



Photobiomodulation-Assisted Vital Pulp Therapy in a Mature Permanent Tooth: A Case Report

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Abstract

Introduction: Maintaining pulp vitality in mature permanent teeth with deep caries is challenging, especially when initial vitality tests are negative.

Case Presentation: A 45-year-old male presented with extensive caries in the maxillary left lateral incisor, asymptomatic but non-responsive to cold testing, and with delayed electric response. Selective caries removal was performed without anesthesia to assess sensitivity. Photobiomodulation (PBM) using a 635-nm diode laser (100 mW, 4 J/cm²) was applied over deep dentin near the pulp with a 2-mm tip. Subsequent sessions irradiated buccal and lingual surfaces with an 8-mm tip. Pulp sensitivity returned by the fifth session, and after seven sessions, the tooth was restored with composite resin. A well-sealed adhesive restoration was placed without a liner.

Conclusion: At 6-month follow-up, it remained vital and asymptomatic with normal radiographic findings. Diode laser PBM may restore pulp reactivity in mature teeth, supporting conservative vital pulp therapy.

Keywords: Vital pulp therapy, Photobiomodulation, Diode laser, Mature permanent tooth, Pulp regeneration

Introduction

Preserving pulp vitality in permanent teeth with deep carious lesions remains a primary clinical objective, given the long-term advantages of maintaining a functional and immunocompetent pulp-dentin complex.^{1,2} Historically, teeth showing signs suggestive of irreversible pulpitis or loss of vitality have been managed through root canal treatment. However, evolving biological concepts and emerging technologies now challenge this paradigm, emphasizing Vital Pulp Therapy (VPT) even in cases previously deemed non-viable.^{3,4} Recent studies highlight that pulp tissue retains some healing potential, even in mature teeth presenting with symptoms of irreversible pulpitis.⁵ This has led to increased interest in minimally invasive regenerative techniques, including the application of diode lasers. Diode laser therapy has biomodulatory and anti-inflammatory effects which increase tissue regeneration and improve healing outcomes in VPT procedures.^{6,7} The main clinical challenge is often observed in managing immature teeth with progressive necrosis; however, evidence supports the efficacy of various lasers in regenerating damaged soft tissues and facilitating peripheral nerve repair. Clinical trials have shown promising results with diode laser pulpotomy in both primary and young permanent teeth, suggesting its potential to stimulate pulp recovery.⁸ Yet, its use in asymptomatic teeth with extensive caries and absent

initial cold response remains largely undocumented. This case report presents a unique scenario in which diode laser therapy successfully restored pulp reaction in an asymptomatic permanent incisor with extensive caries and no initial response to vitality testing. This outcome suggests that Diode laser therapy may have regenerative effects even in mature teeth, potentially expanding conventional treatment boundaries.

Case Presentation

A 45-year-old male patient presented with severe carious involvement in the maxillary left lateral incisor. The tooth was without spontaneous pain and any periapical radiographic appearance. Initial pulp vitality testing using the cold test (Endo-Frost) showed no response, while the electric pulp test (EPT) produced a delayed positive response at approximately 22 units. The tooth was non-tender to percussion. Pre-operative radiographic findings are shown in [Figure 1](#). To further assess pulpal status, selective caries excavation was initiated without local anesthesia to evaluate intraoperative sensitivity as an indicator of residual pulp vitality. Despite reaching deep dentin, the patient reported no discomfort. The procedure was halted before pulp exposure, and a temporary restoration was placed. The low-level laser used was a 635-nm diode laser (Smart M, Lasotronix, Warsaw, Poland), which was applied using the 'nerve

damage’ setting with an output power of 100 mW and an energy dose of 4 J/cm². During the initial visit, the laser irradiation was performed directly over the deep dentin in proximity to the pulp using a 2-mm applicator tip. In subsequent sessions, following temporary restoration placement, the laser was applied to the buccal and lingual surfaces adjacent to the coronal pulp using an 8-mm applicator tip. Treatments were continued every other day for a total of seven sessions. Laser device settings are shown in Figure 2, Figure 3. After the fifth session, the patient reported sensitivity to cold in the previously non-responsive tooth.

In accordance with a systematic review by Anagostaki et al. (2020), which identified the use of non-thermal photonic energy within the 650-1350-nm optical window as an effective range for photobiomodulation in endodontics, we applied laser parameters designed within this spectrum for permanent teeth in the present study.⁹ This selection was made to ensure alignment with high-quality evidence and current recommendations in the literature. The laser parameters used in this case are summarized in Table 1. Following this improvement, caries removal was completed. This time, the patient experienced discomfort, indicating restored pulp sensitivity. Local anesthesia was administered, and the tooth was definitively restored using composite resin without a liner or base. At 6-month follow-up, the tooth exhibited a normal and reproducible positive response to both the cold and electric pulp tests, with no evidence of pain or periapical pathology on radiographs. Follow-up

radiographic evaluation is presented in Figure 2.

Discussion

This case shows a novel approach for managing a mature permanent tooth with deep caries and an initial absence of pulpal response to vitality tests. Following low-level diode laser photobiomodulation (PBM), pulp sensitivity was restored, and the tooth remained asymptomatic for six months. This supports the potential role of PBM as an adjunctive therapy in VPT for teeth at risk of pulpal necrosis. A negative response to pulp testing is often associated with necrosis; however, it may reflect transient neural dysfunction rather than irreversible damage.^{2,3} Despite repeated negative cold and EPT results, clinical and radiographic findings in this case showed no periapical changes, justifying a conservative regenerative approach rather than immediate endodontic intervention. These findings are consistent with the concept that inflamed or partially damaged pulps may demonstrate false-negative responses due to impaired neural conduction rather than full necrosis.¹ Selective caries removal without anesthesia was therefore used as an adjunctive assessment method to evaluate residual pulpal sensibility. Recent literature highlights VPT as a viable alternative to root canal treatment in teeth with deep caries, even in cases of early irreversible pulpitis.⁵ Selective caries removal and partial pulpotomy have shown favorable long-term results.^{10,11} Furthermore, diode laser PBM stimulates cellular metabolism, modulates



Figure 1. Pre-operative periapical radiograph showing extensive caries



Figure 2. Post-operative periapical radiograph at 6-month follow-up

Table1. Laser parameters

Parameter	Value
Type of laser	Diode laser
Emission mode	Continuous wave (CW)
Time on / Time off	Therapy time (calculated to supply energy 8mm:20s and 2mm:1s)
Delivery system	Handpiece 635 with 2 mm & 8 mm applicator tips
Energy distribution	-
Peak power	100 mW
Average power	-
Spot diameter at the focus	2 mm (initial session), 8 mm (subsequent sessions)
Focus spot area	0.03 cm ² (2 mm tip) 0.5 cm ² (8 mm tip)
Spot diameter in the tissue	Same as the tip (2 mm / 8 mm)
Focus-to-tissue distance	Contact mode (tip in contact with dentin)
Spot area in the tissue	0.03 cm ² (2 mm tip) 0.5 cm ² (8 mm tip)
Peak power density at the spot area	3.33 W/cm ² or 3.33 J/cm ² (2 mm tip) 0.2 W/cm ² or 4 J/cm ² (8 mm tip)
Peak power density at the tissue	Same as above
Average power density at the spot area	-
Average power density in the tissue	-
Beam divergence	-
Water irrigation	-
Air and aspirating airflow	-

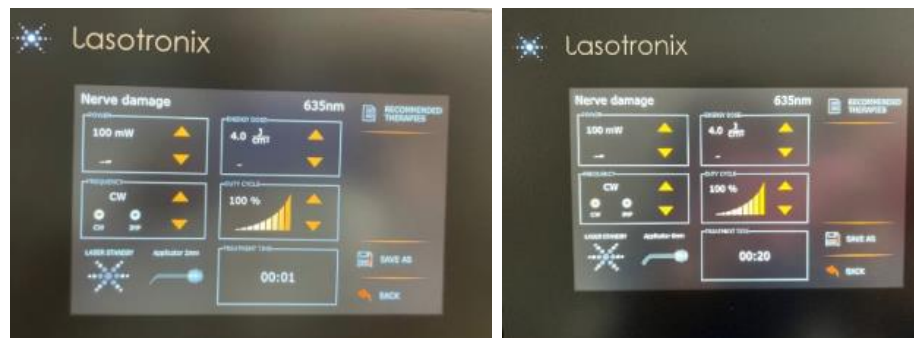


Figure 3. Laser device setting

inflammation, and promotes neural regeneration.^{7,8} The restoration of pulp responsiveness without pulp exposure or root canal therapy aligns with evidence showing that pulp vitality can be preserved if bacterial ingress is prevented and healing is supported.¹² Histopathological studies also support the pulp's reparative potential in advanced carious lesions.¹³ Imaging evidence, including CBCT, in some studies suggests that PBM is associated with increased dentin mineral density and the area of neoformed dentin; however, most data are derived from nonhistologic methods, and in the absence of histologic correlates, drawing definitive conclusions remains difficult.¹⁴

Given the absence of histological data and the single-case design, conclusions regarding PBM's efficacy in neural regeneration should be regarded as preliminary. Interestingly, in this case, the tooth was restored without any liner or base and remained asymptomatic over the follow-up period. This observation supports studies indicating that adhesive restorative protocols alone can provide sufficient sealing for pulpal healing.¹⁵

It should be noted that this report describes a single clinical case with a limited follow-up period of six months, and no histological confirmation was available to assess the true status of the pulp tissue. While the findings suggest the potential of diode laser PBM in restoring pulp vitality in mature permanent teeth, these results cannot be generalized. Randomized controlled trials and larger case series with longer follow-up and histological validation are needed to confirm the efficacy, safety, and clinical applicability of this approach.

Conclusion

This case highlights the potential of diode laser PBM as a promising adjunctive treatment for managing deep caries in mature permanent teeth lacking an initial pulp vitality response. The return of pulp sensitivity, absence of symptoms, and radiographic stability over 6 months suggest that PBM may promote neural recovery and help preserve pulp vitality in selected cases.

These findings support a conservative, biologically based approach to vital pulp therapy (VPT); however, further well-designed controlled clinical trials are warranted to validate the efficacy, safety, and clinical applicability of PBM protocols in endodontics.

Bulleted Learning Points

Photobiomodulation (PBM) with a 635-nm diode laser can restore pulp vitality in mature permanent teeth with deep caries.

Negative pulp test results do not always indicate irreversible pulp necrosis.

Although direct neural regeneration cannot be assumed, diode laser PBM may provide neuromodulatory and biostimulatory effects that support conservative vital pulp therapy (VPT).

Selective caries removal combined with PBM can preserve pulp vitality without pulp exposure.

PBM may serve as a minimally invasive adjunct in regenerative endodontics.

Authors' Contribution

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Ethical Approval

Written informed consent was obtained from the patient for the publication of this case report, and the study was approved by the Research Ethics Committee under the code IR.NKUMS.REC.1404.036.

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