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Revitalization of a necrotic mature tooth with external root resorption: Case report and mini review of the literature

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Abstract

Although the conventional apexification procedure—which uses long-term intracanal calcium hydroxide medication to promote the formation of a calcified barrier at the apical foramen—has been widely accepted for more than 40 years, it has significant drawbacks. The weakening effect of prolonged calcium hydroxide application on thin dentinal walls, the resulting high incidence of root fractures, the failure to promote canal wall thickening even when a mineralized barrier is formed using mineral trioxide aggregate, and the unfavorable crown-to-root ratio all contribute to increased susceptibility to fracture. Regenerative endodontic procedures, which apply the tissue-engineering triad of stem cells, biomimetic scaffolds, and growth factors, have therefore been proposed as a biologically based alternative for teeth with pulp necrosis arising from trauma, caries, or developmental anomalies. Although these procedures were developed for immature teeth, protocols employing revascularization and autologous platelet concentrates as scaffolds are increasingly being explored in mature teeth, for which the supporting evidence remains limited. This report describes the regenerative endodontic treatment of an asymptomatic necrotic mature left mandibular second premolar with a chronic apical abscess and external inflammatory root resorption in a 19-year-old woman, using autologous platelet-rich fibrin as a scaffold sealed with mineral trioxide aggregate. Over 12 months of follow-up the tooth remained asymptomatic, the sinus tract resolved, the periapical radiolucency decreased, the resorptive defect appeared arrested, and the tooth responded to thermal testing while remaining unresponsive to electric pulp testing. A focused review of the literature is included to situate this approach among the available alternatives. Within the limitations of a single case with short-term follow-up, this procedure may represent a treatment option for mature necrotic teeth with external inflammatory root resorption; controlled studies with longer follow-up are required.

Keywords: Regenerative endodontics, revitalization, platelet-rich fibrin, root resorption, mineral trioxide aggregate

Introduction

Revascularization preserves tooth vitality and promotes root development in immature permanent teeth through regeneration. This is achieved by inducing a blood clot in the apical region during root canal disinfection (1).

Regenerative endodontic procedures (REPs) are currently among the most promising biologically based treatment options for immature permanent teeth diagnosed with pulp necrosis and apical periodontitis (2–4). Although the long-term prognosis remains uncertain, REPs may support the revitalization and preservation of necrotic immature teeth, particularly in cases involving wide open apices and early-stage root development, where conventional techniques using calcium hydroxide or mineral trioxide aggregate (MTA) apical plugs may have limited reliability (5).

The resorption of dental hard tissues is associated with osteoclastic cell activity (6). Continuous loss of dentine and cementum due to clastic cellular function is undesirable (7). Increased clastic activity, often resulting from bacterial infection or chronic pulpal inflammation, may be considered a predisposing factor for resorption (8). External inflammatory root resorption (EIRR) is defined as a dynamic process that leads to loss of various dental tissues, including the periodontal ligament (PDL), dental hard tissues, and, in advanced cases, the dental pulp itself (9). This phenomenon often presents as small cemental lesions within the PDL and may progress to pulpal involvement if left untreated (10). Factors that trigger EIRR include traumatic injuries, replantation of avulsed teeth, intentional (auto)replantation, and autogenous tooth transplantation (11). Because EIRR is a progressive lesion that can result in gradual destruction of the tooth structure and, ultimately, tooth loss (12), it must be diagnosed promptly, managed appropriately, and treated effectively. Consequently, the treatment of EIRR varies depending on its etiology, severity, and relationship with the pulpal tissue (13). A recent study suggested that REPs may be a potential therapeutic option for managing EIRR; however, they are not currently considered a first-line treatment and further clinical research is warranted (14). Nevertheless, it has been demonstrated that prompt endodontic intervention—applying an appropriate calcium silicate-based biomaterial and eliminating microorganisms—may halt and counteract the progression of root resorption in reimplanted and avulsed teeth (11).

In this case, dental revitalization was performed on a young permanent tooth with pulp necrosis accompanied by external root resorption. This treatment protocol is presented as an alternative to traditional approaches. Furthermore, in light of the current literature, the role and efficacy of dental revitalization in endodontic practice are discussed in the form of a mini-review.

Case Presentation

A 19-year-old female patient with no reported systemic diseases was referred to the Department of Endodontics by the Department of Oral Diagnosis and Radiology for a routine dental examination. Clinical evaluation revealed a sinus tract in the buccal mucosa at the apex level of the left mandibular second premolar. The tooth was not tender to percussion or palpation, and no mobility was detected. It gave no response to cold testing and was unresponsive to electric pulp testing, findings consistent with pulp necrosis. Radiographic examination showed a periapical radiolucency associated with the left mandibular second premolar, leading to a diagnosis of chronic apical abscess (Fig. 1a). An EIRR lesion was also diagnosed in the apical third of the same tooth.

At the first visit, local anesthesia was administered, and rubber dam isolation was achieved. An access cavity was prepared (Fig. 1b), and the working length was established 1 mm short of the apex using a #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland), which was confirmed radiographically (Fig. 1c). Canal irrigation was performed using 20 mL of 1.5% sodium hypochlorite, followed by 10 mL of distilled water, and 20 mL of 17% EDTA for 5 minutes. After irrigation, the canal was dried with paper points, and calcium hydroxide was placed as an intracanal medicament. The tooth was temporarily restored with glass ionomer cement (CX-Plus Glass Ionomer Cement; Shofu Dental Corporation, Kyoto, Japan) (Figure 1d), and the patient was scheduled for a second appointment 2 weeks later. At the second visit, the patient's venous blood was collected into a tube without anticoagulant and centrifuged at 3000 rpm (approximately 400 g) for 10 minutes to obtain platelet-rich fibrin (PRF). Rubber dam isolation was reestablished under local anesthesia without a vasoconstrictor. The canal was irrigated with 20 mL of 17% EDTA and dried with paper points. Bleeding was induced by over-instrumenting 2 mm beyond the apical foramen with a #25 K-file. The PRF clot was separated from the red blood cell and plasma layers using sterile scissors and inserted into the canal using sterile pluggers. MTA (MTA Angelus; Angelus Dental Solutions, Londrina, PR, Brazil) was placed over the PRF (Fig. 2a), and the tooth was permanently restored using resin-modified glass ionomer cement (Ruby Liner Light-Cured Glass Ionomer; Rubydent, Istanbul, Türkiye) and composite resin (Kerr Herculite Classic; Kerr Dental, Orange, CA, USA) (Fig. 2b).

Follow-ups were conducted at 1, 3, 6, 9, and 12 months (Fig. 3). At the 1-month follow-up, the radiograph revealed a radiopaque band in the cervical region, which was attributed to compaction of MTA into the canal. In subsequent follow-ups, this area gradually transformed into a radiolucent zone. At the 6-month follow-up, the tooth remained asymptomatic and responded to thermal testing.

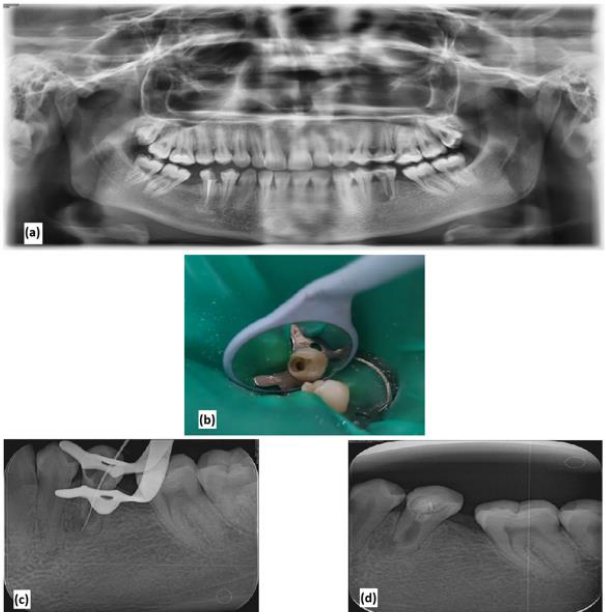

Figure 1. First session treatment protocols. (a) Panoramic radiograph taken prior to treatment. (b) Access cavity preparation. (c) Working length determination. (d) Radiograph taken after the first session.

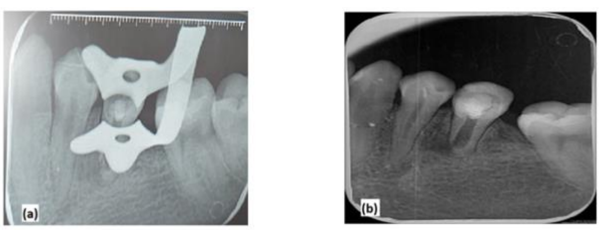

Figure 2. Second session treatment protocols. (a) Radiograph taken after PRF and MTA application. (b) Radiograph taken following final restoration.

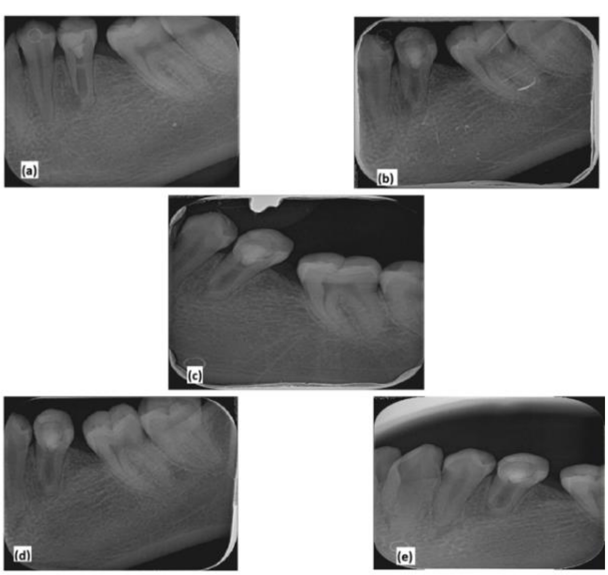

Figure 3. Follow-up radiographs. (a) One-month post-treatment radiograph. (b) Three-month post-treatment radiograph. (c) Six-month post-treatment radiograph. (d) Nine-month post-treatment radiograph. (e) Twelve-month post-treatment radiograph.

Clinical and radiographic assessment at 9 months confirmed that the tooth remained asymptomatic. No symptoms were observed at the 12-month follow-up. Radiographic evaluation showed increased radiopacity within the canal, closure of the resorption defect, a reduction in periapical radiolucency, and an enhanced trabecular pattern. As in previous follow-ups, the tooth responded to thermal tests but remained unresponsive to electric pulp testing. At the time of writing, clinical and radiographic monitoring is ongoing.

Mini Review

All steps related to REP, from diagnosis to treatment, are organized under three main headings.

A. Case selection criteria

Biologically based approaches, referred to in the literature as 'revascularization' or 'regenerative endodontic procedures (REPs),' aim to stimulate the influx of stem cells from the apical papilla, leading to the (re)formation of pulp-like tissue within the root canal space (15). This treatment resolves pain and inflammation and promotes the healing of periapical lesions (2). Additionally, it is expected to enhance the mechanical strength of the root through an increase in both root length and thickness—a process referred to as maturogenesis (2, 3).

The key elements of revitalization procedures include:

- Minimal or no instrumentation of the canal walls
- Disinfection using irrigants
- Application of intracanal medicaments
- Induction of bleeding into the canal space and clot formation
- Sealing with a hydraulic silicate cement and achieving an effective coronal seal (4)

Regeneration refers to the restoration of the original tissue architecture and function. However, histological studies following revitalization have shown that, although healing or repair may occur, true regeneration is not achieved in many cases. Repair is defined as the formation of fibrous tissue, cementum, or bone within the root canal, resulting in partial loss of function and ectopic tissue formation (16–20). Provided that mineralized tissue is deposited and alveolar bone health is maintained, the precise histological identity of the tissue may be of limited clinical significance. According to the European Society of Endodontology (ESE) position statement, revitalization treatment is indicated for necrotic immature permanent teeth. However, contraindications for this procedure include:

- Recently replanted avulsed teeth (revitalization may occur naturally)

- Inability to achieve proper tooth isolation
- Extensive coronal tissue loss requiring post-restoration, which obstructs the space needed for blood clot formation
- Luxation injuries, due to insufficient clinical evidence supporting revitalization protocols
- Medically compromised patients (ASA Class III or above), for whom conventional treatments may be more appropriate

In addition to these criteria, the American Association of Endodontists (AAE) guidelines emphasize the importance of patient compliance and the absence of allergies to the materials used. Both associations strongly recommend that patients be fully informed about the treatment procedures, potential side effects, and alternative treatment options (4, 21). A comparison of the first-visit protocols outlined in the ESE and AAE guidelines is presented in Tables 1 and 2.

Table 1. Comparison of first appointment protocols in ESE and AAE guidelines.

Step	ESE (European Society of Endodontology) Protocol (4)	AAE (American Association of Endodontists) Protocol (21)
Clinical evaluation	Performed according to a checklist (history, age, gender, etiology, signs, symptoms, systemic and dental background, current medication).	Clinical assessment is performed (including history, initial appointment symptoms, antimicrobial use, systemic and dental history, etc.).
Cleaning & Isolation	Cavity is cleaned; local anesthesia (if necessary), rubber dam isolation, and disinfection (e.g., chlorhexidine) are performed.	Local anesthesia is administered, and rubber dam isolation is applied.
Access cavity preparation	Access cavity is prepared.	Access cavity is prepared.
Pulp tissue removal	Loose and necrotic pulp tissue is removed with endodontic instruments.	Loose and necrotic pulp tissue is removed with endodontic instruments.
No mechanical instrumentation of canal walls	No mechanical instrumentation is performed on canal walls.	No mechanical instrumentation is performed on canal walls.
Irrigation	1.5-3% sodium hypochlorite (NaOCl) is used as irrigant (20 mL, 5 min), delivered 1 mm short of working length. During irrigation, low concentrations are preferred to minimize cytotoxicity and preserve stem cell viability.	20 mL of 1.5% NaOCl is used as irrigant, placed 1 mm short of working length.
Additional irrigation	Bleeding or exudate control may require additional irrigation.	Additional irrigation may be required in case of bleeding or exudation.
Sterile saline irrigation	Final rinse with sterile saline; low-concentration NaOCl is used to minimize cytotoxicity.	Final rinse with sterile saline is performed.
Drying	Canals are dried with sterile paper points.	Canals are dried with sterile paper points.
Edta irrigation	17% EDTA (20 mL) is used as a final irrigant.	20 mL of 17% EDTA is used as a final irrigant.
Medicament placement	A calcium hydroxide paste with a colorless vehicle is placed using a lentulo spiral or syringe to the working length.	Calcium hydroxide or triple antibiotic paste (metronidazole, ciprofloxacin, minocycline) is placed using a lentulo spiral or syringe.
Temporary restoration	A temporary coronal seal is placed with minimum 3-4 mm thickness (e.g., Cavit™, IRM™, or glass ionomer).	A temporary coronal seal is placed with minimum 3-4 mm thickness (e.g., Cavit™, IRM™, or glass ionomer).

Abbreviations: ESE: European Society of Endodontology; AAE: American Association of Endodontists; NaOCl: Sodium hypochlorite; EDTA: ethylenediaminetetraacetic acid.

Table 2. Comparison of second appointment protocols in ESE and AAE guidelines.

Procedure	ESE Protocol (4)	AAE Protocol (21)
Clinical assessment	Evaluated according to checklist (including cold test, electrical pulp test, pain, mobility, percussion sensitivity, radiographic evidence of root development, periapical lesion healing, and absence of symptoms).	Reassessment for signs of pain, mobility, swelling, or sinus tract. Pulp vitality tests and radiographs are used to confirm root development and healing.
Anesthesia	Administered without vasoconstrictor.	Administered without vasoconstrictor.
Irrigation	17% EDTA (20 mL) for 5 minutes without mechanical instrumentation.	20 mL of 17% EDTA for 5 minutes without instrumentation.
Induction of beeding	Apical tissues are over-instrumented 2 mm beyond apex to induce bleeding.	Bleeding is induced by over-instrumentation using a sterile K-file, ensuring a scaffold for tissue ingrowth.
Scaffold placement	A resorbable collagen matrix is placed over the blood clot (2-3 mm below CEJ).	A resorbable collagen matrix or blood clot is placed 2-3 mm below CEJ. PRP or PRF may be used as alternative scaffolds.
Sealing material	MTA (2-4 mm thickness) is placed over the scaffold.	MTA or bioceramic material is placed over the scaffold.
Waiting period	Permanent restoration is placed 2-4 weeks after initial appointment.	Permanent restoration is placed 2-4 weeks after initial appointment.
Follow-up	Systemic antibiotics may be necessary; radiographic and clinical assessments are advised.	If clinical signs are present, systemic antibiotics or further treatment options are considered.

Abbreviations: ESE: European Society of Endodontology; AAE: American Association of Endodontists; EDTA: ethylenediaminetetraacetic acid; MTA: mineral trioxide aggregate.

B. Follow-up appointments

According to the ESE position statement, follow-up appointments should be scheduled at 6, 12, 18, and 24 months following treatment and then annually for up to 5 years. In cases where signs of persistent infection or inflammation are observed, where retreatment becomes necessary, inflammatory root resorption is detected, or alternative treatment options (such as autotransplantation) are being considered, follow-ups at 3-month intervals are recommended. Additionally, it should be noted that teeth undergoing orthodontic treatment may be more susceptible to inflammation and apical root resorption following revitalization. Therefore, it is advisable to allow adequate time for healing before initiating orthodontic movement and to shorten the intervals between follow-up appointments during the orthodontic treatment period (4). In the present case, follow-ups were conducted every three months because of external root resorption.

C. Success criteria

The success of the treatment is evaluated based on the absence of pain and inflammation, healing of existing periapical lesions, increases in root length and thickness, cessation of external root resorption, positive response to sensibility tests, patient acceptance of the treatment, an acceptable degree of tooth discoloration, and radiographic evidence of newly formed PDL along the inner root canal wall (4).

Discussion

Root canal revascularization is a biologically based alternative to apexification. Promoting continued root development has the potential to preserve immature permanent teeth that are structurally fragile, helping to thicken canal walls and protect them against fractures in the long term. Additionally, it can lead to the healing of periapical lesions, continued apical development, and possible sensibility recovery, while preventing the loss of permanent teeth in children and young adults and reducing the future need for implants, bridges, or removable prostheses. However, despite these advantages, undesirable outcomes may occur (22).

Although the literature demonstrates the effectiveness of REPs in healing apical lesions and promoting root development, cases of REP failure and the absence of root maturation have also been reported (23-25). Only a few studies have investigated prognostic factors influencing the outcomes of REPs to guide clinical practice (26-28). However, these studies vary in methodology and are limited by small sample sizes (50, 62, and 46 cases, respectively), making it difficult to draw definitive conclusions (26–28).

REPs in immature teeth with apical periodontitis have generally shown favorable outcomes, with high success rates ranging from 83.3% to 100% (26, 29, 30). Nevertheless, there is increasing evidence of REP failures due to persistent infection, root resorption, and fractures (31–34). In a systematic review by Almutairi et al. (35), 79% of failed REP cases presented with persistent infection; 56% of the 37 failed cases were associated with dental trauma, and 39% failed after a follow-up period exceeding 2 years. Dental trauma has been shown to impair apical vascularity and reduce resistance to infection, contributing to early failure. In the present case, by contrast, no history of dental trauma was reported and the etiology was attributed to external inflammatory root resorption. It should be noted that the follow-up period in this case report was relatively short—limited to 12 months—compared with the longer-term follow-up periods reported in the literature.

In failed REP cases, Lee and Song (34) recommended evaluating all available endodontic options, including a second REP attempt, apexification, conventional root canal therapy, surgical approaches, and extraction, based on factors such as tooth restorability, canal accessibility, and the presence of an apical barrier. In non-vital, immature permanent teeth, apexification supported by corona-radicular adhesive restorations may provide a successful long-term conservative alternative when REP fails (37).

Various intracanal medicaments, such as calcium hydroxide and triple antibiotic paste (TAP), have been used for disinfection (38–41). Although TAP has been applied with varying success in recent REP cases, its disadvantages include crown discoloration and adverse effects on the physical and mechanical properties of dentine (38). As a result, modifications of TAP and its antibiotic combinations have been explored to improve outcomes (38, 42, 43). One such formulation, PMC, comprising penicillin G, metronidazole, and ciprofloxacin, has recently been introduced, with promising clinical results. This modified antibiotic mixture is delivered via biopolymer-coated microparticles and has demonstrated broad-spectrum antimicrobial activity against the dominant microflora of the root canal system (44). Although calcium hydroxide was used as an intracanal medicament in this case, no studies have compared the effects of PMC versus calcium hydroxide in REPs.

Following EDTA irrigation in regenerative procedures, growth factors embedded in the dentine matrix are released into the canal space (15). These growth factors have been shown to signal dental pulp stem cells to differentiate into odontoblast-like cells and produce reparative dentine (45–47). Although mesenchymal stem cells have been shown to be delivered into the canal space during REPs (48), animal and human histological studies indicate that they frequently fail to differentiate into odontoblast-like cells and do not reconstitute a true dentine-pulp complex (17, 20).

In addition, to strengthen dentine and promote root development in immature teeth, a scaffold or biologically active procedure that supports mineral deposition and vital tissue formation is often placed within the root canal (1, 3, 49). In comparative studies between blood clot revascularization, platelet-rich plasma, and PRF, platelet-rich plasma and PRF were found to produce better outcomes in terms of apical closure, apical diameter reduction, periapical healing, and root lengthening (50). In a case report by Prasad et al. (51), apical bridge formation was observed only in the incisor teeth treated with PRF. In the present case, we chose PRF as the scaffold.

MTA was used as the sealing material in the present case because of its documented capacity to support cell proliferation and odontoblastic differentiation of stem cells from the apical papilla (52). Although this case report is limited by the short follow-up period (12 months) and the inability to compare the procedure with alternative methods because it was a single case, it documents the short-term success of REP in a necrotic mature tooth with coexisting external resorption.

Conclusion

Within the limitations of a single case followed for 12 months, REP performed on a mature necrotic tooth with concomitant external inflammatory root resorption produced favorable short-term clinical and radiographic outcomes. Controlled studies with follow-up of at least 24 months are required before REP can be recommended for comparable cases.

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This study was evaluated by external independent reviewers. Informed consent was obtained from each patient participating in the study. The authors declare that they all contributed to the design, execution, and analysis of the manuscript and approved its final version. The authors have no conflicts of interest to disclose, and the study was conducted without any financial support.

Disclosures

Informed Consent: Written informed consent was obtained from the patient for the publication of the case report and the accompanying images.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – A.Ç.; Design – A.Ç.; Supervision – M.Y.Ö.; Materials – A.Ç., M.D., A.B.; Data collection and/or processing – A.Ç., M.D., M.Y.Ö., A.B.; Analysis and/or interpretation – A.Ç., M.Y.Ö.; Literature search – A.Ç., M.D.; Writing – A.Ç.; Critical review – M.Y.Ö., A.B.

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