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Case Report

Retrieval of multiple separated endodontic instruments using ultrasonic vibration: Case report

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الملخص

يهدف هذا التقرير لشرح تدبير حالة معقدة لثلاثة أدوات لبية مكسورة في سن واحدة. راجع مريض عمره ٣٢ عاما، لديه ثلاثة أدوات لبية دوارة مكسورة في الرحى الثانية العلوية اليمنى. تم تحضير درجة الاستناد فوق الجزء العلوي من الأداة المكسورة. ثم تم إزالة العاج حول الجزء العلوي من الأداة المكسورة بواسطة رأس خاص لجهاز الأمواج فوق الصوتية، وذلك بمساعدة التكبير بالمجهر الجراحي السني. وبعد ١١ دقيقة أصبحت الأداة المكسورة مهتزة وتم استخراجها. وباتباع نفس الطريقة تم إخراج الأداة المكسورة الثانية من نفس القناة الجذرية بعد ١٧ دقيقة. بعد ذلك فشلت المحاولة الأولى لاستخراج الأداة المكسورة الثالثة من القناة الجذرية الأخرى. لذلك تمت محاولة المرور بجانبها ولكن المحاولة فشلت. ونتج عن المحاولة الثانية للاستخراج كسر الجزء العلوي من الأداة المكسورة، وبعدها نجحت المحاولة الثالثة للاستخراج بعد ٧ دقائق. يمكن الاستنتاج من هذا التقرير أنه حالما يتم العبور بجانب الأدوات المكسورة يجب إنهاء تنظيف الأقنية الجذرية بمبارد يدوية. كما يجب على الممارس أن يحدد إمكاناته ويأخذ بعين الاعتبار تحويل الحالات التي يصعب عليه التعامل معها. تساعد الخبرة الكافية وتوفر الأدوات المناسبة على تدبير الحالات المعقدة. ويسهم استعمال تقنية الأمواج فوق الصوتية والتكبير بالمجهر السني في الاستخراج الناجح للأدوات المكسورة.

الكلمات المفتاحية: الاهتزاز فوق الصوتي؛ شظايا سنية؛ قمة المجس فوق الصوتي؛ مبرد؛ قناة إنسية شدقية

Abstract

This report describes the management of a complicated clinical case with three instruments fractured in one tooth. A 32-year-old patient presented with three Pro-Taper rotary files fractured in the upper right second molar (S2 and F2 in the disto-buccal canal and S1 in the mesio-buccal canal). A staging platform was prepared in the distal canal coronal to the fragments. Under dental microscope magnification, an Endo-4 ultrasonic tip was activated to dislodge the more coronal fragment (S2) by trephining dentine around the coronal aspect of the fragment. After 11 min, the fragment became loose and was removed. Following the same protocol and using an Endo-5 ultrasonic tip, the second fragment (F2) was removed in approximately 17 min. The first attempt to remove the S1 fragment from the mesio-buccal canal was not successful. An attempt to bypass this fragment using a K-file also failed. A second attempt using the ultrasonic technique resulted in a secondary fracture of the coronal aspect of the fragment. An Endo-5 ultrasonic tip was used to dislodge the fragment, which was successfully removed in 7 min. This report concludes that once a fractured file is bypassed, the instrumentation of a root canal is best completed with hand files. Clinicians should identify their limitations and consider referring cases that are beyond their abilities. Good experience and an appropriate armamentarium enable successful management of complicated cases. Ultrasonic vibration and dental microscope magnification contribute to successful removal of fractured instruments.

Keywords: Complications; Endodontics; Removal; Separated; Ultrasonics

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Introduction

Successful root canal treatments (RCTs) depend on a sequence of procedures. Sufficient cleaning and shaping of the root canal system is essential.[1] However, unpleasant accidents or mishaps, such as fracture of endodontic instruments, may occur during this step. Factors contributing to this unfortunate accident have been identified.[2–5] One of the most important factors is root canal anatomy: the rate of file fractures increases as the radius of the root canal curvature decreases.[6] It is generally accepted that the more endodontic files are used, the greater the likelihood of fracture. Therefore, a single use policy has been highly recommended to reduce files fracture.[7] However, even with a single use, instruments still sometimes fracture.[7] This has been explained by the fact that fracturing of endodontic files is greatly influenced by the way they are used,[4] which, in turn, is affected by the experience and proficiency of the clinician using them. A previous clinical study showed that the most important factor influencing instruments' failure was the operator.[8] This relationship was explained by clinicians' clinical skills or by their decision to use instruments either a specific number of times or until defects were evident.[8] Another important factor is instrumentation procedures and techniques.[3,4] For example, pre-flaring the root canal system by using hand files enables rotary files to be used a greater number of times.[9] Other factors, such as the design and metal composition of instruments, sterilization, using irrigation during instrumentation, and manufacturing process have been found to influence instruments fracture[2,4]. In addition, studies have suggested many kinds of instrument fractures, including fatigue and flexural fracture.[2,4]

Management of fractured endodontic instruments can involve surgical or conservative approaches.[2,10,11] The latter set of options includes attempting to bypass the fractured instrument, attempting to remove it, and instrumenting and obturating the root canal system to the level of the fragment. It is generally accepted that the optimum management strategy is removal of the fractured instrument to enable sufficient debridement of the root canal system. Such an approach is recommended when the clinician has good experience and is competent enough to address such cases,[11] when complications are less predictable and when the tooth is strategically important.[11] Additionally, this approach can be considered when the instrument fracture occurred during the early stages of instrumentation, when the root canal system is not cleaned.[10,11] Nevertheless, before a clinician attempts removing a fractured instrument, the complete armamentarium required for such cases should be available.

Many techniques, devices, instruments and methods have been used in the last several decades. The ultrasonic technique involves generating ultrasonic vibrations that are transmitted to the fractured fragment to loosen it and then move it out of the canal.[12,13] Hand files or spreaders were initially used to transmit the vibration to the fractured instrument.[14–17] However, specially designed ultrasonic tips are currently used.[18,19] Ultrasonic vibration is one of the most common techniques.[20] However, like any other technique, it may be associated with undesired complications, particularly if it is not used carefully.[21–24] Nevertheless, it has been an effective technique, and high success rates have been reported recently.[25,26] Studies have shown that the combination of ultrasonics with magnification provided by a dental operating microscope has made the removal of fractured instruments more predictable.[25,26] Cujé *et al* indicated that one important factor contributing to the high success rate of fragment removal was the use of magnification provided by a dental microscope.[25] Additionally, Nevares *et al* reported a higher removal success rate (85.3%) when the fragments were visualized with a dental microscope compared to when the fragments were not visible,[27] in which case the success rate was a low 47.7%.

Fracture of endodontic instruments may occur even in experienced hands.[28,29]. A previous study showed that the proportion of endodontists who had experienced instruments fracture (94.8%) was significantly greater than that of general dentists (85.1%).[29] Moreover, while the plurality of endodontists had experienced more than 10 fractured instruments, a plurality of general dentists had experienced just 1–5 fractured instruments. However, there are few reports in which more than one instrument fractured within one tooth or even one canal.[17,30] Management of such cases can be more challenging and may entail greater difficulty compared to cases with a single fractured instrument.

The aim of this case report was to describe the management of a complicated clinical case in which three instruments fractured in one tooth using the ultrasonic vibration technique.

Materials and Methods

A 32-year-old healthy male Sudanese patient presented at the General Dentistry clinics at the College of Dentistry, Taibah University, with irreversible pulpitis of the upper left second molar (Figure 1A). Following diagnosis, administration of local anaesthesia and rubber dam isolation, the dentist (a demonstrator) started performing RCT. Following location of three canal orifices (palatal, mesio-buccal and disto-buccal), a size 10 K-file was used to obtain initial canal patency. Cleaning and shaping was performed using the ProTaper rotary system (Dentsply Maillefer, Ballaigues, Switzerland). The clinician started with the SX, S1 and S2 instruments. The root canal system was irrigated during instrumentation using 2.5% sodium hypochlorite after each file use. During instrumentation, the S2 file fractured in the disto-buccal (DB) canal (Figure 1B). The dentist successfully bypassed the fragment using K-files up to size 20 (Figure 1C & D). Then, he started cleaning and shaping the other two canals. While instrumenting the mesio-buccal (MB) canal, the S1 ProTaper file fractured in the apical one-third of the canal (Figure 1E). The dentist became stressed and went back to the DB to complete cleaning and shaping of the DB canal using rotary files. Subsequently, an F2 ProTaper fractured next to but slightly more apically than the previous fragment (Figure 2A). At that point, the dentist referred the patient to the endodontic specialty clinic to be managed by an endodontic specialist (the author).

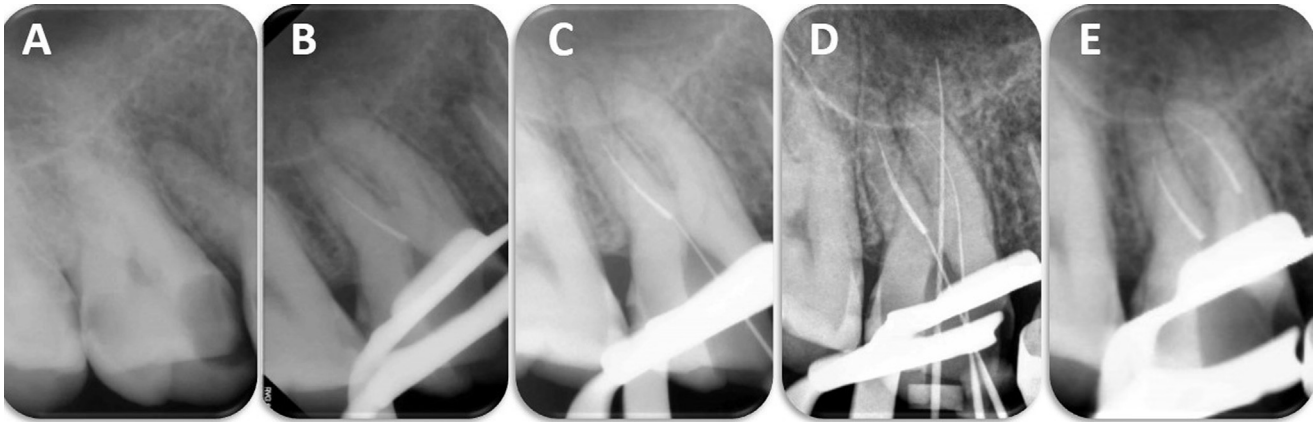

Figure 1: A: Diagnostic radiograph, B: Fracture of the S ProTaper in the DB canal, C: Attempt to bypass the fragment, D: Working length measurement of three canals, E: Fracture of the S1 ProTaper in the MB canal.

A first removal attempt was carried out on the more coronal fragment in the DB canal (S2 fragment). Gates Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland) (No 2 – 4) were modified by cutting the burs perpendicular to their long axis at the maximum cross-sectional diameter.[26] These were used to prepare a *staging platform* coronal to the fractured instrument. This allowed the use of ultrasonic tips to trephine dentine circumferentially around the fragment. Under surgical dental microscope (*Leica Microsystems* Inc. Buffalo Grove, Illinois) magnification (10 and 25×), an Endo-4 ultrasonic tip (Dentsply Tulsa Dental Specialties, Tulsa, Oklahoma) was ultrasonically activated without coolant at a low power-setting (1.5) for about one minute to trephine dentine around the fragment. After each activation, the canal was irrigated with sodium hypochlorite to cool the operating field and flush dentine debris out of the canal. After approximately 11 min, the fragment loosened and came out. Following the same protocol and using an Endo-5 ultrasonic tip, the second fractured file (F2), which was located more apically in the canal, was removed in approximately 17 min (Figure 2B & C). Non-setting calcium hydroxide was inserted as intra-canal dressing, and Cavit restorative material was placed as an inter-appointment temporary restoration.

During the next visit, an attempt to remove the S1 fragment from the MB canal was carried out using the same protocol used to remove the other two fragments. After 20 min, 2 mm of the fragment was exposed, and the fragment became loose, but it would not come out. Therefore, a K-file was used in an attempt first to bypass it and then to engage with it to pull it out by the braiding technique. However, this procedure proved unsuccessful. An X-ray was taken and revealed that the coronal part of the fragment was obstructed by the outer canal walls (mesial walls) (Figure 3A). The Endo-4 ultrasonic instrument was used again to trephine more dentine around the fragment. While doing this, the coronal aspect of the fragment (1 mm) was fractured. After removing this 1 mm piece, the canal was irrigated and dried to visualize the remaining fragment. An Endo-5 ultrasonic instrument (Dentsply Tulsa Dental Specialties, Tulsa, Oklahoma, USA) was used to dislodge the remaining fragment as

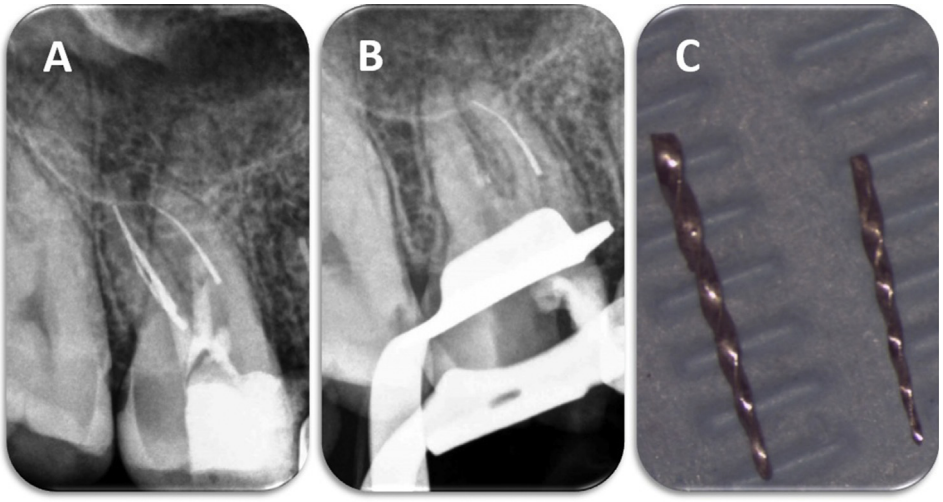

Figure 2: A: A pre-operative radiograph shows fracture of F2 (ProTaper) and S2 in the DB canal and S1 in the MB canal, B: Removal of two fragments from the DB canal, C: Close view of the F2 (left) and the S2 (right) fragments.

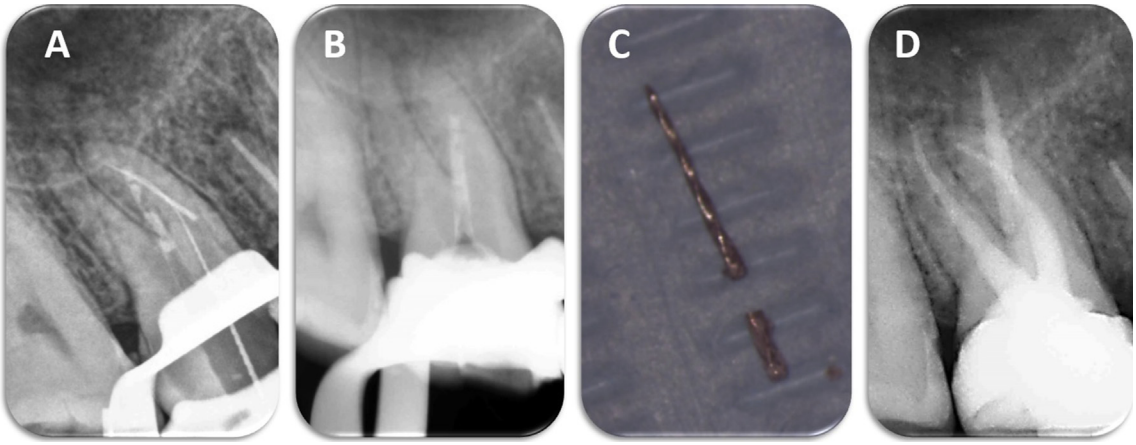

Figure 3: A: an attempt to bypass the S1 fragment with a size 10 K-file, B: Removal of the S1 fragment, C: Close view of the removed S1 fragment showing its secondary fracture into two segments, D: Tooth with canal obturated and intra-canal post in the palatal canal and coronal composite restoration.

described above. After approximately 7 min, the fragment was removed, and an x-ray was taken to confirm the complete removal (Figure 3B & C). Cleaning and shaping of the root canal system was performed using a ProTaper rotary system. Canals were obturated with gutta-percha filling material using the thermoplastic continuous wave of compaction provided by a Calamus unit (Dentsply Maillefer, Ballaigues, Switzerland). The tooth was temporized with light-cured glass ionomer cement (GC Fuji II LC Capsule, GC America Inc, Alsip, IL, US). The patient was referred back to the dentist, who inserted an intra-canal fibre post and composite restoration material (Figure 3D).

Discussion

Many factors may contribute to fracture of endodontic instruments.[2–5] The pre-operative X-ray of the current case showed a reduced space in the pulp chamber and narrow canals, which predispose instruments to fracture (Figure 1A). This necessitated a proper access cavity, straight line access and glide-path preparation, and these factors might not have been fully considered by the referring dentist. Another possible reason for fracture is the presence of pre-use defects resulting from the manufacturing process.[4] This is especially true here because a single use policy applies in College of Dentistry clinics. Operator factors are an important contributor to instruments fracture.[4] It is generally accepted, though there is no evidence, that once a fragment is bypassed, cleaning and shaping of the canal accommodating the fragment is better completed by hand files to avoid further instruments fracture. In the current case, the clinician finished instrumentation of the DB canal using a rotary file. With rotary files, the clinician's tactile sensation can be less than with hand files. Additionally, when a rotary file contacts a metallic fragment while rotating, it becomes more fatigued. The friction between two metallic objects is expected to be greater than that between a rotary file and the dentine of root canal walls.[24] This poor decision (using rotary instruments in a canal accommodating a fragment) may be explained by the pressure the dentist experienced after the second instrument fractured in the MB canal. Consequently, the F2 files fractured in the DB canal (Figure 2A). Nevertheless, the dentist eventually decided to refer the case to a specialist, which is a good option in such a scenario.[11]

Management of fractured endodontic instruments is a delicate and challenging process that is influenced by several factors, such as the strategic importance of the tooth, the presence/absence of periapical diseases, the operator's experience, the available armamentaria, tooth factors, patient factors, and the methods, instruments and techniques used.[11] In addition, each management procedure may be associated with complications that may jeopardize the prognosis of the tooth. Consequently, the clinician should constantly reassess the progress of management procedures and consider alternative treatment options when necessary.

The clinician who first dealt with the current case opted first to attempt to bypass the fractured file. This was a good and acceptable option for many reasons. The clinician had no previous experience removing fractured instruments. Also, the fragment was coronally located and thus easily accessible, to some extent, with hand files, which have fewer predictable complications[11] (Figure 1B & C). In addition, bypassing a fractured instrument fulfils, to great extent, one main objective of RCT: proper cleaning and shaping of the root canal system followed by good obturation. Finally, bypassing a fractured instrument has been considered a successful approach.[2,32–35] However, it was not appropriate to complete instrumentation with rotary instruments. This decision may be due to the dentist's limited experience and the pressure he experienced.

When the case was referred to an endodontist, the author, management options were discussed with the patient, and a decision to attempt at removal was reached. The endodontist had reasonable experience in dealing with fractured instruments. However, this was his first experience dealing with a tooth involving three fragments. The endodontist started with the fragments in the DB canal because they were located more coronally (Figure 2A). For the same reason, he decided to start with the more coronal fragment. As expected, once this fragment had been removed, it was not difficult to remove the second fragment. Both fragments were removed successfully

without complications. Aggressive dentine removal has been reported as one of the most common complications of fragment removal.[16] However, removal of fragments from the coronal one-third of the root canal does not result in significant loss of root substrate[21–23]; this consideration was relevant to the removal of the fragments from the DB canal in the current case. On the other hand, more dentine was prepared when the S1 fragment was removed from the MB canal (Figure 3A). Previous studies had reported significant tooth structure loss associated with the removal of fractured files located more apically in the root canal.[21–23]

Secondary fracture of a separated file or instruments used for removal is another potential consequence of a removal attempt when the ultrasonic technique is used. When ultrasonic tips are activated against canal walls' dentine or a fractured instrument, heat results from the friction of ultrasonic tips and root dentine or the fragment.[24,35] The higher the power settings of the ultrasonic unit, the greater the generated heat.[24,36] Additionally, greater heat is generated with longer activation time.[24,35,36] The clinician treating the current case was careful to activate ultrasonic tips only at a low power-setting (1.5) and for no longer than one minute, as recommended in previous research.[24] However, the coronal 1 mm portion of the segment fractured during the removal attempt (Figure 3C). It is generally known that NiTi instruments are more prone to fracture when the ultrasonic removal technique is used. A recent study reported that temperature increases induced on NiTi fragments' surface as a result of ultrasonic activation were significantly greater than those induced on stainless steel (SS) fragments.[37] Therefore, lower power settings and shorter application times were recommended while removing NiTi fragments compared with those recommended for SS fragments.[37] Nevertheless, the methodologies of all previous reports investigating temperature increases during ultrasonic removal of fractured instruments focused on temperature increases after a single ultrasonic activation rather than multiple activations.[24,35–37] The accumulated impact of temperature increases resulting from multiple activations may contribute to faster fragment fatigue and eventually lead to its secondary fracture. Such an incident or secondary fracture of the ultrasonic tip itself may complicate the retreatment procedure and jeopardize the outcome. In the current case, the fragment shook, but it did not come out because it was long, and the outer root canal walls (mesial) obstructed its movement out of the canal. After the fracture of its coronal 1 mm part, the fragment was successfully removed (Figure 3B & C). Nevertheless, it should be noted that the magnification provided by the surgical dental microscope also contributed to the successful ultrasonic removal in the current case. Dental microscope magnification increased the success rates of ultrasonic removal from the 67% reported by Nagai *et al*[13] to 88% and 95% in more recent reports.[25,26]

Conclusions

Within the conditions of the current case report, the following can be concluded:

- Working under stress may result in secondary procedural errors.
- Once a fractured instrument has been bypassed, cleaning and shaping of the root canal is better completed by hand files.
- Clinicians need to identify their limitations and consider referring cases that are beyond their ability and experience.
- Although dealing with fractured instruments is a challenging process, good experience as well as sufficient armamentarium enable good management.
- The ultrasonic technique and the magnification provided by a dental microscope contribute to successful management of fractured instruments.

Conflict of interest

None.

Authors' contributions

Dr A Madarati is the solo author and contributor of this work. Dr Madarati performed the clinical procedures of this case report related to management of the fractured instruments, reviewed the literature, wrote and revised the manuscript. As Dr Madarati is the solo author, he acted as the corresponding author.

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