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Surgical Management of Extruded Fractured Instrument Beyond the Periapical Area: A Case Report with Two-year Follow-up

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ABSTRACT

A fractured instrument is an undesirable endodontic mishap that can prevent complete root canal disinfection, thereby affecting the root canal treatment outcome. The present case discussed the surgical management of an extruded fractured barbed broach at the apical third of maxillary right first premolar. A 28-year-old female presented with an endodontic failure on tooth 14 and was diagnosed as previously root canal treated with symptomatic apical periodontitis. Radiographic examination revealed a straight-line radiopacity structure that was 2 mm in length extruded from the apical root-end, suggesting a fractured instrument. The case was successfully managed through endodontic microsurgery. The present case emphasises the significance of cone-beam computed tomography as a valuable tool for diagnosis and investigation, while also offering supplementary information for the planning of surgical treatment.

Keywords: *Cone-beam computer tomography; endodontic microsurgery; fractured instrument; outcome; periapical infection*

INTRODUCTION

Fractured instruments inside the root canal are distressing and can cause unpleasant complications that occurs during root canal treatment. While not all fractured instrument situations result in a poor prognosis; any mistake that compromises microbial control by the insufficient disinfection and obturation of the root canal might lead to the unfavourable outcome (Spili *et al.*, 2005).

Endodontic files, barbed broaches, and Gates-Glidden burs are all examples of fractured instruments, regardless of whether they are made of nickel-titanium (NiTi) or stainless steel. The frequency rate for broken instruments has been found to range anywhere from 0.7% to 6% (Spili *et al.*, 2005; Terauchi *et al.*, 2022). Stainless steel hand instruments exhibit metal distortion prior to fracture, making it easier to detect, in contrast to the separation of NiTi instruments, which can occur even in the absence of any such signs of fatigue. These instruments can fracture due to the torsional failure or cyclic fatigue (Sattapan *et al*., 2000; Cheung, 2009). Torsional stress occurs when the tips of the instrument become locked within the canal while the shank of the file continues to rotate. Subsequently, the file fractures as the elastic limit of the alloy is surpassed. Conversely, cyclic fatigue transpires when an instrument undergoes continuous rotation within a curved canal, subjecting it to repetitive cycles of tension and compression. Eventually, these mechanical stresses lead to the fracture of the instrument (McGuigan *et al*., 2013).

Numerous treatment regimens have been published for removing fractured instruments, including non-surgical and surgical approaches. The non-surgical approaches encompass various options, such as attempting to remove the fragment, bypassing it, or electing to leave it *in situ* (Madarati *et al*., 2013). If the fragment is inaccessible through a non-surgical approach and there is a presence of a periapical lesion, surgical intervention is recommended. During the treatment planning of a fractured instrument case, numerous factors need to be taken into account. These factors encompass the presence or absence of periapical pathosis, the specific stage at which the instrument fractured during root canal instrumentation, the precise location of the fractured instrument, the root's anatomical structure, the length of the broken fragment, the proficiency of the clinician, the available tools and equipment, potential associated complications, and the strategic significance of the affected tooth (Parashos & Messer, 2006; Madarati *et al*., 2013; Setzer & Kratchman, 2022).

Throughout the past two decades, endodontic surgery has seen significant transformations in a variety of armamentarium and modern technique that have led to a better outcome. Traditional endodontic surgery was performed with limited magnification, bevelled apical resection, retrograde preparation with a slow-speed straight hand piece and bur, and retrograde filling with amalgam. On the contrary, contemporary endodontic microsurgery makes use of a dental operating microscope, smaller osteotomy, zero degree root-end resection, ultrasonic retrograde preparation, and biocompatible calcium silicate cement as retrograde filling material (Setzer & Kratchman, 2022).

This case report aims to delineate the surgical technique employed for removal of an extruded fractured instrument in the maxillary first premolar.

CASE REPORT

A 28-year-old female with no known medical condition was referred to the Endodontic Specialist Clinic for the management of endodontic failure on the maxillary right first premolar. The patient complained of discomfort in the gingiva adjacent to the tooth 14. The tooth had root canal treatment completed in 2015. The extraoral examination was unremarkable. At the site of the complaint, tooth 14 was restored with a metal-ceramic crown with an intact margin (Fig. 1). The shade of the crown slightly radiopaque compared to adjacent tooth. There is present of greyish discolouration of the gingivae due to metal presence from the metal-ceramic crown. It was tender to percussion, and no mobility was detected. Periapical radiographic (Kodak Insight, Carestream Dental LLC, Atlanta, GA) examination revealed a periapical lesion and a straight-line radiopacity structure which was 2 mm length extruded from the apical root-end suggested a fractured instrument beyond the radiographic apex (Fig. 2).

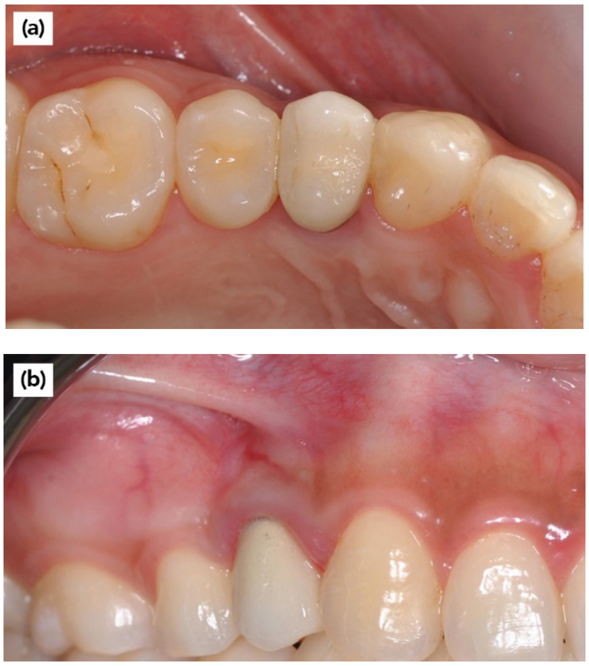

Fig. 1 The pre-operative clinical picture of tooth 14 (a) occlusal and (b) buccal view.

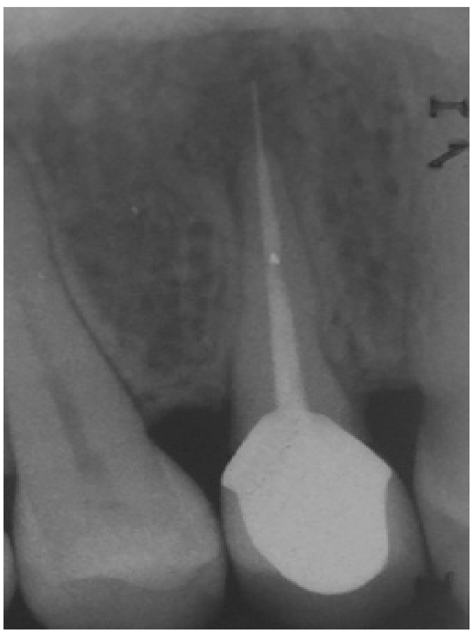

Fig. 2 Pre-operative radiograph of endodontically treated tooth 14.

The extension of the periapical lesion was demonstrated in the axial and coronal views of the cone-beam computed tomography (CBCT). The discontinuity of the buccal plate in the axial view of the CBCT suggested apical fenestrations through the buccal plate at the apical of tooth 14 (Fig. 3a). Utilising the measurement feature of the software (CS 3D Imaging Software, Carestream Dental LLC, Atlanta, GA, USA), the root canal length was determined to be approximately 17 mm, measured from the buccal cusp to the radiographic apex (Fig. 3b). The measurement of root canal length is important as a guide for the clinician to accurately locate the root apex and location of the buccal fenestration.

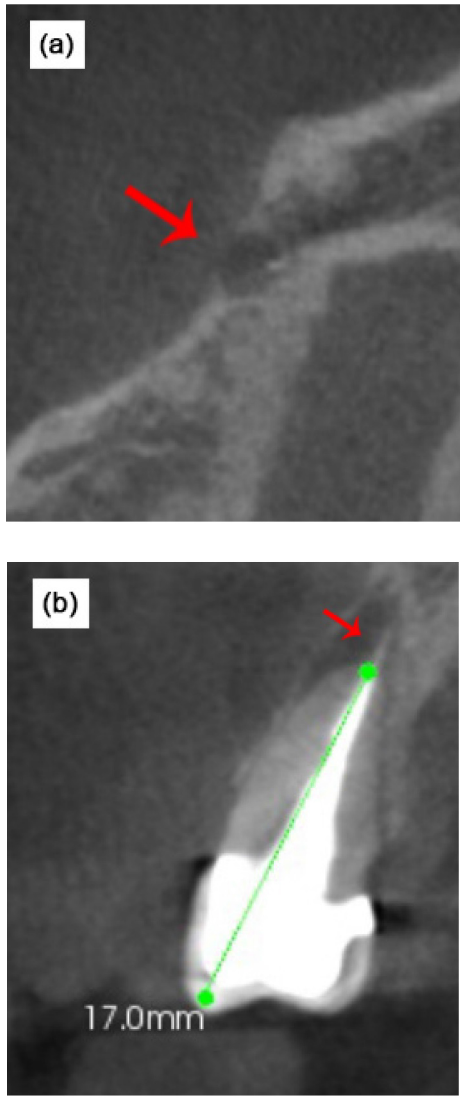

Fig. 3 (a) Axial view of CBCT showing discontinuity of the buccal plate suggested apical fenestrations through the buccal plate at the apical of tooth 14; (b) Coronal view showing 17 mm of root canal length and present of 2 mm fractured instrument beyond the radiographic apex.

Based on the classification by the American Association of Endodontists (2020), the clinical diagnosis of tooth 14 was previously root canal treated with symptomatic apical periodontitis. Treatment options were deliberated with the patient, which encompassed alternatives such as tooth extraction and subsequent implant placement. The treatment plan, advantages and risks were well outlined to the patient prior to surgery. The patient expressed a desire to retain the tooth, and the patient agreed and signed the informed consent for the endodontic microsurgery to remove the extruded instrument.

The patient was administered pre-emptive analgesia Ibuprofen 400 mg 30 min before the surgical procedure. Pre-emptive analgesia is the administration of analgesic medication prior to a surgical procedure used to help manage pain and discomfort that patients may experience during and after the procedure. Non-steroidal anti-inflammatory drug (NSAID) has been recommended for pre-emptive analgesia to potentially decrease the inflammatory response following surgery. This approach may also have benefits in reducing post-operative swelling (Chong & Rhodes, 2014).

The patient was then instructed to rinse with 0.12% chlorhexidine gluconate for a duration of 1 min (Oradex Antibacterial Mouthwash, Oradex, Malaysia). It has been suggested that a mouth rinse containing chlorhexidine, which reduces the number of bacteria in the mouth, be used to lower the risk of infection and facilitate post-operative healing. A surgical operating microscope (Extaro 300, Carl Zeiss, Germany) was utilised during the surgical procedure. Throughout the whole surgical procedure, medium to high magnification (×6 to ×16) was employed.

The patient was anaesthetised using two carpules of 2% mepivacaine (Scandonest®2% L, Septodont, USA) with 1:100,000 epinephrine for buccal and palatal infiltration. A papilla base flap was raised, extending from the mesial papilla of tooth 13 to the distal papilla of tooth 15. Following reflection of the flap, a bone defect in the buccal plate at the apical of tooth 14 was observed (Fig. 4). Granulation tissue was excised entirely using curettes (Medesy, Italy) (Fig. 5a), preserved in formalin solution, and submitted for histopathologic examination. The size of the granulation tissue is 4 mm in diameter (Fig. 5b). At the apical portion of root tip tooth 14, the extruded bard broach was visualised and removed using Stieglitz forceps (Medesy, Italy) (Fig. 6). The fractured barbed broach was 2.5 mm in length (Fig. 7).

A root-end resection of approximately 3 mm was performed utilising a 45-degree surgical handpiece (NSK, Japan) and a Lindemann bur (Meisinger, Neuss, Germany) (Fig. 8). The apical portion was stained with methylene blue (Vista-Blue, Vista Dental Products, Racine, USA) using a microbrush tip saturating the surface and the periodontal ligament and leaving it undisturbed for 10 sec to 15 sec. The staining is then rinsed with saline and dried with sterile cotton pellets. The stained area is examined at ×16 magnification using a dental operating microscope. No crack line was observed. An isthmus could be seen connecting the buccal and palatal canal (Fig. 9). Subsequently, using an angled microsurgical ultrasonic tip ET25 (Acteon, Satelec, France), a 3 mm root-end preparation was made into the resected canal (Fig. 10). The minimum of 3 mm depth of the cavity preparation was determined when the 3 mm ultrasonic tip was fully submerged inside the preparation cavity. After completing the apical preparation, gutta percha should be compressed with an endodontic plugger (Medesy, Italy), dried, and examined with a micromirror (Medesy, Italy).

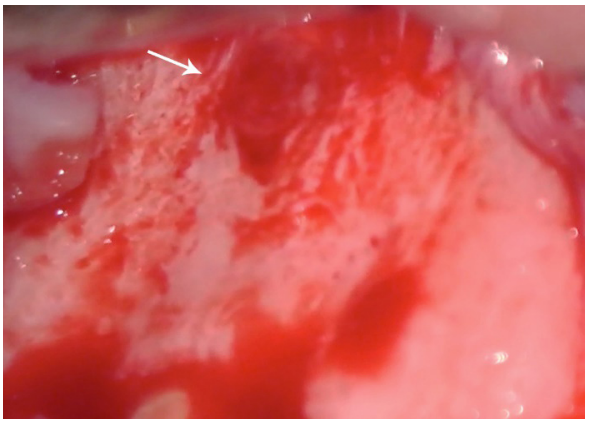

Fig. 4 Buccal fenestration in the buccal plate at the apical of tooth 14 with a size of 4 mm in diameter.

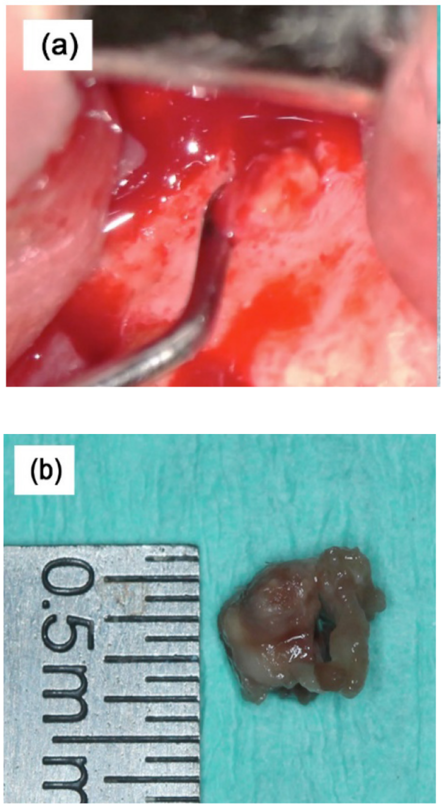

Fig. 5 (a) Removal of granulation tissue using curettage; (b) The size granulation tissue was 4 mm in diameter.

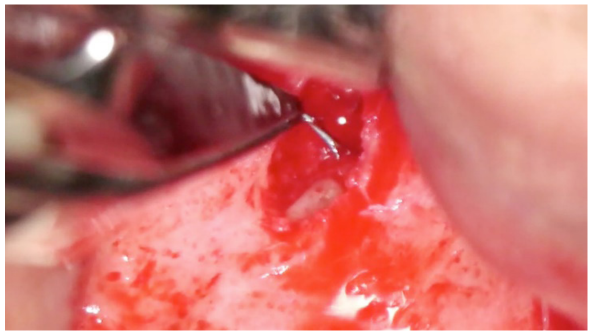

Fig. 6 Removal of the fractured instrument using Stieglitz forceps (Medesy, Italy).

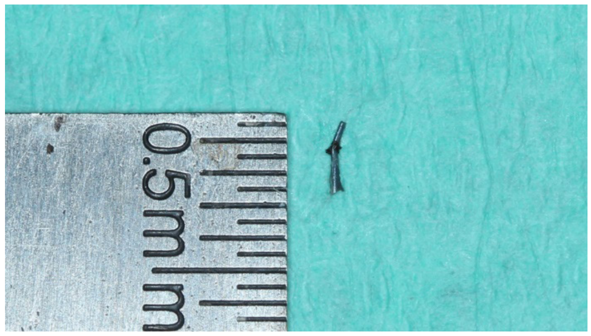

Fig. 7 The fractured instrument was a barbed broach measuring 2.5 mm in length.

The patient attended a recall visit at 6 months and 24 months post-surgery. The patient was asymptomatic, and clinical examination indicated that the tooth was functioning with normal probing pocket depths of not more than 3 mm without bleeding as measured using a periodontal probe (UNC-15, Hu Friedy, USA) with no sensitivity to percussion or palpation (Fig. 14). Periapical radiograph examination at 6 months and 24 months review showed the apical lesion had healed (NanoPix, Eighteeth, China) (Figs. 15 and 16).

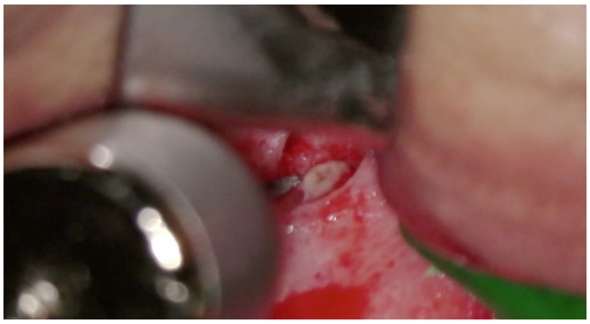

Fig. 8 Root-end resection using Lindemann bur.

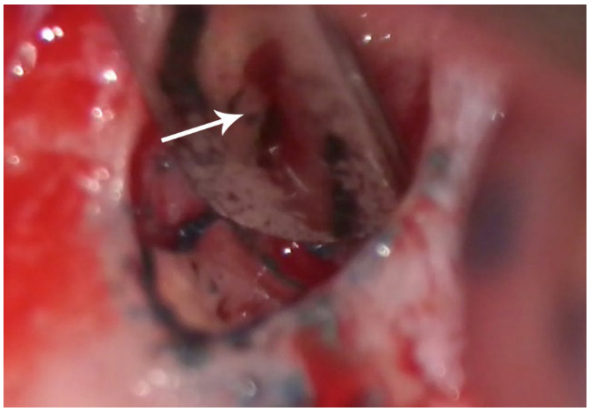

Fig. 9 Staining of the root-end with methylene blue. An isthmus could be seen connecting the buccal and palatal canal.

Fig. 10 Root-end preparations of 3 mm in depth using an angled micro-surgical ultrasonic tip.

Fig. 11 Placement of Bioceramic iRoot BP putty as root-end filling material.

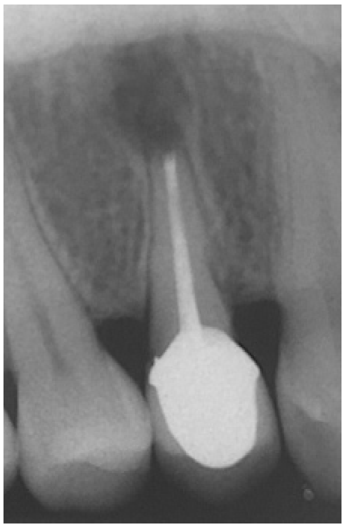

Fig. 12 Periapical radiograph confirmed the proper root-end filling with no void.

Fig. 13 The flap was repositioned and sutured with 5-0 silk sutures.

Fig. 14 Clinical presentation at six months follow-up.

Fig. 15 Periapical radiograph at six months follow-up.

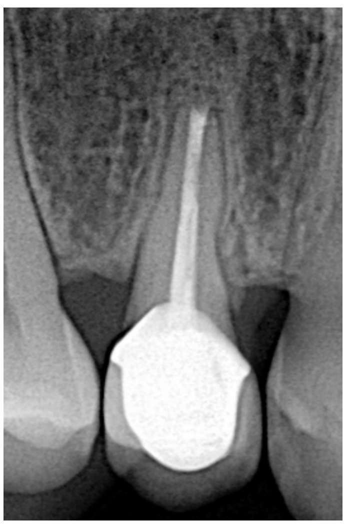

Fig. 16 Periapical radiograph at 24 months follow-up.

DISCUSSION

In the present case, it can be reasonably inferred that the root canal treatment performed on tooth 14 had encountered failure primarily due to the presence of a persistent infection within the canal despite prior treatment attempts. The presence of a fractured instrument posed a challenge to the thorough cleaning and shaping of the root canal system during the root canal treatment. The insufficient disinfection of the root canal resulted in the persistence of bacteria and their by-products, which negatively impacted the treatment outcome (Sjogren *et al.*, 1990). Moreover, the inadvertent extrusion of a foreign body, such as the fractured instrument, into the periapical region during root canal treatment, can significantly intensify the inflammatory response and trigger a foreign body reaction, amplifying the complexity of the case (Nair, 2006).

A barbed broach is an instrument used in endodontic procedures to remove pulp tissue from the root canal of a tooth. It is a thin, flexible, and pointed instrument with tiny barbs or hooks along its shaft that allows it to remove pulp tissue more efficiently. Choosing a broach of appropriate size is crucial; it should be smaller than the diameter of the canal. In the present case, excessively pushing the barbed broach apically may likely encounter resistance and forcing it to the limit may result in breaking the instrument. Removing fracture barbed broaches from the apical parts of the canal is challenging due to their barb design.

The use of CBCT scans has led to an increase in the level of accuracy achieved in both the planning and execution of endodontic surgery. Information from the CBCT scan help to view and understand many aspects of the endodontic surgery that could not be observed in 2-dimensional periapical radiographs. The preferred field of view in endodontics is often considered to be small, as it significantly enhances diagnostic accuracy while minimising radiation exposure to patients (Patel *et al.*, 2019). The imaging was critical not only for making the diagnosis of this periapical lesion, but also for determining its precise position and how far it had spread. It is crucial to point out the importance of CBCT in the process of determining the site of the fracture instruments, which, in this particular instance, benefited the process of surgical planning (Ayatollahi *et al.*, 2019). In the present case, by measuring the root length of the tooth, clinicians will have the knowledge of location of the apical tip and location of buccal fenestration.

Conservative approach using a non-surgical root canal retreatment technique entails significant risks due to the presence of a metal-ceramic crown and a thinner root. The removal of the existing crown and root filling material has the potential to compromise the integrity of the healthy dentin structure, consequently increasing the risk of a vertical root fracture. Additionally, removing fractured instruments in the apical third may result in undesirable outcomes such as ledge development, root canal over-enlargement and transportation, or perforation. Therefore, when devising the treatment plan, it is crucial to incorporate a comprehensive risk assessment that takes into account various factors influencing the probability of successfully extracting a fractured instrument from the root canal, including the degree of canal curvature, the precise positioning of the fractured instrument within the canal, the specific type of instrument that is fractured, and the length of the fractured segment. Such a meticulous evaluation will aid in formulating an appropriate approach and determining the feasibility of the instrument retrieval procedure, ultimately leading to improved clinical decision-making and enhanced treatment outcomes (Madarati *et al.*, 2013).

In this specific case, the requirement for surgical intervention arose due to the presence of a fractured instrument located in anatomically intricate regions, characterised by limited direct visual accessibility and the absence of a straight-line trajectory for instrument retrieval through the root canal. As a result, alternative approaches were essential to successfully address the situation, necessitating surgical intervention to access and remove the fractured instrument from these challenging areas. After flap reflection and removal of granulation tissue, the fractured instrument was easily accessed and successfully removed. The fractured instrument in question was a barbed broach, which can be described as a thin, slender, and flexible manual hand instrument made of metal. Typically tapered and pointed, it features sharp projections that curve in a backward and oblique design (American Association of Endodontists, 2020). Due to instrument design, it was impossible to retrieve non-surgically once it was locked in the dentin, especially when it was extruded apically.

Endodontic microsurgery has changed in many ways over the past two decades. By integrating contemporary methods like high-power magnification for improved vision and illumination, ultrasonic microsurgical tips, and the utilisation of biocompatible calcium silicate cement as a root-end filling material, the approach has achieved an impressive success rate of nearly 90% (Setzer *et al.*, 2010; Tsesis *et al.*, 2013; Kang *et al.*, 2015). In the present case, the surgical procedure was conducted following the modern endodontic microsurgery protocol (Kim & Kratchman, 2006; Royal College of Surgeons of England, 2020; Setzer & Kratchman, 2022).

Magnification is very important aspect during endodontic surgery because it helps to improve the precision and accuracy of the procedure. Surgical techniques that employ magnification yield superior outcomes compared to conventional techniques. The microscope provides a high level of magnification and illumination, which allows the clinician to see the tooth and surrounding structures in greater detail. This improves the accuracy of the procedure and reduces the risk of damage to adjacent structures. Microscope can help the clinician to identify and diagnose dental problems that may not be visible with the naked eye includes cracks, fractures or missed canal (Low *et al*., 2018) AO.

Placing a root filling material during root-end surgery creates an apical seal. The properties of the root-end filling material should be biocompatible, non-toxic, promote bone regeneration, and antimicrobial (Camilleri *et al*., 2022). The invention of calcium silicate cement can be regarded as a breakthrough moment in the history of root-end filling materials. Currently, the first generation of calcium silicate cement available in the market, known as mineral trioxide aggregate (MTA), is regarded as the gold standard for root-end filling material. Tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetra calcium aluminoferrite are stated as the composition in the original patent, along with bismuth oxide powder as a radiopacifying agent. MTA has been proved to possess good sealing ability, biocompatible, and periradicular tissue regeneration capabilities. Despite these advantages, MTA is difficult to handle due to the sandy-like mixture, has a long setting time, and causes tooth discolouration (Torabinejad *et al*., 2018). Additional modifications to the MTA include the addition of chemicals that improve material consistency and handling.

In the present case, a newer calcium silicate-based material, Bioceramic iRoot BP Plus (Innovative BioCeramix Inc., Vancouver, BC, Canada), was used as root filling material. The iRoot BP Plus is an injectable bioceramic-based root repair material that is pre-mixed and ready to use in the form of paste or putty. It has similar biological and physical properties to MTA once it is set but has better handling properties (Walsh *et al*., 2014; Parirokh *et al*., 2018). In a randomised controlled trial conducted by Safi *et al*. (2019), the results revealed no notable distinction in the outcomes of endodontic microsurgery after a 15-month period involving 120 teeth, regardless of whether mineral trioxide aggregate (MTA) or bioceramic root-end filling material was utilised. This result is consistent with the findings of a prospective randomised controlled trial that examined the clinical and radiographic outcomes of endodontic microsurgery employing a novel bioceramic material, the iRoot BP Plus or MTA as root-end filling material. MTA and iRoot BP Plus had a success rate of 93.1% and 94.4%, respectively (Zhou *et al*., 2017). Hence, the iRoot BP Plus is appropriate for root-end filling material due to its biocompatibility, antibacterial and excellent sealing capabilities.

The prognosis of the treatment was considered good in view of the absence of symptoms and evidence of bone regeneration at a 24-month follow-up post-surgery. Further reviews are needed to monitor the healing of the lesions, and its complete resolution is anticipated.

CONCLUSION

Endodontic surgery is the preferred treatment when orthograde endodontic retreatment is not feasible. Employing a dental operating microscope during endodontic surgery has the potential to enhance the level of care and improve treatment outcomes. It enables more precise diagnosis, accurate treatment, and reduce the risk of complications. The advent of BCT marks a significant milestone in advancing modern endodontic treatment. The evolution of CBCT is crucial for diagnosing, evaluating, planning and assessing the outcomes of root microsurgery when it is deemed necessary.

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