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Case Report

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Successful Periapical Lesion Healing without Root Canal Obturation Associated with Photodynamic Therapy: A Case Report

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Abstract

Introduction: Total bacterial disinfection in root canal therapy is challenging due to residual infected dentin, which may harbor bacteria. Photodynamic therapy (PDT) enhances antibacterial efficacy and supplements conventional endodontic treatment.

Case Presentation: This case report describes the healing of a large periapical lesion in a 22-year-old male patient with pulp necrosis and a secondary acute apical abscess in the mandibular left incisors. The patient underwent cleaning and shaping of the root canal system, but did not return for obturation. After chemo-mechanical preparation and calcium hydroxide dressing, the patient received PDT using 0.1 mg/mL Toluidine Blue (FotoSan®; CMS Dental, Denmark) and an LED lamp (630 nm, 3 W/cm^2). Despite the absence of root canal obturation and delayed treatment, radiographic examination at the 1-year follow-up showed complete healing of the periapical lesion with no symptoms.

Conclusion: This unexpected outcome suggests that PDT may improve disinfection and lead to successful treatment even without conventional root canal obturation. PDT, when combined with conventional root canal therapy, may enhance treatment outcomes.

Keywords: Photodynamic therapy; Periapical periodontitis; Root canal therapy; Endodontics; Calcium hydroxide; Bone regeneration; Healing.

Introduction

The primary goal of root canal therapy is to eliminate microorganisms from the root canal system by both mechanical instrumentation and chemical irrigation procedures. This approach involves canal debridement and shaping, irrigation with disinfecting agents such as sodium hypochlorite or chlorhexidine, application of intracanal medication, and finally, sealing of the root canal system with obturation.[1,2]

However, achieving complete bacterial elimination from the root canal system is still a challenge in endodontic treatment. This challenge can be attributed to two primary factors: the complex anatomical structure of root canals and the inherent limitations of current instrumentation techniques. Root canals show intricate morphological anatomy, including lateral canals, isthmuses, and dentinal tubules,[3] which create numerous microscopic spaces where bacteria can establish colonies. These anatomical complexities make it extremely difficult for both irrigants and mechanical instruments to access all areas effectively. Furthermore, research has demonstrated that regardless of the sophistication of the instrumentation techniques employed, certain portions of canal walls inevitably remain untouched during the cleaning and shaping procedures. This mechanical limitation results in the incomplete removal of the internal layer of infected dentin, known as the contaminated dentin layer. The persisting contaminated layer can harbor viable bacteria, potentially compromising the long-term success of root canal treatment.[4]

In search of bacteria disinfecting strategies, photodynamic therapy (PDT) shows promising results in both in vivo and in vitro studies.[5] PDT is simply defined as the light-induced toxin effect of a photosensitizer (PS) agent. At first, the PS is nontoxic, and it is applied in the root canal system and is absorbed by the microorganisms inside the root canal, but it is then activated when illuminated by a specific wavelength and releases molecular oxygen. These free radicals will eliminate the microorganisms and disinfect the root canal system.[6] However, there are not many studies reporting the effectiveness of the combination of conventional root canal therapy and PDT in patients.[7]

This case describes the successful treatment of mandibular incisors (teeth #23 and #24), with large, well-defined periapical lesions. The treatment approach

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combined conventional, thorough cleaning and shaping methods with PDT, but root canal filling was unintentionally not performed.

This case describes unusual healing of the large, well-defined periapical lesion surrounding mandibular incisors (teeth #23 and #24), even with no root canal obturation due to the delayed return of the patient for completing the treatment. The hypothesis of the authors is that this rare outcome happened due to the application of PDT accompanied by conventional root canal therapy. This case underscores the efficacy of PDT when utilized along with RCT in the reduction of the bacterial load.

Case Presentation

A 22-year-old male patient presented to a dental clinic with severe pain and swelling in his anterior mandibular region. His medical history was unremarkable (ASA I), but his dental history revealed childhood trauma resulting in the fracture of his maxillary anterior teeth that were restored with composite veneers. No lymphadenopathy, trismus, or facial swelling was observed on extra-oral clinical examination. The intra-oral clinical examination revealed lingual swelling in the mandibular anterior region, crowding of mandibular anterior teeth, and calculus on tooth #24 (mandibular left lateral incisor). Tooth #23 had no restoration, while tooth #24 had a composite veneer (Figure 1).

Diagnostic tests were performed to assess the vitality status of the affected teeth. Pulp sensibility tests (cold and electric) yielded negative responses for teeth #23 and #24 (mandibular left lateral and central incisors), while adjacent teeth responded normally to the sensibility tests. Both teeth #23 and #24 exhibited Grade I mobility and severe pain on percussion. Palpation of the area revealed tenderness. Periodontal probing revealed a 5-mm periodontal pocket on the buccal aspect of tooth #23, while tooth #24 showed a normal probing depth (Figure 1).

Radiographic examination revealed a large, well-defined unilocular radiolucency surrounding the roots of mandibular anterior teeth (Figure 1). Based on the clinical and radiographic findings, a diagnosis of pulp necrosis with a secondary acute apical abscess was made for teeth #23 and #24. The treatment plan included root canal therapy for both affected teeth.

The treatment was commenced under local anesthesia with 1.8 mL of lidocaine HCl 2% with epinephrine 1:80000 (Darupakhsh Pharmaceutical Mfg. Co., Tehran, Iran) following rubber dam isolation. Upon access cavity preparation, purulent discharge was observed from both teeth (Figure 1). Working length was determined by using an apex locator (Root ZXII, Morita). Radiographic examination revealed the presence of a single canal in each tooth. Chemo-mechanical preparation was performed using endodontic hand files (Micro Mega, France). The S1, S2, F1, F2, and F3 files of the ProTaper rotary system (Dentsply Maillefer, Ballaigues, Switzerland) with E-Connect Pro rotary motor (Eighteeth®, Jiangsu, China) were used for root canal instrumentation, accompanied by a thorough irrigation protocol consisting of 5.25% sodium

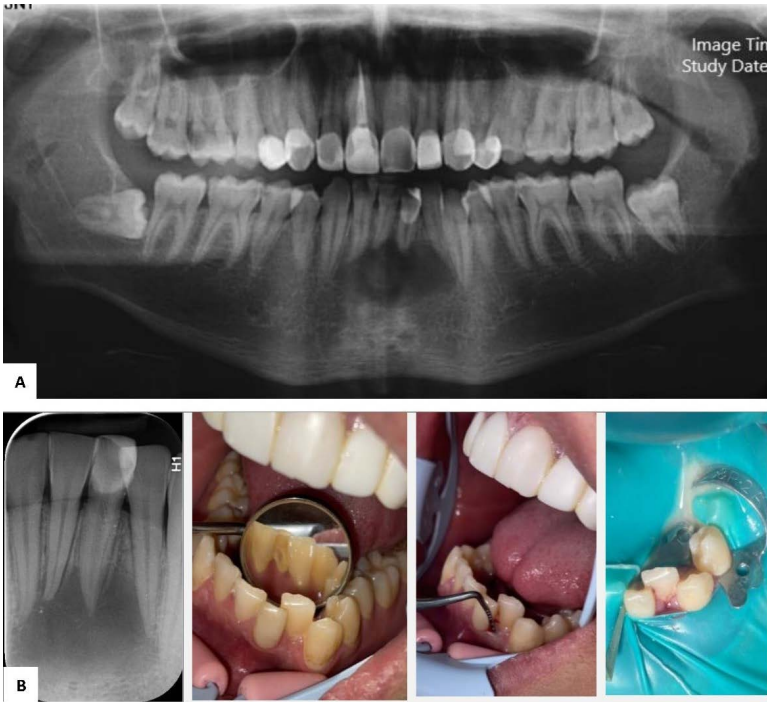

Figure 1. (A) Initial panoramic radiograph; (B) Initial periapical radiograph of teeth #23, #24, and #25 demonstrating periapical radiolucency; (C) Initial clinical photograph of mandibular incisors; (D) Periodontal probing which revealed a 5-mm pocket on the buccal aspect of tooth #23; (E) Purulent discharge observed from access cavities of teeth #23 and #24 during treatment

hypochlorite (Hyponic; NikDarman, Tehran, Iran), 17% EDTA (NikDarman, Tehran, Iran), and saline, along with ultrasonic activation (Woodpecker U6 Ultrasonic device). The finishing file F3 was used for both teeth #23 and #24. After final irrigation, sodium thiosulfate 5% (Merck, Darmstadt, Germany) was used to balance NaOCl effects in the root canal environment. The PS used for this case was low viscosity 0.1 mg/mL Toluidine Blue (FotoSan® agent; CMS Dental, Denmark). Following the injection of PS in each root canal, the extra PS was brushed to the canal walls with circumferential movement of a #20 endodontic hand file. After letting the PS agent remain for one minute, it was illuminated by the light-emitting diode (LED) lamp (FotoSan®; CMS Dental, Denmark) operated at a mean wavelength of 630 nm and a mean power density of 3 W/cm2 for three 20-second periods. This procedure was performed for each tooth (Figure 2). After the PDT, canals were irrigated and then dried with sterile absorbent paper cones (GAPADent Co, Tianjin City, China). After that, a calcium hydroxide dressing (Golchadent, Tehran, Iran) mixed with 0.2% chlorhexidine (Iran Najo, Tehran, Iran) was placed in the canals, and the access cavities were temporarily sealed with 3 mm of Coltosol (Aria Dent, Tehran, Iran). The patient was prescribed antibiotics (500-mg amoxicillin and 500-mg metronidazole) every 8 hours for one week. The root canal treatment was not completed in this session due to severe pain and swelling.

Contrary to the treatment plan, the patient failed to return for his scheduled second treatment session. He showed up approximately 6 months later, presenting clinical improvement with reduced swelling, pain, and tooth mobility. Radiographic examination revealed periapical healing and bone formation (Figure 3). However, the temporary restorations showed significant leakage. Therefore, it was decided to carry out the cleaning and shaping procedure one more time. The irrigation protocol was repeated, and a new calcium hydroxide dressing was placed. Unfortunately, the patient did not return for treatment completion as scheduled.

The patient's third visit took place approximately 12 months after the initial treatment. Clinical examination showed that the temporary restorations were either lost or leaking. Surprisingly, radiographic examination revealed complete healing of the periapical lesion with lamina dura formation (Figure 3). The patient reported no symptoms.

Considering these findings, the final treatment steps were carried out. The irrigation protocol was repeated, and after a final rinse with 5.25% sodium hypochlorite, the root canals were obturated with the lateral compaction technique using an EndoPlus root canal sealer (President Dental, Germany). The access cavities were then sealed with Coltosol (Figure 3).

This case presents an interesting scenario where the complete resolution of a large periapical lesion was

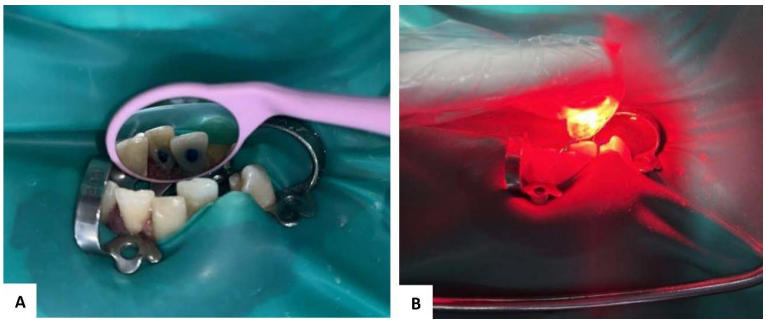

Figure 2. (A) Injection of methylene blue into the root canal system to ensure penetration and coverage; (B) Irradiation of the photosensitizer using an LED to activate the photosensitizer and generate reactive oxygen species for antimicrobial effect

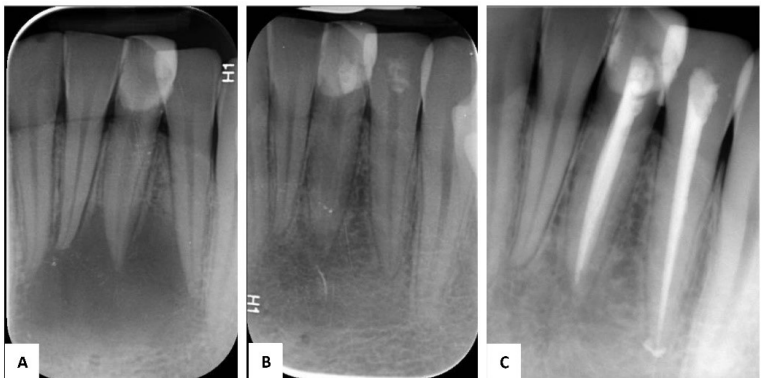

Figure 3. (A) Initial periapical radiograph showing the large periapical radiolucency around teeth #23 and #24; (B) Periapical radiograph taken at the second treatment session, 6 months after initial treatment, demonstrating evidence of bone formation and lesion reduction; (C) Final periapical radiograph at the third session, approximately 12 months after initial treatment, showing complete healing with lamina dura formation

achieved despite the patient's irregular attendance and extended treatment duration. Notably, this healing occurred in the absence of a conventional obturation during the healing phase, suggesting that thorough disinfection and adjunctive methods as Photodynamic therapy (PDT) may be the critical factors in promoting periapical healing, even in the case of delayed treatment completion.

Patient Consent and Treatment Delay

The patient was fully informed about the novel use of PDT and the deviation from the conventional protocol of root canal obturation, including potential risks related to delayed or incomplete treatment. Informed consent was obtained prior to treatment initiation, covering possible outcomes such as prolonged healing time, need for further interventions, or failure of treatment. The patient acknowledged these risks and agreed to proceed, despite interruptions in follow-up care. These discussions and consent documentation ensured ethical transparency and respect for patient autonomy throughout the extended treatment period.

Discussion

This case report highlights an unusual and significant finding: successful healing of a large periapical lesion without conventional root canal obturation, potentially facilitated by PDT. While root canal obturation is considered a cornerstone of endodontic treatment, our case suggests that thorough disinfection, enhanced by PDT, may suffice to promote periapical healing in some scenarios.

Root canal obturation is the standard practice in endodontics, with numerous studies focusing on obturation techniques and materials and their efficacy for leakage prevention. However, the necessity of obturation itself has rarely been questioned. Researchers have explored various obturation lengths, materials ranging from gutta-percha to novel options like bioceramics and Resilon, and methods for minimizing leakage. Many clinicians link treatment failures primarily to improper obturation. Nevertheless, root canal obturation may be theoretically unnecessary if root canals are thoroughly disinfected and coronal leakage is prevented efficiently.[8] Occasionally, poorly obturated root canals are observed without symptoms or periradicular radiolucencies, although such cases are uncommon.

Shah and Logani reported successful endodontic outcomes in both short- and long-term evaluations of cases with the placement of calcium-sulphate-based cement and permanent restoration over the orifice of non-obturated cleaned and shaped canals.[9] Similarly, Asgary and Fazlyab reported successful treatment of a severely decayed mandibular second molar with periradicular periodontitis by leaving the mesial root non-obturated.[10] They sealed the canal orifices with calcium-enriched mixture cement followed by final restoration. The concept of leaving a properly disinfected canal empty remains largely unexplored and challenges traditional endodontic assumptions, warranting further investigation to potentially refine root canal therapy approaches.

The present case report demonstrates successful healing of a large periapical lesion without conventional root canal obturation, which may be attributed to the use of PDT alongside conventional root canal treatment. PDT combines a photosensitizer, light of a specific wavelength, and oxygen to produce reactive oxygen species (ROS) that exert potent antimicrobial effects by damaging bacterial lipids, proteins, and nucleic acids.[11] Beyond microbial inactivation, PDT may promote periapical tissue healing through bio-stimulatory effects such as enhanced fibroblast proliferation and angiogenesis, thereby accelerating tissue repair. These dual antimicrobial and healing mechanisms make PDT a promising adjunct in endodontic treatment, especially in complex cases where conventional disinfection is insufficient. However, further clinical studies are needed to confirm and optimize these benefits.

In recent studies, PDT has demonstrated great potential in disinfecting root canal systems, specifically in non-reachable areas such as anatomical variations that make the conventional cleaning and shaping impossible, in pulp canal obliteration or severe calcification cases where endodontic files fail to reach the apical 1/3 of the root canal, or in the cases with fractured instruments where the fractured piece cannot be removed or bypassed.[6,7,12]

Periapical healing and its required time can vary based on the size of the lesion and the patient's immune response. However, based on the literature, periapical repair and bone formation usually occur 12 to 24 months after conventional endodontic treatment, and assessments should take place within 24 to 48 months after the treatment.[13,14]

Nonetheless, this case report demonstrated periapical healing, bone formation, and lamina dura formation in a duration of 6 months - even without complete root canal obturation. This rapid periapical healing and new bone formation may be related to adjunctive PDT. Moreover, Firmino et al. report a similar outcome in their case report. They treated a patient with chronic dentoalveolar abscess with a radiolucent lesion next to the apexes of teeth #11 and #21 using a combination of conventional root canal therapy and PDT. The periapical lesion in this case had completely disappeared after 6 months. While Firmino et al. demonstrated PDT's ability to accelerate periapical healing when used as an adjunct to conventional root canal therapy, their protocol still relied on complete obturation following treatment. Similarly, Amaral et al. showcased PDT's remarkable capacity to salvage cases complicated by separated instruments, yet their approach

also maintained the standard obturation protocol. In contrast, our results challenge fundamental endodontic principles by demonstrating that complete periapical healing can occur without root canal filling when PDT is properly implemented.[7,15]

There is more supporting evidence on the positive effects of PDT on periodontal bone formation. De Almeida et al studied the effect of PDT on furcation bone loss in rats and demonstrated that the rat group treated with PDT showed less bone loss compared to other groups.[16] Sarkarat et al studied the efficiency of PDT in reducing bisphosphonate-related osteonecrosis of the jaw (BRONJ) in rats. They demonstrated that PDT is extremely effective in preventing BRONJ and it can maintain bone remodeling by inducing osteoclasts.[17]

Among different PS compounds, methylene blue was chosen for its hydrophilic characteristic, low molecular weight, effectiveness in releasing more reactive oxygen particles, and promising results in similar endodontic cases.[6,15]

LEDs were used in this case report as they are less harmful due to their lower thermal activity and their minimum induced tissue injury.[18]

Limitations

This case report is limited by its nature as a single-patient observation, restricting the ability to generalize findings broadly. Although radiographic evidence indicated healing of the periapical lesion following PDT without root canal obturation, these outcomes cannot be assumed for all patients or clinical contexts. Larger, controlled studies are necessary to validate the efficacy and safety of PDT as a standalone and an adjunctive treatment in endodontics.[11] Furthermore, radiographic healing does not equate to histologic healing; radiographs offer an indirect assessment and cannot demonstrate cellular-level repair or true biological regeneration. Without histological confirmation, conclusions about the completeness and quality of tissue healing remain provisional. Future research incorporating histopathological evaluation would be valuable to better characterize PDT's healing potential.

Conclusion

In conclusion, this case report demonstrates that RCT accompanied by PDT can increase the success rate of endodontic treatment, and adjuvant PDT therapies can minimize the bacterial load in the root canal environment and can have satisfactory periapical healing effects by inducing bone formation. However, more detailed clinical studies are still needed to identify its efficacy in routine clinical procedures.

Authors' Contribution

Conceptualization: Navid Nasrabadi.
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Formal analysis: Navid Nasrabadi.
Investigation: Mohadeseh Asgari.
Methodology: Navid Nasrabadi.
Resources: Mohadeseh Asgari.
Software: Mohadeseh Asgari.
Supervision: Nazanin Zargar.
Validation: Nazanin Zargar.
Visualization: Navid Nasrabadi.
Writing–original draft: Ghazal Hemmati.
Writing–review & editing: Ghazal Hemmati, Mohadeseh Asgari.

Ethical Approval

The patient provided written informed consent prior to treatment initiation. The consent process included comprehensive discussion of treatment success rates, prognosis, and the critical importance of follow-up care. The patient was also informed of alternative treatment options available in the event of treatment failure. All procedures were conducted in accordance with the principles of the Declaration of Helsinki and institutional ethical guidelines.

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