JOURNAL of ENDODONTICS and RESTORATIVE DENTISTRY
E-ISSN: 2980-3748

Case Report

Separated Instrument Retrieval from the Maxillary Canine using only Ultrasonic Energy and Non-Vital Bleaching with Hydrogen Peroxide: A Case Report

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ARTICLE INFO
Received: 08.11.2025
Completion of First Review: 16.12.2025
Accepted: 31.12.2025
Published: 01.03.2026

KEYWORDS
Cone-beam computed tomography
Root canal therapy
Separated instrument
Tooth bleaching

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CLINICAL SIGNIFICANCE

This case demonstrates that the exclusive use of ultrasonic energy allows for safe and conservative retrieval of a separated instrument, while subsequent non-vital bleaching with hydrogen peroxide effectively restores aesthetics in discoloured teeth.

ABSTRACT

A fractured file within the root canal system can hinder the root canal's mechanical and chemical cleaning, adversely affecting the treatment prognosis. Ineffective cleaning of the root canal system and the corrosion of the fractured instrument within the canal can lead to tooth discoloration. This case report presents the successful removal of an obliquely positioned fractured instrument in a partially obliterated and discoloured maxillary right canine tooth using only ultrasonic energy, followed by non-vital bleaching with hydrogen peroxide. It emphasizes the efficacy of integrating ultrasonic tools, a dental operating microscope, and cone-beam computed tomography in treating such challenging cases. The removal of the fractured instrument using ultrasonic tips can be defined as a safe and conservative technique. Non-vital bleaching can provide quick, cost-effective, and aesthetically pleasing results in discoloured teeth with pulp canal obliteration, which can be challenging for clinicians.

1. Introduction

Instrument fracture is a highly distressing complication with an incidence rate of 0.25-6% during root canal treatment.[1] A fractured instrument creates significant challenges, including the possibility of canal corrosion and obstruction of cleaning and shaping procedures. Therefore, bypassing or removing the fractured instrument is necessary to access the apex.[2] Orthograde removal of the fractured instrument is often time-consuming and difficult, with a success rate of 55-79%.[3] Depending on the technique used, potential outcomes during preparation include perforation, extrusion, additional instrument fracture, and excessive loss of radicular dentin. Therefore, risk assessment is crucial in managing this complication.[4]

For instance, an engaged instrument adheres to the canal wall, exhibiting greater resistance to removal due to increased torsional connection.[1] Hence, preoperative identification of factors such as the position, angle, and length of the fractured file is a prerequisite for successful treatment.[4] Removal attempts require the use of a non-invasive or minimally invasive technique with an appropriate methodological approach under good visualization.[5]

Minimally invasive approaches are paramount in these scenarios. Ultrasonic technology has revolutionized the management of intracanal obstructions, offering a superior alternative to traditional mechanical methods. By utilizing high-frequency vibrations, ultrasonic tips can selectively remove dentin surrounding the fractured segment without imposing excessive stress on the root structure. When combined with visual magnification, such as a dental operating microscope, ultrasonic energy facilitates precise trenching around the fragment, loosening it through vibration and acoustic streaming, thereby enhancing the predictability of retrieval.[1]

Teeth are significant elements for first impressions and psychosocial well-being. Even a single tooth colour discrepancy can be easily perceived by individuals, disrupting the harmony of a smile. Correctly identifying the ethology of discoloration is crucial for the clinician to apply adequate treatment.[6, 7] Known etiological factors for discoloration in endodontically treated teeth include materials containing silver, Mineral Trioxide Aggregate (MTA), temporary restorations, and remnants of pulp tissue after treatment.

It is important to emphasize that inadequately performed root canal treatments are a predominant etiology of intrinsic tooth discoloration. When the root canal system is not thoroughly debrided and obturated—often a consequence of procedural errors like instrument fracture—necrotic pulp tissue remnants and blood breakdown products penetrate the dentinal tubules. Over time, the degradation of these organic substances releases chromogenic compounds that significantly alter the optical properties of the tooth structure.[8,9]

Additionally, caries, pulp necrosis, trauma, and canal calcifications are common causes of internal discoloration.[8] In endodontically treated teeth with significant discoloration, bleaching is a less invasive and economical treatment option compared to full crowns, veneers, and composite restorations.[9]

This case report aims to present the successful removal of an obliquely positioned fractured file in the coronal-middle third region of a discoloured and partially obliterated maxillary right canine tooth using ultrasonic energy and non-vital bleaching with hydrogen peroxide.

2. Case Presentation

A 54-year-old male patient with no pain or symptoms presented to the Department of Endodontics, complaining about the unesthetic appearance of his maxillary anterior tooth. The patient had no systemic conditions and was not on any medications that could cause tooth discoloration. A detailed anamnesis revealed that the affected tooth had undergone treatment 20 years ago, but the patient could not recall the exact procedure.

Clinical examination revealed a mismatched composite restoration and intense gray discoloration on the maxillary right canine (#13) (Fig. 1a). The tooth was not sensitive to percussion. Electric pulp testing (Parkell Digitest II, NY, USA) and cold testing (Pulp Spray, Cerkamed, Stalowa Wola, Poland) indicated that the tooth was non-vital. Periapical radiography (Xmind Satelec-Acteon X-ray source, Mérignac, France; 70 kV, 10 mA, and 100 ms) showed no pathology in the periapical region. A radiopaque foreign body was observed apical to the coronal third of the root canal space. The canal space could not be fully visualized coronal to the radiopacity (Fig. 1b).

For a more detailed radiological examination, the patient was referred for cone-beam computed tomography (CBCT). CBCT images were acquired using a Planmeca ProMax 3D Classic (Planmeca Promax 3D; Planmeca Oy; Helsinki, Finland) with the following parameters: 90 kV, 10 mA, 15.02 seconds, 8x8 cm field of view (FOV), and 75 µm voxel size. Although smaller fields of view (e.g., 5x5 cm) are typically preferred for single-tooth endodontic procedures to minimize radiation dose, an 8x8 cm FOV was selected. This larger volume provided a more comprehensive view of the surrounding anatomical structures, including the entire maxillary arch, the adjacent teeth, and the periapical region, to fully rule out pathology, assess the full extent of the root, and confirm the canal anatomy in a complex case involving instrument fracture and partial calcification. The acquisition process was performed according to the manufacturer's recommended protocol. The measurements were performed using Planmeca Romexis 4.6.2.R software (Planmeca Romexis, Helsinki, Finland). Patient gave informed consent for the use of their X-ray examination in scientific research.

CBCT evaluation showed a hyperdense foreign object approximately 2 mm long extending buccally and obliquely at the junction of the coronal and middle thirds of the canal (Figure 1c). Partial obliteration of the root canal coronal to the fractured instrument was also confirmed. There was no pathology in the periradicular region. The patient gave informed about the treatment options and possible outcomes related to the management of the fractured instrument and post-endodontic whitening. Non-surgical root canal treatment followed by non-vital bleaching was decided upon.

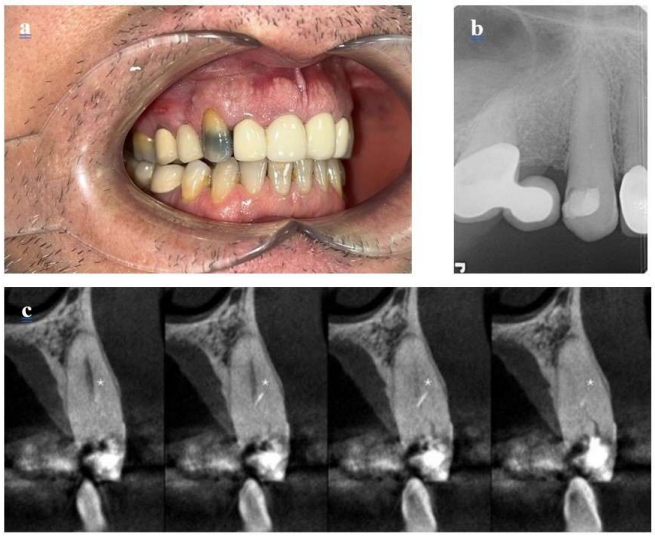

Fig. 1. Preoperative clinical and radiographic findings. a. Preoperative intraoral picture with discolored tooth; b. Initial periapical radiograph revealing a radiopaque foreign body in the root canal space of the maxillary right canine; c. Cone beam computed tomography view (0.1 mm thick, 0.2 mm spaced cross sectional sections) revealing hyperdense foreign object 2 mm long extending buccally and obliquely in the canal and partial obliteration

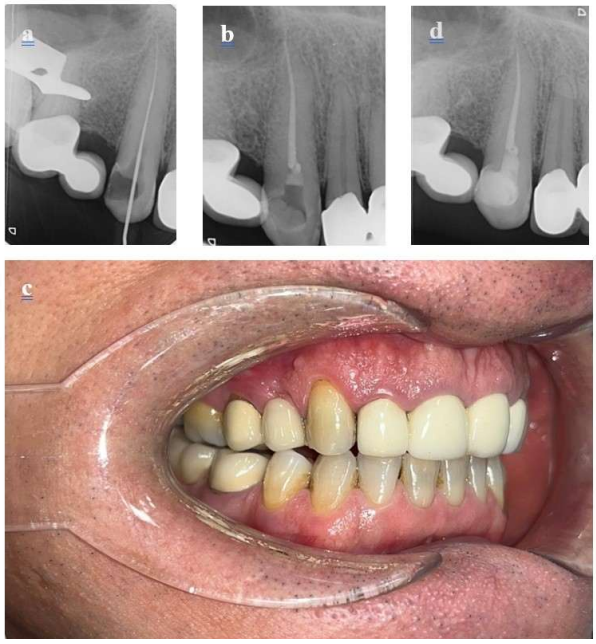

Fig. 2. Endodontic procedures. a. Verification of seperated instrument retrieved and determination of working lenght; b. Glass ionomer cement barrier; c. Photograph showing 48 hours follow up showing complete bleaching of intrinsic stains; d. Periapical radiograph showing post endodontic restoration

After obtaining written informed consent, local infiltration anaesthesia was administered to tooth #13 using 2% articaine with 1:120,000 epinephrine (Ultraver D-S Forte 80 mg + 0.03638 mg/2 ml, HAVER FARMA, İstanbul, Türkiye). Under rubber dam isolation, the old restoration was removed using an air turbine handpiece and diamond fissure bur with copious irrigation. A cotton pellet left under the restoration was removed. The carious tissue at the distal step was completely removed using slow-speed round carbide burs.

Under a dental operating microscope (DOM; Zeiss Extaro 300, Oberkochen, Baden-Württemberg, Germany) at 16X magnification, cement residues in the coronal part of the canal were removed using an ED3D ultrasonic tip (Woodpecker Co., Guilin, Guangxi, China). After the fractured instrument became visible at 16X magnification, it was loosened using an ultrasonic device (DTE S6, Guilin Woodpecker Co.) and an ED87 ultrasonic tip (DTE, Guilin Woodpecker Co.; mode: E, setting: 2) specially designed for instrument removal. To ensure safety and reproducibility, the device was operated in 'Endo' mode (Mode E). The power intensity was carefully modulated, set to 'Setting 2', which corresponds to approximately 20% of the maximum power output. This lower power setting was selected to minimize the risk of heat generation and microcracks in the root dentin.[10] The ultrasonic activation was applied in short, intermittent bursts (5–10 seconds) to facilitate controlled dentin removal while maintaining constant visibility and cooling.[1, 5]

The dentin around the fractured instrument's coronal portion was removed 360 degrees. The instrument was loosened but did

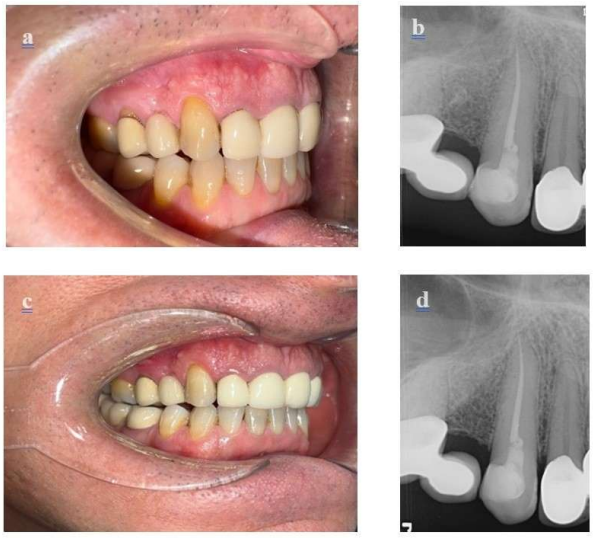

Fig. 3. Postoperative follow-up at 6 and 12 months.
(a) Clinical photograph and periapical radiograph obtained at the 6-month follow-up; (b) Clinical photograph and periapical radiograph obtained at the 12-month follow-up.

not dance because it was stuck to the buccal wall. Therefore, preparation was performed between the instrument and the buccal wall using the same tip. Frequent pauses were taken for cooling, and 2.5% sodium hypochlorite (NaOCl) irrigation was performed. Passive ultrasonic activation (PUI; TD2; DTE, Guilin Woodpecker Co.; mode: E, setting: 6) was conducted during irrigation to better clean dentin debris. The amount of loosening of the instrument was increased using silicone-based oil and ultrasonic tips. Once dancing was observed, 17% ethylenediaminetetraacetic acid (EDTA) was filled up to the cavosurface. The ED87 ultrasonic tip was activated in a coronal-apical direction, and within approximately 10 seconds, half of the file popped out of the canal. The remaining buccal piece of the file was removed using the same technique with the ultrasonic tip placed between the instrument and the buccal wall.

Periapical radiography confirmed the removal of the fractured instrument. Vital pulp tissue was observed apical to the fractured instrument. After the pulp was extirpated, the working length was determined using an electronic apex locator (Root ZX, J. Morita Co., Tokyo, Japan) and periapical radiography (Fig. 2a). The canal preparation was performed by Scope RS (Gtech, Yozgat, Türkiye) files up to K7 Gold (30/0.04). During instrumentation, the canal was irrigated with 2.5% sodium hypochlorite. The final irrigation was performed using PUI (TD2; DTE, Guilin Woodpecker Co.; mode: E, setting: 6) with 2.5% sodium hypochlorite and 17% EDTA. The canal was dried with paper points and filled using the lateral compaction technique with gutta-percha and resin-based root canal sealer (ADSEAL; Meta Biomed Co., Cheongju, Korea).

After removing gutta-percha 2 mm apically from the cementoenamel junction, the cavity was washed and dried. Glass ionomer cement (Ruby liner, Madrid, Spain) was applied over the gutta-percha as a barrier material to minimize bleaching agent leakage. For managing the gray crown, 35% hydrogen peroxide (Opalescence™ Endo, Ultradent, Utah, USA) was injected into the chamber, and a cotton pellet was placed. The access cavity was temporarily sealed with glass ionomer cement (Nova Glass F, Imicryl, Konya, Türkiye) (Fig. 2b).

The patient was recalled for evaluation 48 hours later. After a single bleaching session, the desired results were achieved, and the patient was satisfied (Fig. 2c). Hydrogen peroxide was removed from the pulp chamber using copious saline irrigation. Calcium hydroxide paste was then placed in the pulp chamber for seven days. The tooth was later restored with resin composite (FGM Llis, Santa Catarina, Brazil) (Fig. 2d). At the 6- and 12-month follow-up appointments, the tooth remained asymptomatic and no pathology was observed on periapical radiography. The patient was also satisfied with the aesthetic outcome (Fig. 3).

This case report has been written according to Preferred Reporting Items for Case reports in Endodontics (PRICE) 2020 guidelines (Supplemental File 1).[10]

3. Discussion

Instrument fracture during endodontic treatment is a highly distressing complication that can adversely affect treatment procedures and prognosis. Depending on the moment of the accident and the level of the root canal where the instrument fractures, proper shaping and filling of the canal may be hindered.[11] Improperly filled canals and the corrosive products caused by the instrument can lead to tooth discoloration.[2, 8] This case report describes the treatment of a maxillary canine that had become partially calcified and discoloured following inadequate endodontic treatment and instrument fracture.

Instrument fractures during endodontic treatment obstruct apical access, preventing the complete realization of root canal therapy.[11] In this case, in addition to the failure to fill the apical portion due to the instrument fracture, the coronal part of the canal was also left unfilled. The vital pulp in the apical portion suggests that the instrument likely broke during the early stages of the procedure, possibly during canal exploration. According to Berman and Hargreaves, management strategies for separated instruments range from non-surgical orthograde retrieval to surgical intervention. Since the fragment was located in the coronal third of the root canal, a non-surgical orthograde approach was selected as the most conservative and least invasive treatment modality.[12]

Approaches to fractured instruments include non-surgical orthograde and surgical methods. In this case, the fractured instrument was close to the coronal section of the root canal, leading to the selection of a non-surgical orthograde approach as a less invasive option.[2] The orthograde approach involves bypassing, removing, or obturating at the level of the fractured instrument.[4] According to Machtou and Reit, the best course of action in the presence of a fractured instrument is to remove it.[13] The decision to prioritize the ultrasonic technique over other retrieval methods, such as mechanical extractors or bypassing, was driven by the need for hard tissue preservation. Although bypassing the instrument may be considered a viable alternative, this approach does not eliminate the intracanal obstruction and may compromise effective cleaning and disinfection of the apical third.

For instrument removal, several mechanical retrieval systems, such as the Masserann kit and the Endo Extractor, have been introduced. However, these techniques are associated with notable limitations, including excessive radicular dentin removal, increased risk of perforation and canal deviation, restricted applicability in narrow or curved canals, and possible apical extrusion of the fragment.[2] In particular, mechanical extraction systems often require substantial dentin sacrifice to engage the fractured instrument, which may significantly weaken the root structure and increase the risk of vertical root fracture.[2,14] Given these drawbacks, the use of non-invasive or minimally invasive techniques is advocated for the management of fractured instruments.[2]

The ultrasonic technique is a minimally invasive method that uses ultrasonic vibrations to loosen and then extrude the fractured instrument from the canal. With advancements in this technique, the removal of fractured instruments has become more predictable and less invasive.[2, 5] Therefore, in this report, ultrasonic energy was utilized to remove the fractured instrument. Ultrasonic

tips were used with a DOM to ensure a clear view and to minimize damage to the radicular dentin.[2]

For better visibility and to reduce the likelihood of procedural errors, it is recommended that the root canal preparation be performed in a dry environment when using a DOM during attempts to remove fractured instruments.[12,15,16] Therefore, root canal preparation for instrument removal should be done in a dry environment.[12] Accordingly, in this report, the preparation with ultrasonic tips was conducted dry. To prevent temperature increase and secondary fracture, the tip was used at 20% of the maximum power setting with back-and-forth movements.[1,17,18] It has been reported that to attempt to remove the broken tool, the tool should be seen dancing ("not flexing" or "dancing"), not flexing.[12] In this case, after a 360-degree opening of the coronal part of the instrument, only flexing was observed. Therefore, to achieve the dancing movement and proceed with removal attempts, apical preparation was made between the fractured instrument and the buccal wall.

Terauchi et al. reported that most fractured instruments smaller than 4.6 mm could be removed within 10 seconds using only the ultrasonic method.[1, 19] This method involves filling the canal with EDTA up to the cavosurface (not just the root canal) and using ultrasound to take advantage of cavitation and acoustic streaming. The ultrasonic tip is operated with short up-and-down strokes on the inner curve until the instrument is removed. A higher power setting of 10%-20% more can be used during the preparation stage as the ultrasonic tips are more resistant to breakage in wet conditions than in dry conditions.[1, 20] Similarly, in this case, after observing the dancing movement, EDTA was filled up to the cavosurface, and a straight ED87 ultrasonic tip, specially designed for instrument removal, was placed between the instrument and the buccal wall, and activated with short up-and-down strokes.

Despite efforts to prevent secondary fracture during the procedure, the instrument came out in two pieces, possibly due to its oblique positioning in the canal. Additionally, in this case, before attempting removal with EDTA, silicone-based oil was used to loosen the file from the canal wall and was then removed with paper points.[12]

Terauchi et al.,[1] stated that the treatment protocol for removing a fractured instrument should be determined based on CBCT findings. The initial periapical radiograph identified a radiopaque foreign body but provided limited information on its three-dimensional location and the full anatomy of the canal. The subsequent CBCT examination was therefore instrumental in clarifying the treatment strategy. By accurately localizing the fragment at the buccal aspect and revealing the extent of canal obliteration, the CBCT images guided the precise angle and depth of ultrasonic troughing, thereby reducing the risk of iatrogenic errors such as perforation.[1,21] In line with this, in this case, CBCT was used before the procedure to confirm the presence of the fractured instrument, determine its location, and understand the canal anatomy.[1] However, high atomic number materials cause various artifacts. Although not entirely preventable, the degree of artifact is directly proportional to the FOV area, meaning fewer artifacts occur in low FOV scans than in high FOV scans.[21] In this case report, a small FOV was selected to minimize artifacts, and the presence of foreign material inside the tooth was observed. Although smaller fields of view (e.g., 5x5 cm) are typically preferred for single-tooth endodontic procedures to minimize radiation dose, an 8x8 cm FOV was selected. This larger volume provided a more comprehensive view of the surrounding anatomical structures, including the entire maxillary arch, the adjacent teeth, and the periapical region, to fully rule out pathology, assess the full extent of the root, and confirm the canal anatomy in a complex case involving instrument fracture and partial calcification.[21, 22]

Despite 20 years passing since the initial treatment, no periapical pathology developed in this case. This could be due to the intact apical pulp circulation resisting bacterial invasions.[22] However, CBCT sections showed partial obliteration of the canal coronal to the fractured instrument. The mechanisms underlying canal obliterations are still unclear. It is believed that the reduction in canal lumen after trauma results from excessive dentin apposition due to pulp healing rather than pulp pathology.[23] In this report, damage to the neurovascular bundle and the maintenance of the remaining pulp vitality may have caused excessive dentin apposition, leading to canal narrowing.[22,24] Terauchi et al. noted that any overhangs coronal to the fractured instrument that could obstruct its removal should be eliminated using rotary instruments or ultrasonic tips.[1] In this case, considering the presence of calcification, the coronal part of the fractured instrument was modified using an ultrasonic tip.

The gray discoloration in the crown of the present case could be attributed to various factors. Partial pulp necrosis, remnants of canal paste or cement, or corrosion of the fractured instrument inside the canal could have darkened the tooth.[2,8,23] Yellow discoloration is a common finding (8%-79%) in teeth with canal obliteration. In contrast, gray discoloration is rarely seen (1%).[23] Oginni et al. reported graying in 34 out of 276 teeth with obliterated canals.[25] The gray discoloration observed in this case may also have resulted from partial obliteration of the canal.[23,24] Non-vital bleaching is a more minimally invasive procedure than traditional treatments such as laminate veneers and full crowns for discoloured non-vital teeth.[26] The literature supports the placement of a cervical barrier and the use of 35% hydrogen peroxide as a bleaching agent without heat activation for longer-lasting and faster effects in discoloured teeth. During and after bleaching, a 2 mm layer of glass ionomer cement prevents the diffusion of the hydrogen peroxide solution.[6] In this case, glass ionomer was placed as a 2 mm thick base, and 35% hydrogen peroxide was used as the bleaching agent. Heat was avoided during bleaching to prevent the possibility of initiating cervical resorption.[27] Additionally, as the pH drop caused by hydrogen peroxide plays a role in external root resorption, temporary dressing with calcium hydroxide was used for buffering purposes.[12]

Initially, the tooth in this case did not respond to vitality tests and was considered necrotic, leading to the commencement of treatment. Following the removal of the fractured instrument, the presence of healthy pulp observed under DOM and the ensuing bleeding led to the suggestion of vital pulp therapy using calcium silicate cements for the patient. However, a pulpectomy was performed based on the patient's decision. Calcification in the coronal part and the vital pulp starting at the middle third level of the canal may have caused the initial devital response.[23, 28] During primary endodontic treatment, the inflamed or necrotic pulp tissue might have been removed, preserving the vitality of the remaining pulp. This aligns with current biologically based endodontic treatments.[29] Therefore, the potential for vital pulp to be present apical to inadequately filled root canals should not be overlooked in cases similar to the one presented here.

4. Conclusion

Due to the lack of a standard treatment protocol for instrument removal, a comprehensive assessment of the situation is necessary before the procedure. The use of ultrasonic tips with DOM has been identified as a predictable and conservative technique for removing fractured instruments. Non-vital bleaching provides rapid, cost-effective, and aesthetically pleasing results for discoloured teeth with pulp canal obliteration. Additionally, the possibility that the pulp tissue apical to the fractured instrument may remain vital should not be disregarded.

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AI Declaration
No generative AI used for writing/analysis/figures.

Conflict of Interest
All authors declare no conflicts of interest.

CRediT Author Statement
A.B.K. : Conceptualization, Investigation, Writing-original draft, Visualization
E.M. : Methodology, Writing-original draft, Writing-original draft, Writing-review & editing, Supervision
M.E.N. : Investigation, Writing-review & editing.

Data Availability Statement
No new data were created or analyzed.

Ethics Approval
Not applicable.

Funding
No external funding.

How to cite this article:

Kızıl AB, Maraş E, Naralan ME. Separated Instrument Retrieval from the Maxillary Canine using only Ultrasonic Energy and Non-Vital Bleaching with Hydrogen Peroxide: A Case Report. *J Endod Restor Dent*. 2026; 4(1):27-31. doi: 10.5281/zenodo.18586263