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Case Report

# Conservative retrieval of apically located separated instruments using the XP-3D Shaper: a two-case series

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## Abstract

**Background:** Separation of nickel-titanium (NiTi) rotary instruments during root canal treatment is an important clinical concern. Conventional retrieval techniques usually require radicular dentin removal to establish straight-line access and direct visualization of the fragment, which may compromise root integrity. This case series describes a conservative technique for retrieving apically located separated instruments using the XP-3D Shaper after complete bypass negotiation. The technique was performed without staging platform preparation or direct microscopic visualization of the fragment.

**Case descriptions:** Two male patients, aged 71 and 61 years, presented with separated nickel-titanium rotary instrument fragments located in the apical third of root canals. In Case 1, a 3-mm fragment of a size 15, 0.04 taper Vortex Blue instrument separated during retreatment of a maxillary left lateral incisor (tooth 10) with suspected canal contamination from prolonged coronal leakage. In Case 2, a 2.5-mm fragment of an S1 rotary instrument separated during initial treatment of a mandibular left first molar (tooth 19) with suspected canal contamination from inadequate isolation during prior treatment. In both cases, complete bypass negotiation was achieved using sequential stainless steel hand files, followed by rotary enlargement with Vortex Blue instruments and passive ultrasonic irrigation. The XP-3D Shaper was then introduced at 1000 rpm and 0.4 N·cm torque, successfully engaging and retrieving the separated fragments from the apical third without staging platform preparation, troughing, or aggressive dentin removal. Both teeth were obturated with gutta-percha and a bioceramic root canal sealer.

**Conclusions:** XP-3D Shaper-assisted retrieval after complete bypass negotiation may offer a conservative option for selected cases of apically located separated instruments and may help preserve radicular dentin. The adaptive core design and shape-memory alloy behavior of the XP-3D Shaper may facilitate circumferential engagement and dislodgement of loosened fragments. Larger studies with long-term follow-up are needed to determine the predictability and clinical outcomes of this approach.

**Keywords:** bypass negotiation, endodontic retreatment, instrument fracture, nickel-titanium rotary instruments, separated instrument, XP-3D Shaper

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# Introduction

Separation of nickel-titanium (NiTi) rotary files is an important concern during root canal treatment. Spili et al. (2005) reported a 3.3% prevalence of retained separated instruments among root canal-treated teeth, with rotary NiTi instruments accounting for 78.1% of cases. The reported overall prevalence of rotary NiTi instrument separation ranges from 0.9% to 21% in different studies (Sattapan et al., 2000; Arens et al., 2003; Parashos et al., 2004; Alapati et al., 2005). A systematic review by Panitvisai et al. (2010) reported that the prognosis of root canal treatment is not significantly compromised when a separated instrument is retained in the canal. Similarly, a systematic review by Rao et al. (2022) found no clear consensus regarding the optimal management of separated instruments. The authors concluded that there is insufficient evidence to determine whether leaving a separated instrument in the canal adversely affects tooth prognosis.

Nevertheless, poorer prognosis has been reported when a preoperative periapical lesion is present (Panitvisai et al., 2010) or when the separated instrument is small and located short of the apex (Lin et al., 2005). McGuigan et al. (2013) also reported significantly reduced healing outcomes when apical periodontitis was present before treatment. These findings indicate that instrument separation is most clinically relevant when it limits debridement and disinfection, particularly in contaminated canals.

Conventional retrieval techniques often require considerable dentin removal to establish straight-line access and direct visualization of the fragment, potentially compromising root structure (Terauchi et al., 2006; Yang et al., 2017; Fu et al., 2019). The present report describes a novel technique in which apically located separated instruments were conservatively retrieved using the XP-3D Shaper by a single operator in two separate cases. The XP-3D Shaper (Brasseler USA, Savannah, GA, USA) is a minimally invasive rotary endodontic instrument manufactured from a proprietary alloy (MaxWire; Martensite-Austenite Electropolish-Flex, FKG Dentaire Sàrl, Le Crêt-du-Locle, Switzerland). At room temperature, it has a tip size of 27 with a 0.01 taper; at intracanal temperature, it expands to an effective tip size of 30 with a 0.04 taper (De-Deus et al., 2019). The XP-3D Shaper has been used for several applications during root canal treatment, including root canal instrumentation (Arıcan Öztürk et al., 2020; Gazzaneo et al., 2021; Fontes et al., 2025), removal of previous root canal filling material (De-Deus et al., 2019), removal of triple antibiotic paste (Turkaydin et al., 2017), and activation of sodium hypochlorite irrigation (Loyola-Fonseca et al., 2023). However, to the authors' knowledge, no previous reports have described retrieval of apically located separated instruments using the XP-3D Shaper.

The following cases illustrate a minimally invasive approach for retrieving apically located separated instruments with the XP-3D Shaper after complete bypass negotiation, without staging platform preparation or direct microscopic visualization of the fragment.

**Case 1**

A 71-year-old male patient was referred from the graduate prosthodontic clinic for elective root canal treatment of teeth 7-10 (Maxillary left lateral incisor through right lateral incisor) before definitive prosthodontic rehabilitation for loss of vertical dimension of occlusion (Fig. 1A).

Initial nonsurgical root canal treatment of teeth 7-10 was completed uneventfully. Tooth 10 was instrumented to size 40, 0.04 taper with Vortex Blue rotary instruments (Dentsply Sirona, Charlotte, NC, USA) and copious irrigation using 6% sodium hypochlorite (NaOCl) and 17% ethylenediaminetetraacetic acid (EDTA). Obturation was completed using gutta-percha and a bioceramic root canal sealer, and a post space was

prepared for the planned restoration (Fig. 1B).

Approximately 2 months later, the patient was referred back from the graduate prosthodontic clinic after multiple appointment delays and cancellations. During this interval, the temporary restoration had dislodged, resulting in contamination of the canal space. The patient did not report loss of the temporary restoration to the prosthodontic resident until the day of the appointment. Consequently, the patient was referred back to the department of endodontics for nonsurgical retreatment of tooth 10 (Fig. 1C).

Following removal of the previous obturation material using size 35, 0.04 taper Baek's Pluggers (B&L Biotech, Fairfax, VA, USA), D2 and D3 retreatment files (Dentsply Sirona), chloroform, and Hedström files, the terminal 3-mm fragment of a size 15, 0.04 taper Vortex Blue rotary instrument separated within the apical third of the canal during reinstrumentation. Calcium hydroxide was placed as an intracanal medicament before temporization. The patient was scheduled for a subsequent appointment to complete treatment (Fig. 1D, E).

At the second appointment, bypass negotiation of the separated instrument was completed using sequential stainless steel hand files under copious irrigation with 6% NaOCl between each instrument. Initial negotiation was achieved with a size 6 C+ file

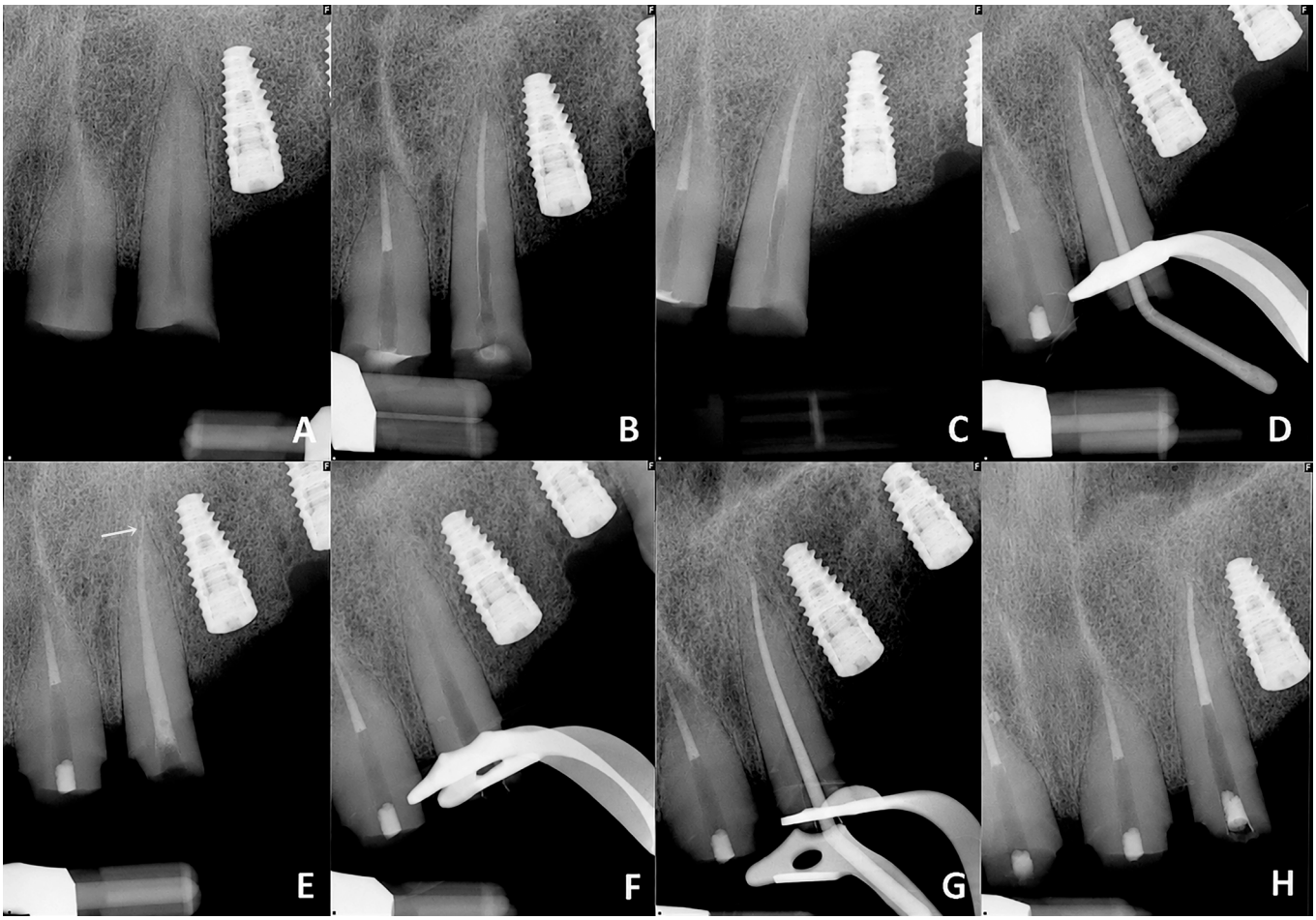



**Fig. 1. Sequential periapical radiographs of tooth 10 during treatment and retreatment.** (A) Initial preoperative radiograph. (B) Obturation following initial nonsurgical root canal treatment with post space preparation. (C) Two-month follow-up radiograph demonstrating dislodgement of the temporary restoration and exposure of the post space. (D) Retreatment radiograph demonstrating separation of the terminal 3 mm of a size 15, 0.04 taper Vortex Blue instrument within the apical third with partial bypass achieved. A master cone was placed for working length verification. (E) Placement of calcium hydroxide intracanal medicament with the separated file fragment (arrow) remaining within the apical third of the canal space. (F) Subsequent appointment demonstrating successful retrieval of the separated file fragment using the XP-3D Shaper. (G) Master cone radiograph following completion of canal instrumentation. (H) Final obturation radiograph following retreatment with post space preparation.

(Dentsply Sirona). This was followed by sequential enlargement with alternating stainless steel K-files and C+ files up to size 30 until working length was reestablished. The canal was then enlarged sequentially from size 15, 0.04 taper to size 45, 0.04 taper using Vortex Blue rotary instruments. After completion of instrumentation, passive ultrasonic irrigation was performed for 1 minute using a K25, 21-mm Irrisafe ultrasonic irrigation file (Satelec, ACTEON Group, Mérignac, France).

An XP-3D Shaper was then introduced into the canal space at 1000 rpm and a torque setting of 0.4 N·cm. After approximately 10 gentle strokes, the XP-3D Shaper successfully engaged and retrieved the separated instrument from the apical third of the canal (Fig. 1F). The fragment was delivered through the canal orifice and visualized under the operating microscope; no tactile feedback signaled engagement while the rotary motor was in use. Final irrigation was performed using 17% EDTA followed by 6% NaOCl. The canal was obturated with a size 45, 0.04 taper gutta-percha cone and a bioceramic root canal sealer. Post space was reestablished for the planned definitive restoration (Fig. 1G, H).

**Case 2**

A 61-year-old male patient was referred from an outside clinic for nonsurgical root canal treatment of tooth 19 (mandibular left first molar) after initiation of root canal treatment by the referring general dentist.

Clinical and radiographic examination revealed previously initiated therapy on tooth 19 with two separated instruments located within the distal root and no associated periapical radiolucency (Fig. 2A). A limited field-of-view cone beam computed tomography (CBCT) scan demonstrated two mesial canals and two distal canals with separate apical exits. One separated instrument was located within the isthmus between the distobuccal and distolingual canals; a second fragment was identified within the middle third of the distolingual canal (Fig. 3B).

During instrumentation of the mesiolingual canal, the terminal 2.5-mm fragment of a ProTaper Gold S1 rotary shaping file (Dentsply Sirona) separated within the apical third of the canal. Initial bypass negotiation beyond the separated fragment was attempted; however, complete bypass was not obtained at the first appointment (Fig. 2B). The two separated instruments within the distal root were successfully retrieved using ultrasonic techniques. Calcium hydroxide was placed as an intracanal medicament, and the tooth was temporized (Fig. 2C).

Prior to the second appointment, the referring dentist permanently cemented the definitive zirconia crown because the patient had returned to the outside office before completion of endodontic treatment. Consequently, access for completion of the endodontics treatment was performed through the newly cemented crown (Fig. 2D). Complete bypass of the separated S1 fragment was achieved using sequential stainless steel hand files under copious irrigation with 6% NaOCl between each instrument. Sequential bypass negotiation and canal enlargement were performed using alternating C+ files and stainless steel K-files from sizes 6 through 30 until working length was established apical to the fragment.

The bypassed canal was then enlarged sequentially with Vortex Blue rotary instruments from size 15, 0.04 taper to size 40, 0.04 taper. Passive ultrasonic irrigation was performed using a K25, 21-mm Irrisafe irrigation file before introduction of the XP-3D Shaper. The XP-3D Shaper was introduced using the same settings as in Case 1 (1000 rpm and 0.4 N·cm torque) and successfully engaged and retrieved the separated S1 fragment from the mesiolingual canal (Fig. 2E). Final irrigation was performed using 17% EDTA followed by 6% NaOCl. Obturation was completed using gutta-percha and a bioceramic root canal sealer using a warm vertical compaction technique (Fig. 2F, G).

The two separated instruments within the distal

root were located in a relatively straight and more accessible portion of the canal system, allowing conventional ultrasonic retrieval with direct visualization under the operating microscope. In contrast, the mesiolingual fragment was located beyond the primary curvature within the apical third, where ultrasonic troughing would likely have required substantial dentin removal to establish straight-line access. Therefore, a conservative bypass-assisted retrieval approach using the XP-3D Shaper was selected.

# Discussion

### Prognosis of teeth with retained separated instruments

Management of separated instruments is controversial because prognosis is influenced by the fragment itself, the pre-existing microbial status of the canal system, the stage of instrumentation at which separation occurs, and the ability of the clinician to disinfect the canal space apical to the fragment (Spili et al., 2005; Crump & Natkin, 1970; Madarati et al., 2013). Previous studies have demonstrated that retained separated instruments do not necessarily compromise healing when adequate disinfection has already been achieved (Spili et al., 2005; Crump & Natkin, 1970). However, prognosis becomes less favorable when instrument separation occurs early during instrumentation or when contamination of the canal system is present (Parashos et al., 2004; Lin et al., 2005).

Lin et al. (2005) reported that prognosis tends to be more favorable when separated instruments are larger and located near working length, whereas smaller instruments separated short of the apex may compromise debridement of the remaining canal space apical to the fragment. Likewise, Parashos et al. (2004) emphasized that early separation during instrumentation may increase the likelihood of inadequate canal debridement. In the present cases, the separated instruments consisted of a size 15, 0.04 taper Vortex Blue instrument and an S1 rotary instrument. Both were relatively small instruments that separated before complete canal enlargement had been achieved.

In the present cases, retrieval was pursued because contamination of the canal system was strongly suspected despite successful initial bypass negotiation. In Case 1, tooth 10 had been exposed to

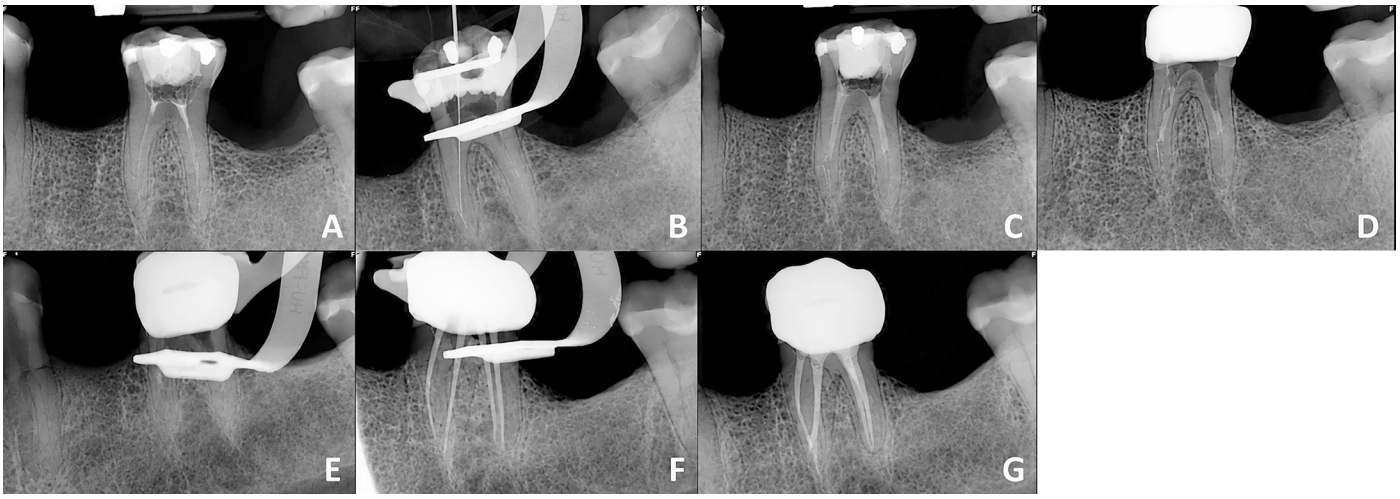



**Fig. 2. Sequential periapical radiographs of tooth 19 during treatment.** (A) Initial preoperative radiograph demonstrating previously initiated therapy with two separated instruments located within the distal root. (B) Attempted bypass negotiation of the separated 2.5-mm S1 fragment within the mesiolingual canal. (C) Placement of calcium hydroxide intracanal medicament with the separated S1 fragment remaining within the apical third of the mesiolingual canal. (D) Preoperative radiograph obtained at the second appointment demonstrating definitive crown cementation by the referring provider before completion of endodontic treatment. (E) Subsequent appointment demonstrating successful retrieval of the separated S1 fragment using the XP-3D Shaper. (F) Master cone radiograph following completion of canal instrumentation. (G) Final obturation radiograph.

salivary and food contamination after dislodgement of the temporary restoration and prolonged exposure of the post space. Although obturation after bypass alone may have represented a reasonable alternative, concerns persisted regarding microbial contamination and limited ability to disinfect the canal space surrounding and apical to the retained fragment.

**Rationale for conservative nonsurgical management**

In Case 1, nonsurgical retreatment was pursued because prolonged dislodgement of the temporary restoration resulted in evident coronal leakage and contamination of the post space. Previous studies have demonstrated that coronal leakage may permit rapid bacterial and endotoxin penetration into obturated root canal systems within days to weeks after exposure (Torabinejad et al., 1990; Khayat et al., 1993; Alves et al., 1998). Surgical management was considered less favorable because the tooth had previously undergone crown-lengthening surgery because of inadequate clinical crown height. Additional apical root resection to retrieve the separated fragment may have further compromised the crown-root ratio and long-term restorative prognosis. Consequently, a conservative nonsurgical approach was selected to facilitate more complete mechanical debridement, irrigation, and obturation of the apical canal space and to preserve remaining root structure.

Case 2 was managed using a similar rationale. Although no periapical radiolucency was observed radiographically, contamination of the canal system was suspected because dental dam isolation may not have been used during the initial treatment according to the patient's recollection. Coronal leakage was also clinically evident at presentation. Although the mesial root of mandibular first molars may often be considered surgically accessible, surgical intervention in Case 2 was considered less favorable because of the thickness of the buccal cortical plate. Consequently, a conservative nonsurgical approach emphasizing bypass negotiation followed by retrieval was selected.

Although successful bypass often permits adequate working length establishment and canal preparation, retrieval was pursued in these two cases because complete disinfection of the contaminated canal system remained a primary concern. In both cases, the canals were considered microbiologically compromised. In Case 1, prolonged coronal leakage after loss of the temporary restoration resulted in exposure of the post space to the oral environment. In Case 2, contamination was suspected because treatment had been initiated without predictable isolation according to the patient's recollection and coronal leakage was also present. In addition, the separated instruments in both cases were located within the apical third of the canal, immediately

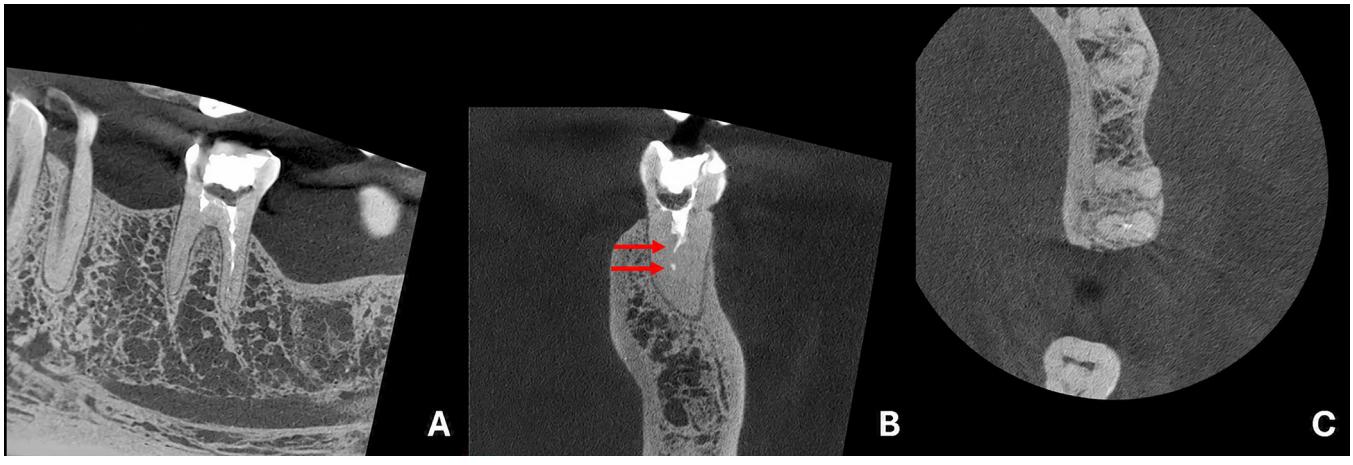



**Fig. 3. Preoperative CBCT screenshots of tooth 19.** (A) Sagittal view. (B) Coronal view of the distal root demonstrating two separated instruments (red arrows). (C) Axial view.

coronal to the apical constriction. Although bypass established working length and created access around the fragment, the retained instrument could still limit irrigant exchange and mechanical debridement of the canal walls immediately surrounding the fragment, particularly within this critical apical portion of the root canal system. Therefore, retrieval was considered to maximize mechanical debridement and chemical disinfection before obturation. Although bypass alone may be sufficient in many cases, particularly when the separated instrument is located more coronally or when the tooth presents with a vital pulp or symptomatic irreversible pulpitis without evident contamination of the root canal system, the authors believed that retrieval offered additional benefit in the present cases because contamination of the canal system was noticed and both separated fragments were located in the apical third of the canal.

**Limitations of conventional retrieval techniques**

Traditional management of separated instruments commonly involves creation of a coronal staging platform and progressive dentin removal to establish straight-line access and direct visualization of the fragment (Terauchi et al., 2006; Yang et al., 2017; Narasimhan et al., 2021; Malentacca et al., 2023).

Terauchi et al. (2006) described a systematic orthograde retrieval technique using coronal enlargement, staging platform preparation with modified Gates-Glidden burs, ultrasonic troughing around the coronal aspect of the fragment, and microtube-assisted retrieval when ultrasonic activation alone was insufficient. This approach established the foundation for many contemporary separated instrument retrieval protocols.

Yang et al. (2017) later evaluated a modified trephine technique using a small-diameter trepan bur in combination with a microtube device. After creation of a staging platform, the trepan bur was used in counterclockwise rotation to trephine dentin around the fragment and expose 1-1.5 mm of its coronal segment. This was followed by microtube engagement for retrieval. Compared with ultrasonics, this method resulted in less dentin removal and shorter retrieval time.

Narasimhan et al. (2021) introduced the Burrow Platform technique for curved and narrow canals. Using diamond-coated ultrasonic tips under magnification, an angulated radicular access pathway was created toward the fragment. This was followed by preparation of a partial platform limited to the inner wall of the canal curvature. Ultrasonic troughing was then performed to expose the coronal portion of the fragment before retrieval. The goal was to minimize dentin removal and reduce the risk of transportation or perforation.

More recently, Malentacca et al. (2023) described a spinal needle technique in which a spinal needle is advanced over the exposed coronal portion of the fragment to mechanically engage and retrieve it from the canal. This method serves as a conservative alternative to traditional microtube systems, can be performed with readily available armamentarium, and can minimize additional dentin removal. However, their technique still required coronal enlargement of the straight portion of the canal using Gates-Glidden burs in a brushing motion to facilitate access to the fragment.

Despite the evolution of instruments and techniques, all these approaches may still require substantial removal of radicular dentin in curved or narrow canals, potentially increasing the risk of strip perforation and weakening root structure (Fu et al., 2019; Souter & Messer, 2005). Preservation of radicular dentin is clinically important because excessive coronal enlargement has been associated with decreased fracture resistance and increased risk of vertical root fracture (Fu et al., 2019).

**Bypass-assisted retrieval without staging platform preparation**

In both cases, the separated fragments were located apical to the primary canal curvature and could not

be directly visualized under the dental operating microscope, even at the highest magnification. Because of their apical position within curved canals, conventional retrieval methods using trephine burs or actively cutting ultrasonic tips would likely have required substantial dentin removal and canal straightening to establish direct access to the fragment. To preserve root structure and avoid excessive dentin removal, no staging platform was prepared and no burs or actively cutting ultrasonic tips were used.

Following successful bypass negotiation, rotary enlargement, and passive ultrasonic irrigation, the XP-3D Shaper was selected for fragment retrieval because of its ability to expand beyond its core size and adapt three-dimensionally to root canal anatomy. Despite bypass enlargement with K-files to size 30, the fragments were not dislodged. Likewise, instrumentation with Vortex Blue to size 45, 0.04 taper in Case 1 and size 40, 0.04 taper in Case 2 did not dislodge the fragments. However, both fragments were successfully retrieved after use of the XP-3D Shaper.

Although the exact retrieval mechanism is uncertain, the XP-3D Shaper's adaptive core design, shape-memory alloy behavior, and expansion within the prepared canal space may allow circumferential contact with loosened fragments. This contact may generate a multidirectional wobble and dislodging effect that facilitates retrieval. Progressive enlargement of the bypassed space likely contributed to loosening the fragments before final engagement with the XP-3D Shaper. This proposed mechanism is consistent with previous studies demonstrating that the XP Shaper contacts a greater percentage of canal walls in oval-shaped canals compared with Vortex Blue (Azim et al., 2017) and achieves a higher percentage of root filling removal during retreatment (De-Deus et al., 2019). The enhanced ability of XP-3D Shaper to adapt to canal irregularities and contact canal walls more circumferentially may explain its effectiveness in engaging and retrieving separated instruments located in the apical third of curved canals.

Because retrieval was attempted only after circumferential enlargement of the bypassed canal space, direct coronal troughing and aggressive radicular dentin removal were avoided. This conservative approach avoided the extensive coronal enlargement frequently associated with conventional retrieval techniques. Postoperative radiographs of these cases did not demonstrate the funnel-shaped or parallel dentin removal often evident after staging platform preparation.

The XP-3D Shaper was not intended to replace conventional ultrasonic retrieval in all situations. When fragments are coronally located and directly accessible, ultrasonic retrieval remains an effective and predictable option. The present technique may be most useful when fragments are located beyond canal curvature where conventional staging platform preparation would require substantial dentin removal.

**Limitations**

The present report has several limitations. Only two cases are presented, and both involved successful bypass negotiation before retrieval attempts. Consequently, the predictability of this approach is uncertain in cases with severe canal curvature or when instruments cannot be bypassed. Long-term follow-up is also required to evaluate healing outcomes and structural prognosis after retrieval using this technique.

# Conclusion

Within the limitations of this case series, XP-3D Shaper-assisted retrieval after complete bypass negotiation may represent a conservative alternative for selected cases of apically located separated instruments with minimal unnecessary radicular dentin removal. Further investigation is necessary to determine the predictability and long-term

outcomes of this approach.

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## Patient consent

Patient consent was obtained for publication of the clinical details and radiographic images.

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