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Management of Separated Endodontic Instruments Using Ultrasonics and BTR-Pen® System: A two-case report

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Abstract:

Introduction:

Separation of endodontic instruments is a common procedural complication that can compromise canal disinfection and affect treatment prognosis. While ultrasonic techniques are widely used for fragment retrieval, deeply engaged or difficult-to-access fragments may require adjunctive mechanical systems, such as the BTR-Pen®.

Case Presentation:

This article presents two clinical cases of separated endodontic instruments in molars with complex canal anatomy. In both cases, ultrasonic tips under dental operating microscope guidance were initially employed to mobilize the fragments. When ultrasonic retrieval alone was insufficient, the BTR-Pen® loop system, available in three different loop sizes, was used to securely engage and remove the fragments without excessive dentin removal.

Discussion:

The combination of ultrasonics and loop-based retrieval allowed successful fragment removal while preserving radicular dentinal structure. This approach highlights the importance of careful canal and fragment assessment, proper preparation, and selection of retrieval technique according to fragment position, length, and canal curvature.

Conclusion:

Ultrasonic and loop-based retrieval systems are complementary techniques that provide a predictable and minimally invasive approach for managing separated endodontic instruments. Their combined use can enhance clinical outcomes and maintain tooth integrity in challenging endodontic cases.

Keywords: Endodontic instrument fracture; Ultrasonic retrieval; Loop system; BTR-Pen®; Case report

Introduction:

Instrument Separation is a common clinical challenge during root canal treatment, potentially compromising canal disinfection, limiting apical sealing, and affecting treatment prognosis (1). The prevalence of instrument separation varies according to material and clinical conditions: stainless steel files exhibit a fracture rate of (0.25%–6%), while rotary Nickel-Titanium (NiTi) of instruments have a higher rate, estimated around (1.3%–10.0%) especially in canals with complex anatomy (2).

Instrument fractures are mainly caused by cyclic fatigue, resulting from repeated tension and compression cycles at the point of maximum canal curvature, as well as torsional stress, which occurs when the tip or another part of the file binds in the canal while the shank continues to rotate. Additional contributing factors include canal complexity (severe curvatures, narrow canals) and manufacturing defects (3,4).

Although rotary NiTi instruments are widely used for their flexibility and elasticity, they are more prone to fracture compared to manual stainless-steel files. This highlights the importance of effective and safe strategies for managing separated instruments (1).

Several retrieval systems have been developed to extract fractured fragments while preserving dentin. Among them, the BTR-Pen® (Broken Tool Removal Pen) has gained attention due to its innovative and minimally invasive design. When combined with ultrasonic techniques, the system uses a micro-tube and a loop mechanism to securely engage and remove fragments, minimizing dentin loss and reducing the risk of procedural complications (2,5).

This article presents two clinical cases demonstrating the retrieval of fractured instruments using ultrasonic tips in combination with the BTR-Pen® system. The aim is to highlight the advantages, and practical application of this technique in managing instrument fractures and improving the success of endodontic treatments complicated by file separation.

Case report 1:

First visit:

The department of conservative dentistry and endodontics received a 38-year-old female patient for endodontic management of the mandibular left second molar 37, which had undergone endodontic treatment at a private clinic. During the retreatment of the root canal, a 5mm fracture of an H file coated in gutta-percha occurred within the mass of gutta-percha in the distal canal at its apical third. (**figure 1**)

The instrument removal approach was carried out as follow under visual control using a dental operating microscope:

The removal of the remaining Gutta percha gave us a direct access and clear visibility of the instrument using Ultrasonic generator and Ultrasonic Tip E18D **(figure 2).**

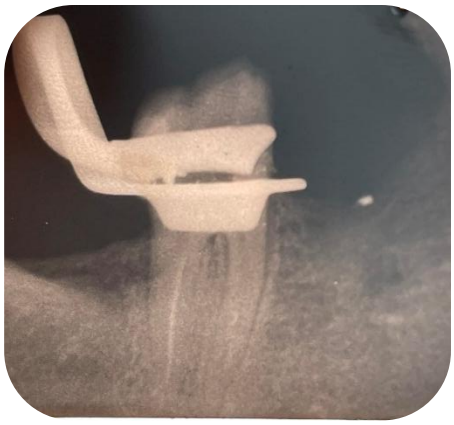

Fig 1: Periapical radiograph revealing a fractured instrument coated in gutta percha located in the apical third of the left

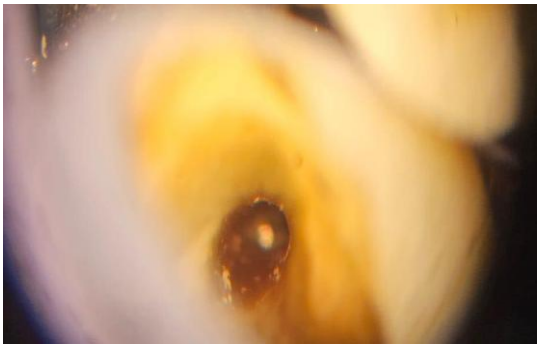

Figure 2: View under the operating microscope of the instrument exposure in the distal canal.

After coronal enlargement, the Ultrasonic Tip ET25 was used to free the head of the instrument in order to grasp it with the BTR-Pen® system.

The loop size needs to be adjusted to match the coronal diameter of the fractured instrument, utilizing an endodontic explorer such as the DG16 for accurate adjustment. We used a 0.4mm loop in this case.

Following the adjustment of the loop size, it was bent at a 45° angle instead of 90° to ease its placement over the fractured instrument, as it requires more space. Once positioned, the loop is inserted into the canal and then readjusted back to a 90° angle above the tip of the instrument. The loop then was carefully tightened around the coronal 2mm loosened fractured instrument and pulled gently to smoothly retrieve it from the canal (**figure 3**).

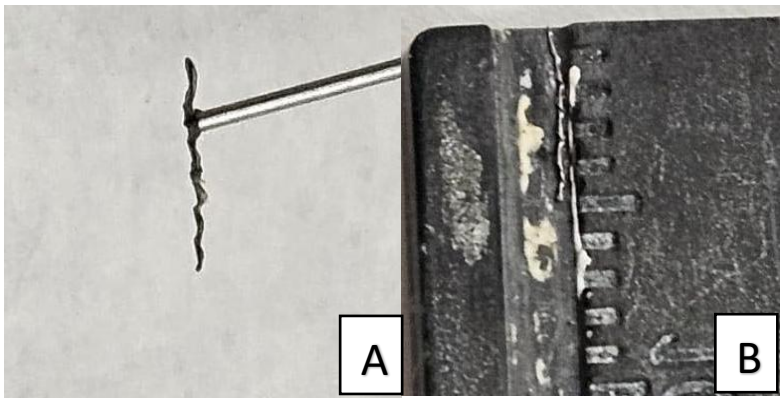

Fig 3: Retrieval of a fractured endodontic instrument with BTR-Pen® system (A) Measurement of the fragment length using a millimetric scale (B).

Working lengths of all remaining canals were measured with an apex locator and chemo-mechanical preparation of the mesial canals was carried out with 25.04% and distal canal with 25.06% and an intercanal medication using chlorhexidine 2% was placed.

Second visit:

Ultrasonic activation of irrigation with various irrigants: NaOCl 3.5%, Saline solution and 2% chlorhexidine and the root canals were then filled using a gutta-percha cone and bioceramic sealer (Bioroot, Septodent).

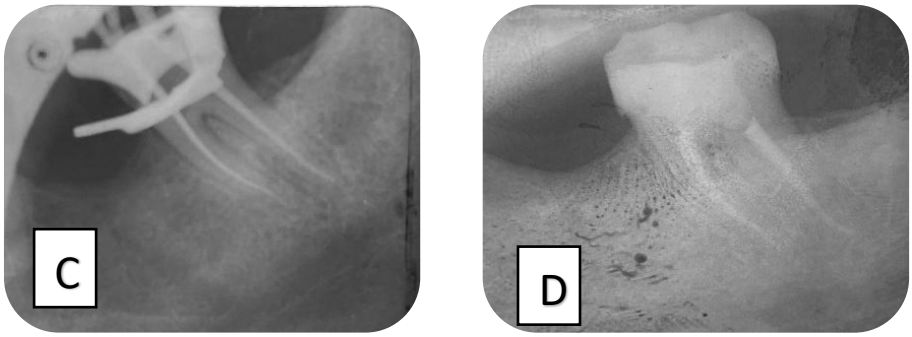

Fig 4: cone fit in place (C), Post-operative radiograph after coronal obturation (D).

Case report 2:

First visit:

The department of conservative dentistry and endodontics received a 54-year-old male patient referred for the manegement of a broken file (**manuel Protaper F2**) in tooth 47 in the mesio-lingual canal at its apical third, beyond the curvature (**figure 1'**).

The instrument removal approach was applied as follow under visual control using an dental operating microscope:

Initially, an ultrasonic tips E18D was used to establish a staging platform to ensure a direct access of the fractured instrument.The removal of dentin was carried out to create a space around the separated instrument using the ultrasonic tip ET25. Further, the Acteon ET25 tip was vibrated in the space created between the root canal walls and the separated fragment (**figure 2'**). After 35minutes the instrument's head was exposed up to 2mm using the ET25 insert, the instrument became loose, but its removal was not possible.

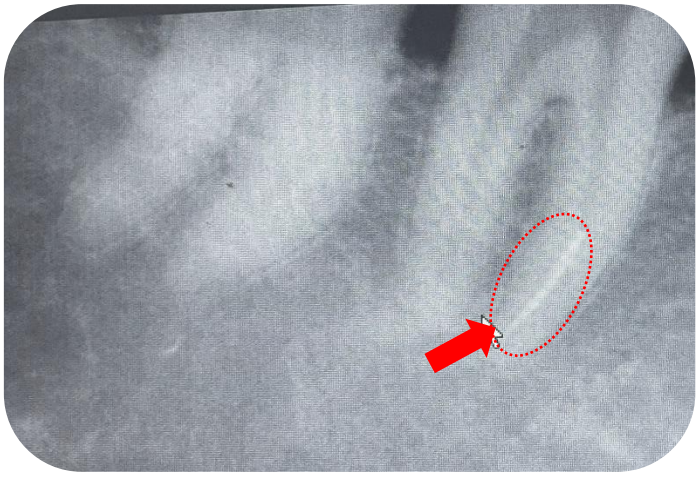

Figure 1' : Periapical radiograph revealing a fractured instrument located in the apical third of the right mandibular second molar

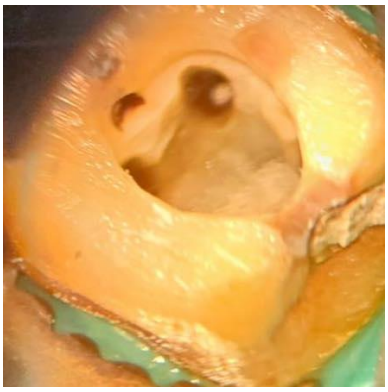

Figure 2' : View under the operating microscope of the instrument after exposure in the mesiolingual canal.

The use of a loop system BTR-Pen® system proved to be necessary in this case.

The loop size must be adjusted to match the coronal diameter of the separated instrument, using a calibrator provided with kit, a 0.4mm loop was used.

To facilitate placement over the fractured instrument, the loop is initially bent at a 45° angle instead of 90°, providing additional space for maneuvering. Once positioned, the loop is inserted into the canal and then returned to a 90° angle above the fractured instrument. It is then carefully tightened around the loosened 2mm coronal portion of the fragment and gently pulled to ensure a smooth retrieval from the canal (**figure 3').**

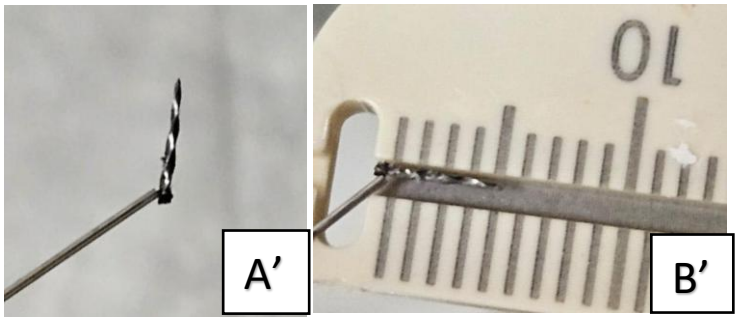

Figure 3' : Retrieval of a fractured endodontic instrument with BTR-Pen® system (A') Measurement of the fragment length using a millimetric scale (B').

After the instrument removal from the canal, a periapical radiograph is necessary to ensure that no fragments remain (**figure 3'**). The main challenge was to regain canal patency due to the ledge created by the ultrasonic instrumentation.

The management of the ledge using small-diameter files is carried out (file k8 k10 k15 Genendo)

Working lengths of all remaining canals were measured and chemo-mechanical preparation of mesial canals was done to 25.04% and distal canal to 25.06% (Vplex by ORODEKA).

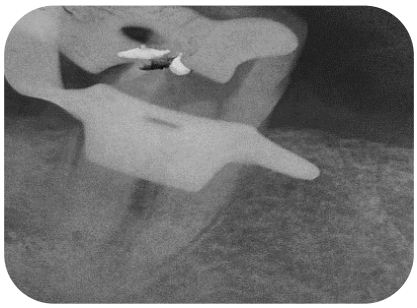

Figure 3': Periapical radiograph showing the removal of the instrument.

Second visit:

Ultrasonic activation of irrigation with various irrigants: NaOCl 3.5% , Saline solution and 2% chlorhexidine, then the root canals were then filled using a gutta-percha cone and bioceramic sealer (Bioroot, Septodent) (**figure 4'**).

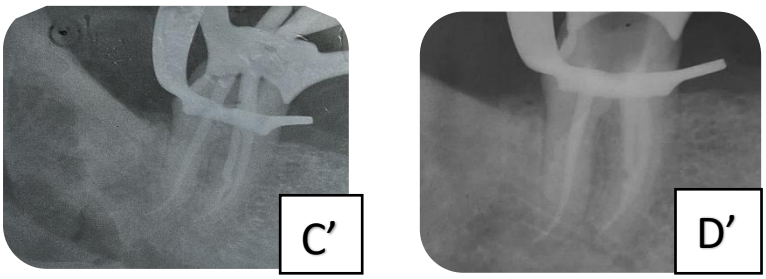

Fig 4: cone fit in place (C'), Post-operative radiograph after coronal obturation (D').

Discussion:

The retrieval of a separated instrument is a complex and sensitive procedure that demands adequate training, clinical experience, and a thorough understanding of the available methods and tools (6).

The decision to attempt removal is influenced by multiple factors such as the location of the fragment, canal anatomy, visibility. And the type of the seperated file (7).

These factors include the anatomical type of the tooth, the cross-sectional shape and diameter of the root canal, the exact position of the fragment within the canal, and its relationship to canal curvature particularly the degree and radius of the curve (8).

Retrieval tends to be more predictable in maxillary and anterior teeth, where access is generally easier. Additionally, success rates are higher when the fragment is located in the coronal third of the canal or positioned before the start of the curvature. Similarly, removal is more favorable in straight or slightly curved canals, where visibility and instrument manipulation are less restricted. It is proved that if one-third of the overall length of a separated instrument can be exposed, then it is accessible for removal (8,9).

NiTi rotary instruments are generally considered more challenging to retrieve due to their flexibility and tendency to fracture in complex canal anatomies, generally fracture more apically at or beyond the root canal curvature, making their removal difficult like our second case report (1).

The geometry of the fractured instrument is another key factor influencing retrieval difficulty. K-files are generally easier to remove than Hedström files, which are known to present greater challenges. This can be attributed to the specific design of Hedström files, which feature a larger helix angle, deeper flutes, and a more aggressive positive rake angle compared to K-files. These

design elements enhance their cutting efficiency but also increase their tendency to become tightly embedded in the canal walls at the moment of fracture, complicating their removal during endodontic procedures (10).

Therefore, the management of separated instruments should be approached in a systematic yet adaptable manner, with the clinician continually evaluating progress and being prepared to modify the strategy by combining effective techniques or consider alternative treatment options when necessary (2,11).

Appropriate lighting and magnification particularly with the use of an operating microscope are essential in the management of cases involving separated instruments. The combination of magnification and ultrasonic techniques has been shown to significantly enhance the likelihood of successful retrieval. Microscopic visualization allows precise navigation within the root canal, while ultrasonic tips can be safely and effectively applied in the deeper portions of the canal, adjacent to the fractured fragment, facilitating its dislodgement and removal (6,12).

However, when ultrasonic preparation does not achieve adequate fragment loosining after 10 s particularly in cases of deep engagement, limited straight-line access, or severe canal curvature or removal of separated instruments exceeding 4.5 mm in length, adjunctive techniques such as loop-based retrieval systems may be required to improve the predictability of removal. Unlike ultrasonic techniques, which are typically performed under wet conditions, loop-based retrieval requires a dry operative field to ensure optimal visualization and precise manipulation under magnification (2).

Preparation Phase by Ultrasonic for Instrument Removal

The preparation phase is a critical step for the successful ultrasonic removal of fractured instruments. It aims to achieve adequate exposure of the coronal portion of the fragment, optimize visibility, and create favorable conditions for ultrasonic activation. Once sufficient dentin has been removed to fully expose the coronal end of the fractured instrument, the canal should be thoroughly dried using dedicated devices. The preparation phase should ensure adequate peripheral space around the fractured instrument, with a minimum diameter of 0.4 mm and a coronal exposure depth of at least 0.7 mm.

Loop dimension adjustment:

After the canal and fragment have been properly prepared, the loop must be adjusted to ensure secure engagement of the fractured instrument. In our cases, the BTR-Pen® system was used, which offers three different loop sizes to accommodate varying fragment diameters. The appropriate loop is selected and calibrated to match the coronal portion of the fragment using the calibrator. To facilitate insertion into the canal, the loop is initially bent at approximately 45°. Once positioned over the exposed fragment, it is reoriented to a 90° angle to fully encircle the instrument. Tightening the loop around the fragment allows controlled coronal traction during retrieval. If resistance occurs, gentle multidirectional or swaying movements help disengage the fragment without applying excessive vertical force, which could deform or break the loop. Careful selection and adjustment of the loop size and angulation are therefore critical to maximize retrieval success while preserving surrounding dentin (8).

Although the overall endodontic outcomes are generally similar for teeth with either retained or retrieved separated fragments, the prognosis can be influenced by the preoperative pulpal

and periodontal status (14). Minimizing additional damage to the radicular dentin during fragment removal is therefore critical.

Risks of Instrument Retrieval in Curved Canals and the Role of Bioceramics

Despite these favorable retrieval outcomes, canal anatomy particularly curvature remains a critical determinant of procedural risk, irrespective of the retrieval system employed. Curved canals increase stress concentration within dentinal walls and limit tactile control, thereby predisposing to ledge formation, canal transportation, strip perforation, and excessive dentin removal, especially along the inner aspect of the curvature. Moreover, during ultrasonic troughing, prolonged activation or improper angulation may exacerbate dentinal thinning, generate thermal damage, or induce secondary instrument fracture (15,16).

Within this clinical context, bioceramic materials have emerged as a key adjunct in managing the consequences of iatrogenic complications. Calcium silicate–based bioceramics demonstrate superior sealing ability, bioactivity, and dimensional stability, making them particularly suitable for the repair of strip perforations and dentinal defects resulting from instrument retrieval procedures. In addition, the use of bioceramic sealers in canals affected by ledges or anatomical irregularities enhances adaptation to complex canal morphology, reduces microleakage, and contributes to the reinforcement of structurally compromised roots (17).

Conclusion

The management of separated endodontic instruments remains a significant clinical challenge that can influence treatment prognosis. Ultrasonic techniques, combined with a dental operating microscope and proper staging platform preparation, offer high success rates while minimizing dentin removal and procedural time (8,10).

However, in cases where ultrasonic retrieval alone is insufficient such as deeply engaged fragments, limited straight-line access, or complex canal anatomy, loop-based systems like the BTR-Pen® provide a predictable and safe adjunct, with multiple loop sizes to accommodate varying fragment diameters (13,12).

Clinicians must carefully assess canal anatomy, fragment position, and preoperative tooth status to select the most appropriate retrieval strategy, balancing efficacy, efficiency, and preservation of radicular dentin (5,9).

The combined use of ultrasonic and loop retrieval techniques represents a versatile and effective approach to optimize outcomes in endodontic instrument retrieval.

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