54-yr-old male presented for the removal of a fractured instrument and continuation of endodontic treatment of the mandibular left first molar. The history indicated and the radiograph showed a 2.5-mm segment of a #2 (30/.06) ProFile orifice shaper at mid-root level in the mesiolingual canal (Fig. 2A). This tooth was asymptomatic with radiolucencies evident at the mesial and distal root apices. The fractured instrument segment could be seen using 8× magnification with the dental operating microscope. The fractured segment was removed in approximately 20 min (Fig. 2B). All canals were negotiated with small stainless-steel hand files and then prepared with ProFile rotary nickel-titanium instruments to working length and obturated with .04 taper gutta-percha and AH

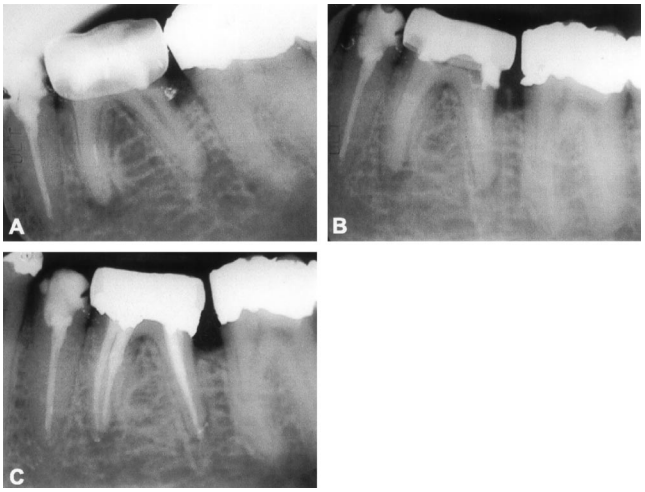

FIG 2. (*A*) Mandibular left first molar with 2.5 mm of a #2 (30/.06), ProFile orifice shaper, fractured in the mesiolingual canal. (*B*) Fractured instrument segment removed. (*C*) Final obturation, showing the extent of widening of the mesiolingual canal after platforming and file removal.

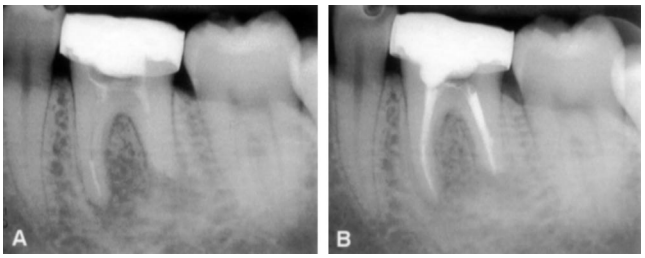

FIG 3. (*A*) Mandibular left first molar with evidence of considerable inflammatory root resorption. A fragment of a ProFile 30/.04 is lodged in the apical third of the mesiolingual canal. (*B*) Final obturation, showing file segment incorporated within the obturation. Patient to return to referring dentist for final restoration.

26 sealer. An amalgam core was placed and the patient was sent to the referring dentist for the final restoration (Fig. 2C).

Case 3

A 26-yr-old female was referred for endodontic treatment of the mandibular left first molar. This tooth presented with a buccal draining sinus and radiographically showed extensive apical external inflammatory root resorption. A ProFile 30/.04 instrument fragment, approximately 3.5 mm in length, was lodged in the apical third of the mesiolingual canal (Fig. 3A). After coronal and radicular enlargement, Gates Glidden platforming was performed. The fractured segment was almost entirely around a distobuccal curve in the canal and only the most coronal aspect could be seen with the use of the dental operating microscope. After a 60-min appointment, the fractured instrument segment could not be removed. Instead, the coronal portion of the instrument segment broke off, leaving approximately 3 mm of the fragment remaining. This remaining segment was entirely around the curve and could not be directly visualized. Because the instrument segment could not be seen, further removal attempts were abandoned because it was deemed likely that further attempts could perforate or significantly weaken the mesial root.

The mesiolingual canal was prepared up to the instrument fragment and after the remaining canals were fully prepared, the tooth was dressed with Pulpdent® paste (Pulpdent Corporation, Watertown, MA) for 3 months. At 3-month review, the buccal sinus had healed and some radiographic resolution of the periapical radiolucencies was noted. The mandibular left first molar was then obturated with gutta-percha and AH 26 sealer, and the patient returned to the referring dentist for the final cuspal coverage restoration (Fig. 3B).

DISCUSSION

Several studies have evaluated the influence of various factors on the fatigue life and resulting fracture of rotary nickel-titanium endodontic instruments. Instrument design, rotational speed, torque, operator proficiency, and the angle and radius of canal curvature all have been shown to influence failure of rotary nickel-titanium instruments (8–10).

Management of a case with a broken instrument may involve an orthograde or a surgical approach. The three orthograde approaches are: (a) attempt to remove the instrument; (b) attempt to bypass the instrument; and (c) prepare and obturate to the fractured segment. When these instruments can be removed, successful treatment or retreatment generally occurs. If an instrument can be removed or bypassed and the canal can be properly cleaned and filled, nonsurgical endodontics is the more conservative approach. Although it is possible to remove many of these instrument fragments, a number will not be removable because of limited access caused by fracture around a curve. The broken instrument usually prevents access to the root apex. This can influence the operator's ability to adequately prepare, disinfect, and obturate the entire root canal system.

The position of the fractured instrument has an influence on prognosis. The prognosis is best when there is fracture of a large instrument in the latter part of cleaning and shaping close to the working length. The prognosis is poorer for those canals that have not been cleaned at all and in which a small instrument is broken far from the apex (11). In vital pulp cases, as well as those cases where instrument fracture occurs after thorough instrumentation and irrigation, the chances for failure are less than if instrument fracture occurs in an infected case before significant instrumentation and irrigation have been performed (11). Instrument fracture before completion of instrumentation in an infected tooth results in a high chance of failure (11).

Fors and Berg (11) suggest a treatment schedule for the management of broken instruments that is based primarily on the location of the instrument. Objects in the coronal third can be removed by grasping the object with a file extractor or small pliers. Objects in the middle third of the canal should be bypassed because removal attempts will likely cause excessive enlargement of the canal, weaken the tooth, or lead to perforation. If necrotic pulp tissue remains apical to the instrument in the middle third of the canal and the object could not be bypassed, then removal procedures should be attempted (11). Objects in the apical third should be left in situ, with the canal coronal to the instrument cleaned, shaped, and filled as normal. Attempts to remove or bypass apical fragments are likely to result in root perforation, further reducing the prognosis. Apical surgery, intentional replantation, or extraction are the recommended treatment options if further treatment is required. The underpinning foundation for these recommendations is the amount of canal destruction and damage caused by attempt-

ing instrument removal anywhere but in the coronal third of large, straight canals (11).

The ultrasonic technique described in these case reports was more successful at removing small, fractured, rotary, nickel-titanium segments from narrow, curved root canals than the previous study suggested (11). All cases with fractured instruments situated before or at the curve were successfully removed. The removal of this fractured instrument segment allowed optimal preparation, disinfection, and obturation of the entire root canal system, leading to a favorable long-term prognosis. In cases where the fractured instrument was situated beyond the curve, generally this technique was unsuccessful. A major limiting factor was the ability to safely prepare straight-line access and to visualize the coronal aspect of the fractured instrument segment. All canals where instrument removal was successful could be negotiated subsequently and fully prepared and obturated to the radiographic terminus after the instrument removal procedure.

CONCLUSION

An ultrasonic technique using CPR tips combined with the creation of a "staging platform" using Gates Glidden instruments and the use of the dental operating microscope was consistently successful at removing fractured rotary nickel-titanium instruments from narrow, curved root canals when some part of the fractured instrument segment was located in the straight portion of the canal. When the fractured instrument segment was located entirely around the curve, care must be taken because the success rate is significantly decreased and major canal damage may ensue.

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Dr. Ward is a graduate student in endodontics, Dr. Parashos is Senior Fellow, Department of Endodontics, and Dr. Messer is Professor of Restorative Dentistry, School of Dental Science, The University of Melbourne, Victoria, Australia. Address requests for reprints to Professor Harold H. Messer, School of Dental Science, University of Melbourne, 711 Elizabeth Street, Melbourne, Victoria 3000, Australia; E-mail: hhm@unimelb.edu.au.

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