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CASE REPORT

Intentional replantation for refractory apical periodontitis in an adolescent mandibular first molar: a case report with 4-year follow-up

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Abstract

Background: Apical periodontitis develops when bacterial infection occurs within the root canal system or periapical tissues. In adolescents, immature permanent teeth often exhibit incomplete canal division and insufficient calcification, which may compromise root canal preparation and obturation. Moreover, when the infection originates from extraradicular biofilms rather than intracanal bacteria, nonsurgical endodontic treatment alone may not be sufficient. In such cases, intentional replantation can provide access for root-end management and removal of extraradicular biofilms, serving as a feasible treatment option when conventional retreatment fails. This report aims to present the clinical rationale, procedure, and long-term outcome of intentional replantation as a conservative management approach for refractory apical periodontitis in an adolescent mandibular molar. **Case**: A 13-year-old male was referred with a persistent sinus tract on the mandibular right first molar following root canal treatment. Retreatment revealed incomplete canal development with a middle distal canal communicating with the distobuccal and distolingual canals. The previously placed calcium hydroxide with iodoform paste was removed, and the canals were refilled with mineral trioxide aggregate (MTA) based materials. Despite initial resolution, recurrence of the apical lesion, accompanied by sinus tract formation, was confirmed at 9 months. Intentional replantation was then performed with extraoral root-end resection and MTA retrofilling. At the 4-year follow-up, clinical and radiographic evaluations demonstrated complete periapical healing, normal mobility and function, and no evidence of root resorption or ankylosis. **Conclusions**: Endodontic management of immature adolescent teeth requires particular caution due to anatomical complexities. When apical periodontitis persists despite conventional retreatment, intentional replantation may be considered a predictable and viable treatment option in selected adolescent patients.

Keywords

Intentional replantation; Adolescent patient; Refractory apical periodontitis; Extraradicular biofilm; Mandibular first molar

1. Introduction

Root canal preparation is a critical step in achieving disinfection of infected root canals. It combines chemical irrigation with biomechanical shaping and is commonly referred to as chemomechanical preparation [1]. The objectives of this procedure are to effectively eliminate bacteria, neutralize their byproducts and toxins, dissolve necrotic or infected pulp tissue, and simultaneously enlarge and expose the root canal system [2]. However, the complexity of root canal anatomy often compromises the completeness of this preparation. Anatomical features such as isthmuses, transverse anastomoses, accessory canals, and bifurcations can make it difficult for instruments and irrigants to adequately reach and clean these areas [3]. When microorganisms persist in these intricate regions, secondary infection may occur, and postoperative pain can be prolonged.

Beyond local anatomic constraints, host-response mechanisms may also influence periapical disease progression and healing. Recent studies in periodontal research have demonstrated that molecular mediators, including microRNAs, are involved in regulating inflammatory and oxidative stress pathways during tissue remodeling [4]. Moreover, nonsurgical periodontal therapy has been associated with improvements in vascular function and reduced subclinical atherosclerosis, as evidenced by echographic assessments such as flow-mediated dilation and carotid intima-media thickness, suggesting a potential systemic benefit of from oral inflammation control [5]. Based on these observations, it may be inferred that the outcomes of root canal infection and treatment are not solely determined by local anatomical or procedural factors but are also linked to molecular pathways that regulate host inflammation and repair, forming an integrated biological network that can influence not only periapical healing but also overall systemic health.

Intentional replantation refers to a procedure in which a tooth is deliberately extracted, treated extraorally, and then reinserted into its original socket to manage clear signs of endodontic failure [6]. Indications include cases where conventional endodontic treatment or nonsurgical retreatment has failed, when apical surgery is not feasible, when anatomical limitations are present, or when patient management during apical surgery is difficult. A key advantage of intentional replantation is its ability to simultaneously address both root-end and extraradicular infections, making it a viable alternative when nonsurgical endodontic therapy and apical surgery are unsuccessful. Although the procedure carries risks such as root resorption and ankylosis, it is associated with a lower risk of bone dehiscence or perforation, thereby minimizing bone loss [7, 8]. Consequently, although intentional replantation may not yet be considered part of conventional endodontic treatment, it is increasingly being recognized as a procedure with a reasonably predictable prognosis [9].

The mandibular first molar typically erupts between the ages of 6 and 7 years, with root formation completing around 9 to 10 years [10]. This tooth plays a crucial role in establishing occlusion and aligning the dentition. However, because of its early crown formation and eruption, it is more susceptible than other permanent teeth to enamel defects such as hypomineralization, as well as to dental caries, and thus requires special care [11, 12]. In particular, teeth affected by extensive carious lesions should be considered for conservative dental treatment, including endodontic options, prior to extraction in order to preserve proper occlusal development and maintain oral health during the growth period. Nevertheless, management of multirooted teeth with severe structural compromise and pulp necrosis can be particularly challenging in young patients [13]. Given these challenges, this report aims to describe the clinical rationale, procedure, and long-term outcome of intentional replantation in an adolescent mandibular first molar with recurrent apical periodontitis and incompletely matured root canals. The rationale of this study was to explore intentional replantation as a biologically and technically feasible option to manage refractory periapical lesions that persist despite conventional retreatment, while preserving tooth function and supporting periapical healing.

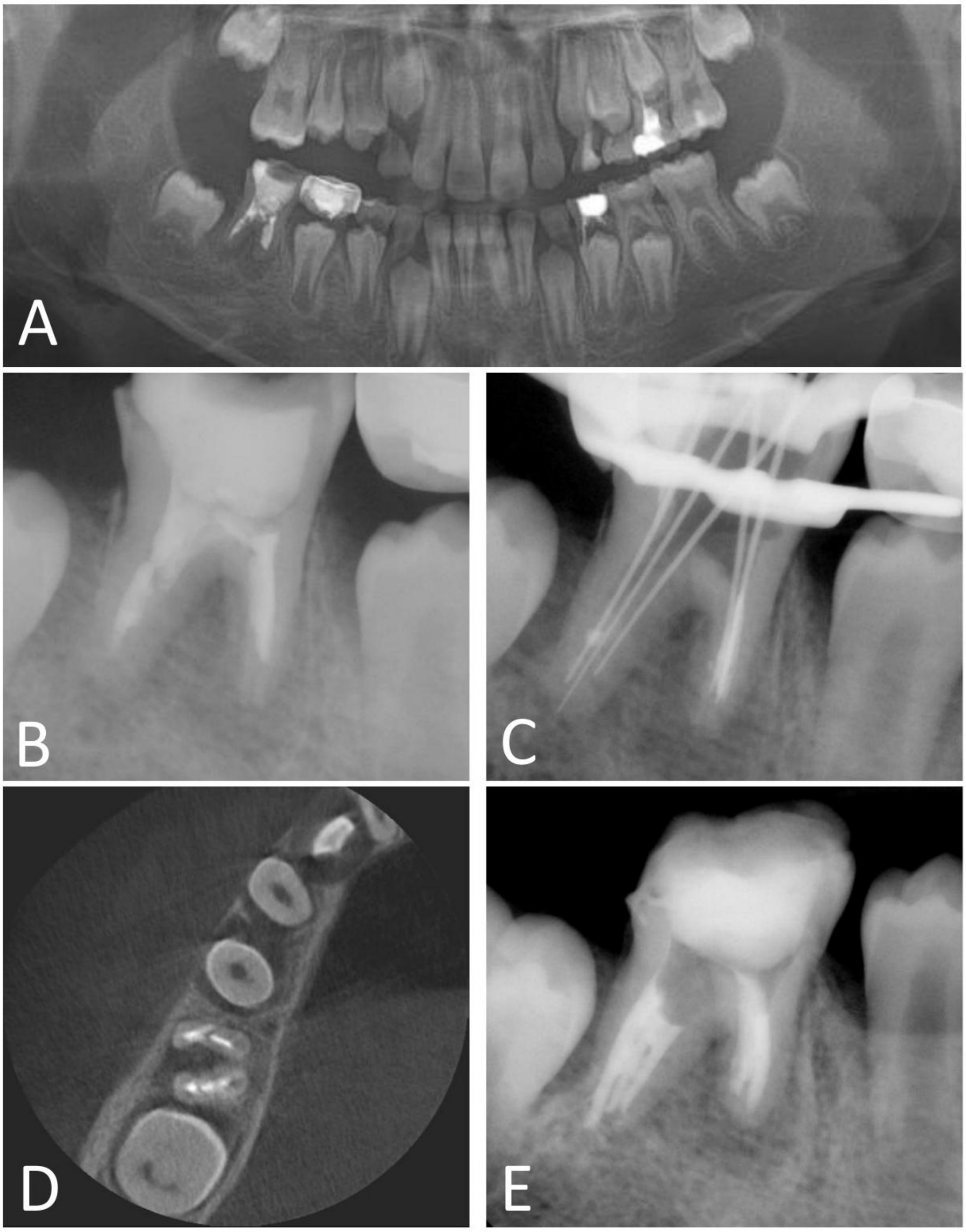
2. Case report

A 13-year-old male patient was referred from a local clinic due to a persistent sinus tract on the gingiva of the right mandibular first molar (#46). According to the referral letter, the tooth had initially undergone pulpotomy and resin filling, but root canal treatment was later initiated because of a periapical lesion. Despite repeated canal irrigation and weekly replacement of calcium hydroxide as an intracanal medicament, the sinus tract did not resolve. The patient was asymptomatic; however, the tooth exhibited grade I mobility and a deep probing depth of 12 mm on the distal aspect. Pre-operative radiographic examination revealed apical lesions in both the mesial and distal roots (Fig. 1A,B), and a sinus tract was present on distal gingiva. The patient's medical history was non-contributory. Based on these findings, nonsurgical orthograde retreatment was indicated according to the inclusion criteria of a tooth with previous endodontic therapy showing persistent apical periodontitis after prior root canal treatment. Exclusion criteria at this stage included structural loss compromising proper isolation or restoration, severe root curvature limiting canal negotiation, and suspected vertical root fracture.

After obtaining informed consent, tooth #46 was isolated with a rubber dam, and all procedures were performed under a surgical microscope (OPMI Pico, Carl Zeiss Meditec, Jena, TH, Germany) without local anesthesia. The previously placed intra-canal medicament, presumed to be calcium hydroxide with iodoform, was removed through canal irrigation and reshaping. Working lengths were determined with an electronic apex locator (Root ZX II; J. Morita, Tokyo, Japan) as follows: mesiobuccal 17 mm, mesiolingual 17 mm, distobuccal 15.5 mm, and distolingual 16.5 mm. Under microscopic inspection, a middle distal canal communicating with the distobuccal and distolingual canals was observed, suggestive of incomplete root development or fusion anomaly. This connecting canal had a working length of 17 mm (Fig. 1C). Root canal preparation was performed using nickel-titanium rotary instruments (ProTaper Next; Dentsply Maillefer, Ballaigues, Switzerland), followed by irrigation with 20 mL of 2.5% sodium hypochlorite. The canals were then medicated with calcium hydroxide paste and temporarily sealed with Caviton (GC, Tokyo, Japan) and resin-modified glass ionomer cement (Fuji II LC; GC, Tokyo, Japan).

At the subsequent visit, cone-beam computed tomography (CBCT) of tooth #46 was performed to better understand the complex root canal morphology observed under the surgical microscope. Consistent with the microscopic findings, the distal canals demonstrated partial communication through a middle canal (Fig. 1D). CBCT images further confirmed the absence of vertical root fracture, thereby supporting the retreatment plan. During the second and third visits, canal irrigation with 2.5% sodium hypochlorite and saline was performed, and the canals were again medicated with calcium hydroxide paste, which was replaced at each visit before temporary sealing. At the fourth visit, after disappearance of the sinus tract was confirmed, root canal obturation was carried out. The mesial canals were obturated with ProRoot MTA (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA), while the distal canals were obturated with gutta-percha and an MTA-based sealer (EndoSeal MTA; Maruchi, Wonju, Korea) (Fig. 1E). At the next appointment, the patient was asymptomatic, and the tooth was restored with a resin core build-up and a stainless steel crown.

At the 6-week follow-up visit, the patient reported no discomfort, and the periapical lesions appeared to have decreased in size (Fig. 2A). However, at the 4-month follow-up visit after canal obturation, the lesion at the mesial root had increased in size compared with the 6-week follow-up (Fig. 2B). And at the 7-month follow-up, the lesion had extended to the distal apex (Fig. 2C). At the 9-month follow-up, sinus tracts were observed in both the mesial and distal gingiva, and gutta-



F I G U R E 1. Preoperative radiographs and treatment procedures. (A) Preoperative panoramic radiograph. (B) Preoperative periapical radiograph. (C) Initial apical files placed in all canals, with the middle canal measured at a working length of 17 mm. (D) Cone-beam computed tomography image showing partial communication between the distal canals through a middle canal. (E) Post-obturation periapical radiograph.

percha tracing indicated communication with the mesial and distal root apices (Fig. 2D). Given the persistent lesion despite appropriate retreatment, intentional replantation was planned. Intentional replantation is indicated when orthograde therapy has failed or when apical surgery is not feasible, provided that the tooth is restorable. Exclusion criteria included severe root curvature or dilaceration that would hinder atraumatic extraction and predictable replantation, vertical root fracture, and nonrestorable coronal or root structure. CBCT was performed to evaluate the extent of the lesion and surrounding anatomy, revealing buccal bone resorption, with the lesion almost completely involving both mesial and distal roots and extending to the area adjacent to the second molar (Fig. 2E,F).

At the next visit, intentional replantation of tooth #46 was performed. Under local anesthesia with epinephrine, the tooth was atraumatically extracted using surgical forceps, after which granulation tissue was carefully curetted and the socket irrigated with sterile saline. Extraoral handling was limited to approximately 10 minutes while the crown was held with saline-moistened gauze to prevent periodontal ligament desiccation. Root-end resection of about 3 mm was then performed perpendicular to the long axis, followed by preparation of a 3 mm retrograde cavity with ultrasonic tips (KiS tips; SybronEndo, Orange, CA, USA) and retrofilling with ProRoot MTA (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA). The tooth was subsequently

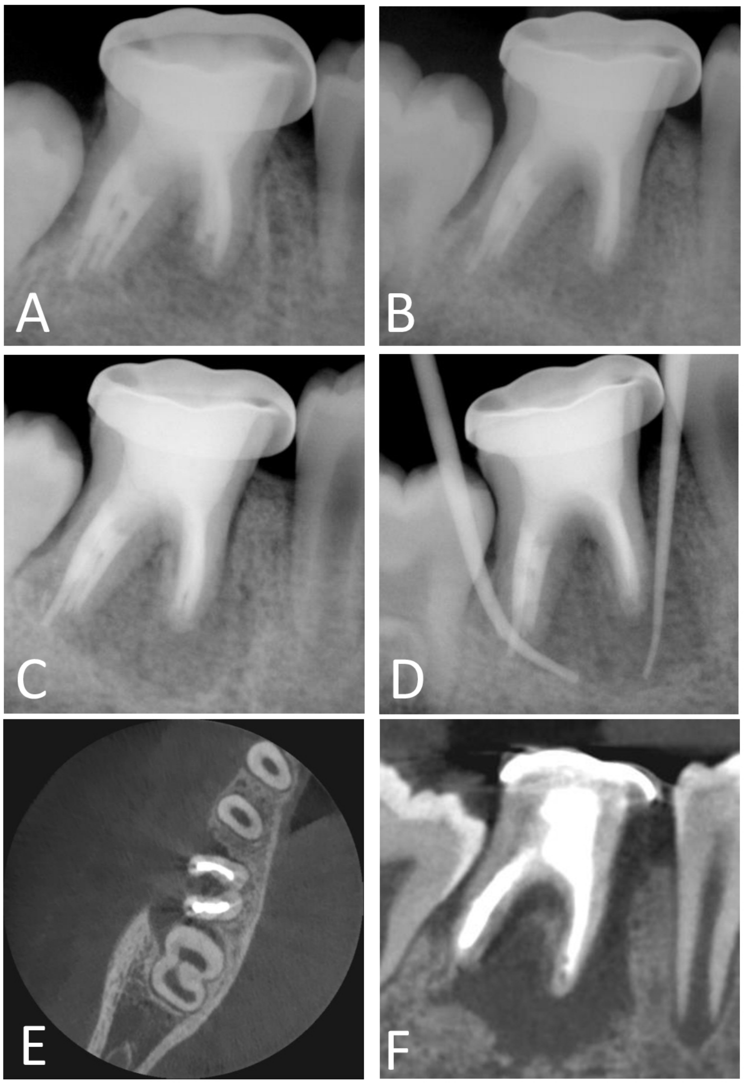


FIGURE 2. Follow-up radiographs after canal obturation, demonstrating progressive enlargement of the periapical lesions. (A) At the 6-week follow-up, the periapical lesion appeared to have decreased in size. (B) At the 4-month follow-up, the lesion at the mesial root had increased compared with the 6-week follow-up. (C) At the 7-month follow-up, the lesion had expanded to involve the distal root. (D) At the 9-month follow-up, further enlargement of the lesion was observed, and gutta-percha tracing of the sinus tract indicated communication with both the mesial and distal root apex. (E) Preoperative axial cone-beam computed tomography image taken prior to intentional replantation, showing buccal bone fenestration and bone loss involving both the mesial and distal roots. (F) Preoperative sagittal cone-beam computed tomography image corresponding to the lesion shown in (E).

repositioned into the socket and stabilized with a resin-wire splint. Postoperative dressing and occlusal adjustment were performed at subsequent visits, and follow-up was continued. Tooth mobility of grade I–II was observed, so the resin wire splint was maintained for 1 month. Once the tooth had stabilized, it was provisionally restored with a polymethyl methacrylate (PMMA)-based computer-aided design/computer-aided manufacturing (CAD/CAM) resin crown (Telio CAD; Ivoclar Vivadent, Schaan, Liechtenstein). At the follow-up evaluations at 15, 21, 36, and 48 months after the initial retreatment, the patient remained asymptomatic, and radiographs demonstrated complete resolution of the apical lesion with no evidence of root resorption or ankylosis (Fig. 3A–F).

3. Discussion

After 4 years of follow-up, the treated mandibular first molar remained asymptomatic and functional, and radiographic assessment confirmed complete periapical healing without any signs of root resorption or ankylosis. Such a result reflects the pathophysiology of apical periodontitis, which is an inflammatory disease caused by bacterial infection, in which bacteria, their byproducts, toxins, and enzymes affect the root canal system and periapical tissues, leading to lesion development. Therefore, elucidating the composition and characteristics of the microbial infection is essential for understanding the pathogenesis of the disease and for establishing effective treatment strategies [14]. The etiology of chronic apical periodontitis is not attributed to a single dominant species

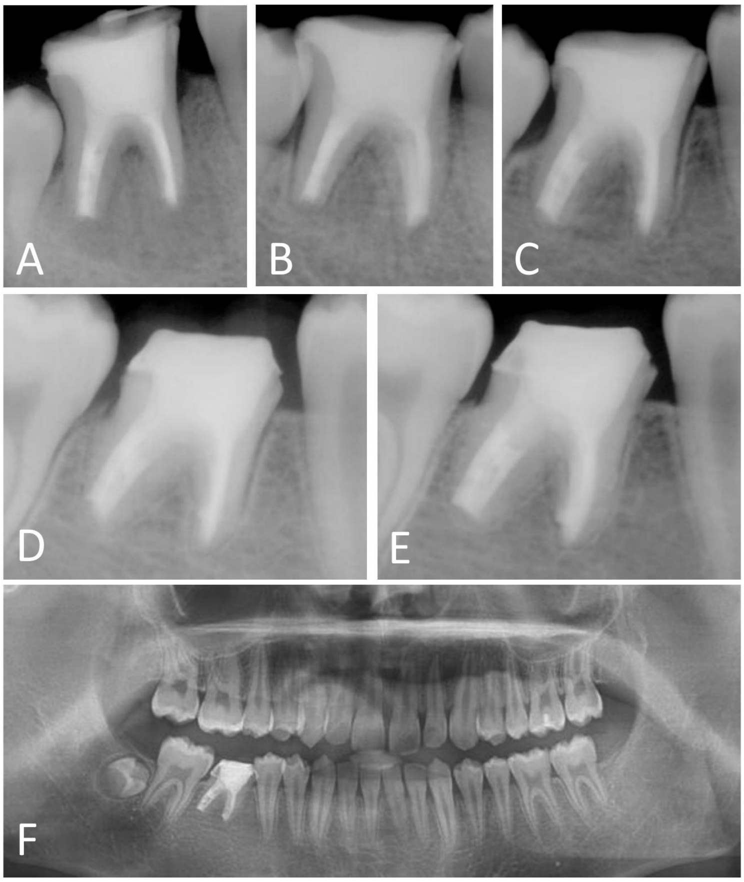


FIGURE 3. Postoperative and follow-up radiographs after intentional replantation (IR). (A) Periapical radiograph taken immediately after IR. (B) Periapical radiograph at 5 months after IR (15 months after the initial retreatment). (C) Periapical radiograph at 11 months after IR (21 months after the initial retreatment). (D) Periapical radiograph at 26 months after IR (36 months after the initial retreatment). (E) Periapical radiograph at 38 months after IR (48 months after the initial retreatment). (F) Panoramic radiograph at 48 months after the initial retreatment. Note: A provisional CAD/CAM resin crown fabricated from a PMMA-based block (Telio CAD; Ivoclar Vivadent, Schaan, Liechtenstein) had been placed 26 months after IR; however, due to the radiolucent nature of this material, its outline is not visible on the radiographs.

but is considered non-specific and polymicrobial, typically consisting of a mixture of obligate and facultative anaerobes [15]. Due to their specific localization within the root canal system, these bacteria are not readily controlled by the host immune response or systemic antibiotics, thereby necessitating professional dental intervention [16]. Nonsurgical endodontic treatment aims to eliminate these pathogens through chemomechanical canal preparation, which combines mechanical shaping by endodontic instruments with the antibacterial and tissue-dissolving effects of irrigants. Additionally, interappointment intracanal medication with calcium hydroxide provides further antibacterial action [17]. However, complete elimination of bacteria may not always be achieved. Gram-negative bacteria, which are commonly found in primary intracanal infections, are more easily reduced during canal preparation, whereas Gram-positive bacteria may persist in the root canal system despite chemomechanical instrumentation and intracanal medication [18]. Moreover, microorganisms residing in inaccessible anatomical complexities such as the apical delta, lateral canals, and isthmuses are difficult to eradicate, often contributing to secondary infections after conventional endodontic treatment [17].

Another possible factor contributing to the refractory inflammatory lesion in this case is the immature canal development associated with adolescence. Because root and canal morphology in adolescents is not fully developed, these teeth are considered endodontically immature compared with those in adults, which inevitably compromises the quality of root canal treatment [19]. With increasing age, the extension of calcification nuclei and the deposition of secondary dentin lead to narrowing of the canals, thereby allowing more predictable instrumentation and obturation [20]. In adolescents, however, insufficient calcification and incomplete canal division may result in inadequate canal instrumentation or obturation [19]. In the present case, when the patient was referred from the local clinic and retreatment was initiated, a middle distal canal communicating with the distobuccal and distolingual canals was observed. This connecting canal showed a working length of 17 mm when measured with a #15 K-file (Fig. 1C). Cone-beam computed tomography images also confirmed the incompletely separated distal canals (Fig. 1D). Moreover, the previously placed calcium hydroxide with iodoform from the local clinic likely failed to achieve sufficient disinfection.

Calcium hydroxide with iodoform paste is widely used in pediatric endodontics as an obturation material. It is composed of calcium hydroxide, iodoform, and an inert vehicle such as silicone oil. Calcium hydroxide exerts antibacterial effects due to its strong alkalinity, while iodoform acts as a bacteriostatic agent through iodine release, and the inert vehicle prolongs the therapeutic effect of calcium hydroxide [21, 22]. Moreover, this paste has a resorption rate similar to that of primary teeth, is antiseptic, and offers convenient handling, which explains its frequent use as a filling material in pulpectomy procedures for primary teeth [23]. However, caution is required when using calcium hydroxide with iodoform in permanent root canal therapy. Because calcium hydroxide components undergo ionization and dissolution over time, void formation and microleakage may increase. In addition, its high resorbability confers a temporary or deciduous-tooth-oriented nature, making it unsuitable as a definitive filling material [24, 25]. Prolonged exposure to calcium hydroxide has also been associated with decreased fracture resistance of roots, raising concerns about structural stability if the material remains long term [26]. In the present case, the calcium hydroxide with iodoform paste that had been placed during initial treatment at the local clinic was removed during retreatment, and the canals were obturated with MTA, an MTA-based sealer, and gutta-percha. In the distal canals, where calcification and separation were incomplete, MTA powder was used, whereas in the mesial canals, conventional obturation with gutta-percha and sealer was performed. The superior sealing ability, biocompatibility, and hard tissue-inducing capacity of MTA as a filling material have been well documented in previous studies [27].

In addition to intracanal factors, the persistence of the lesion despite retreatment suggests the involvement of other etiologic factors. In the present case, although the lesion initially appeared to decrease after retreatment (Fig. 2B), its size increased again 4 months after obturation (Fig. 2C), and a sinus tract reappeared at 7 months (Fig. 2D). This suggests the possibility of a persistent infection caused by bacteria residing in the extraradicular area. The extraradicular area refers to the solid portion beyond the root canal system that communicates with the external root surface through the apical foramen, where bacterial biofilms are particularly difficult to eliminate [28]. Previous studies have demonstrated that in more than 80% of teeth extracted with chronic periapical lesions or resected during apicoectomy, bacterial biofilms were detected on the extraradicular cementum within 2–3 mm of the apex [29–31]. Moreover, the microbial composition of extraradicular biofilms may differ from that of intraradicular biofilms, suggesting an independent pathogenic role that contributes to resistance against antimicrobial agents and the host immune response [32]. Therefore, extraradicular biofilms should not be overlooked as a factor underlying the chronic nature of refractory apical periodontitis, and surgical endodontic treatment should be considered when conventional root canal therapy or retreatment fails to resolve the lesion.

In the present case, intentional replantation was selected after recurrence of the lesion despite retreatment. Although apicoectomy via apical surgery is a possible option when nonsurgical retreatment fails, such an approach requires flap reflection, osteotomy for lesion access, and retrograde preparation and retrofilling under a surgical microscope. These steps prolong the operative time and demand a high level of patient cooperation. In contrast, intentional replantation is a relatively straightforward procedure that avoids flap reflection and involves only careful extraction and repositioning of the tooth, thereby reducing surgical time and complexity. Provided that the root is not severely curved and the periodontium remains healthy, intentional replantation may be considered as a viable alternative [8, 33]. Given that the patient was a 13-year-old adolescent with significant anxiety about surgery, achieving cooperation for a prolonged apical surgery was doubtful. Furthermore, the distal canals showed incomplete separation with a large connecting canal, making thorough debridement and sealing difficult through a conventional surgical approach. Intentional replantation provided extraoral access to the entire root surface, allowing more effective biofilm removal and reliable retrograde filling.

The procedure of intentional replantation allows for the removal of bacterial biofilms located in the extraradicular region by performing an extraoral root-end resection of approximately 3 mm. In addition to root-end resection, exposing the root surface to an aerobic environment outside the alveolar socket may also contribute to the elimination of persistent bacteria, since extraradicular biofilms frequently harbor obligate anaerobic species. Noguchi *et al.* [28] analyzed extraradicular biofilms obtained from teeth with refractory periapical periodontitis using polymerase chain reaction (PCR)-based 16S rRNA gene amplification and identified 113 bacterial species, among which *Fusobacterium nucleatum*, *Porphyromonas gingivalis*, and *Tannerella forsythensis* were most frequently detected. All three species are obligate anaerobes whose survival, metabolic activity, and adherence are significantly reduced upon exposure to oxygen [34]. Therefore, intentional replantation may be considered an effective treatment option for eliminating the causative bacteria of persistent inflammatory lesions through both root-end resection and aerobic exposure.

Recent evidence has also highlighted that oxidative stress acts as a key biological mediator linking oral inflammatory lesions with systemic vascular dysfunction. Polizzi *et al.* [4] demonstrated that specific oxidative stress-related microRNAs, including miR-21 and miR-125b, are involved in the regulation of osteoclastogenesis and bone remodeling during periodontal inflammation, reflecting an epigenetic connection between local tissue responses and systemic inflammatory pathways. Furthermore, a recent systematic review and meta-analysis has reported that nonsurgical periodontal therapy may improve endothelial function and carotid intima-media thickness, supporting a possible systemic link between oral inflammation and vascular health [5]. Collectively, these findings imply that oxidative stress-related mechanisms triggered by oral infection may extend beyond local healing responses, potentially influencing systemic disease progression.

This case report has several limitations. First, it describes the outcome of a single adolescent mandibular first molar, and therefore the findings cannot be generalized to all immature permanent teeth with refractory apical periodontitis. Second, the presumed involvement of extraradicular biofilm was based on the clinical course and radiographic progression rather than on direct microbiological or histopathological confirmation. Third, although the 4-year follow-up supported a favorable outcome, this report does not allow direct comparison with other treatment options such as apical surgery. The broader biological implications discussed in this report should also be interpreted cautiously, as they were not directly evaluated in this case. Further accumulation of well-documented cases and comparative clinical studies is needed to clarify the indications, predictability, and long-term clinical value of intentional replantation in adolescent patients.

4. Conclusions

In adolescents, incomplete root development and indistinct canal division may limit the effectiveness of conventional root canal treatment in eradicating infection. When persistent infection arises from both intracanal and extraradicular biofilms, surgical intervention may become necessary. Intentional replantation offers a conservative yet biologically sound alternative for managing refractory apical periodontitis, as it enables thorough root-end debridement and removal of extraradicular biofilms while preserving the natural tooth. Furthermore, by eliminating the source of chronic inflammation and oxidative stress, such management may facilitate periapical healing and improve host inflammatory balance.

AVAILABILITY OF DATA AND MATERIALS

All data supporting the findings of this case report are included within the article.

AUTHOR CONTRIBUTIONS

MJL—designed the study, performed the clinical treatment, collected and interpreted the data, and wrote the manuscript; read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

According to the Standard Operating Procedure of the Institutional Review Board of Jeonbuk National University Hospital, Jeonju, Korea, studies that do not collect or record personally identifiable information may be exempt from formal ethical review. This anonymized case report met these criteria, and ethical approval was therefore waived. Written informed consent for publication of this case report and accompanying images was obtained from the patient's guardian.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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