folia medica

Folia Medica 67(4)
DOI: 10.3897/folmed.67.e143587

Case Report

Management of perio-endo interface complex case with NaOCl photoactivated with 980 nm to optimize root canal system decontamination with 12-month follow-up

Reem Hanna[1,2,3], Ioana Cristina Miron[2], Stefano Benedicenti[2]

1 *Department of Restorative Dental Sciences, UCL-Eastman Dental Institute, Faculty of Dental Sciences, London, United Kingdom*
2 *Department of Surgical Sciences and Integrated Diagnostics, University of Genoa, Genoa, Italy*
3 *Department of Oral Surgery, King's College Hospital NHS Foundation Trust, London, United Kingdom*

Corresponding author: Reem Hanna, Department of Restorative Dental Sciences, UCL-Eastman Dental Institute, Faculty of Dental Sciences, Rockefeller Building, London, WC1E 6DE, United Kingdom; Email: reemhanna@hotmail.com

Received: 5 December 2024 ♦ **Accepted:** 12 February 2025 ♦ **Published:** 14 August 2025

Citation: Hanna R, Miron IC, Benedicenti S. Management of perio-endo interface complex case with NaOCl photoactivated with 980 nm to optimise root canal system decontamination with 12-month follow-up. Folia Med (Plovdiv) 2025;67(4):e143587. doi: 10.3897/folmed.67.e143587.

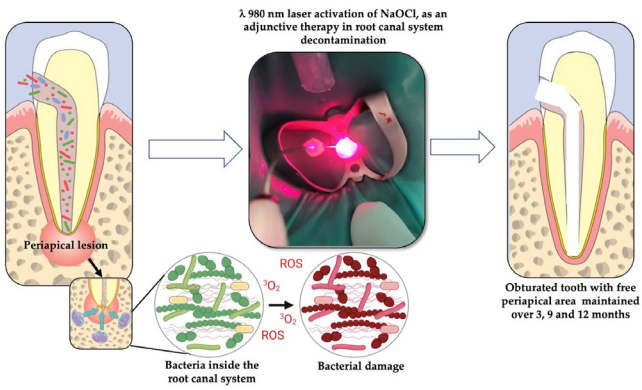
Abstract

Root canal system decontamination is recognized as one of the main pillars of successful endodontic treatment, although variations in the efficacy of current disinfection methods have been reported. In light of this, the present study investigated the activation of 5.25% sodium hypochlorite (NaOCl) using a 980 nm diode laser (laser-activated irrigation) as an adjunct to conventional decontamination, with the addition of photobiomodulation therapy. The objectives were to achieve optimal clinical outcomes over long-term follow-up, to alleviate post-endodontic pain, and to propose effective decontamination treatment protocols.

A 57-year-old female patient presented with a perio-endo lesion of the lower second premolar teeth, which was associated with Grade III mobility. The treatment strategies included conventional decontamination, laser-activated irrigation, and photobiomodulation. Periodontal parameters, tooth mobility, and periapical healing were assessed at baseline and then at 3, 6, and 12 months.

The results showed a significant improvement in these clinical variables, as well as a reduction in post-endodontic pain following photobiomodulation irradiation. The combination of 980 nm laser-activated irrigation and conventional decontamination was found to be significant in optimizing treatment outcomes. However, the study concludes that extensive comparative studies with larger datasets are needed to further validate these results.

Graphical abstract



Keywords

diode laser, laser-activation irrigant, periapical healing, perio-endo interface, sodium hypochlorite

Introduction

Photoactivation of sodium hypochlorite (NaOCl) with a 980 nm diode laser in managing the perio-endo interface is an advanced treatment approach in endodontics, particularly for cases where there is a complex connection between the periodontal and endodontic tissues. This approach leverages both the antimicrobial and tissue-penetrating properties of NaOCl, combined with the laser energy to enhance treatment effectiveness.

Sodium hypochlorite (NaOCl)

Microorganisms (MOS) play a significant role in the development of pulpal and periapical pathologies. Therefore, successful endodontic therapy requires eliminating endodontic biofilms through meticulous root canal disinfection.[1] Despite excellent mechanical debridement and potent antimicrobial irrigating solutions, achieving complete bacterial elimination is very challenging, and residual infections can lead to root canal treatment (RCT) failure.[1] MOS penetration into the surrounding dentine via the dentinal tubules, with contamination potentially reaching a depth of ~1000 μm complicates the process.[1] NaOCl is considered the most efficient antimicrobial agent against MOS. However, residual biofilm removal in lateral canals, grooves, and anastomosis using current routine endodontic procedures remians very challenging, primarly due to the need for chemo-mechanical debridement.[1] NaOCl with a concentration ranging from 0.5% to 5.25% is considered the gold standard for disinfecting the root canal system due to its broad antimicrobial spectrum and ability to dissolve organic tissue, necrotic pulp, and the organic components of the smear layer.[1,2] A 5.25% sodium hypochlorite (NaOCl) solution is more effective in a shorter amount of time due to its higher hypochlorous acid concentration.[2] Upon contact with organic tissue, it acts as a strong oxidizing agent, which contributes to its prophylactic properties.[1] This leads to an oxidation reaction that disturbs the metabolic functions of the bacterial cells. Thus, NaOCl appears to be the most ideal irrigant, fulfilling the requirements for an endodontic irrigant. Moreover, conventional manual irrigation alone showed limited ability to penetrate deeply enough to reach the dentinal tubules.[1,2] NaOCl decontaminates the root canal up to 130 μm into the dentinal wall. However, bacterial colonies can be found up to 1.15 mm away from the main canal within dentinal tubules.[1]

Role of laser-activation irrigant (LAI)

The outcome of root canal treatment for teeth with apical periodontitis depends on the efficiency with which the root canal system is disinfected to prevent reinfection.[1] Several diode wavelengths are used for root canal disinfection, but they are not as effective against bacteria as when used with laser-activated NaOCl.[2,3] The latter demonstrates higher antibacterial properties than NaOCl irrigation alone[2,3] due to the absorption of photonic energy by the irrigant and its absorption coefficient, which depends on the wavelength.[3]

980 nm diode laser

Irradiation with 810- and 980-nm diode lasers can significantly decrease E. faecalis colony counts in the root canal system due to the lasers' large water transmission capacities and ability to reach the deeper layers of dentinal tubules. Consequently, they can effectively eliminate microorganism (MOS) in the root canal system.[2] A study by Kaplan et al.[4] reported that a 980-nm diode laser with a power output of 1.5 W was highly effective in reducing E. faecalis colony counts with minimal temperature increase on the external root surface while maintaining the safety threshold.

Photobiomodulation in pain management and wound healing

Post-operative endodontic pain (POEP) has a prevalence ranging from 3% to 58%[4] and is influenced by pre-operative pain severity.[5] Photobiomodulation (PBM) is a non-ablative treatment that induces a biological response through the absorption of photonic energy within the optical window (660–1200 nm) by cytochrome C oxidase. These processes promote wound healing, modulate pain intensity, and downregulate inflammatory mediators.[6] PBM's analgesic effects primarily result from increased release of β-endorphins, serotonin, and enkephalins, which attenuate substance P, bradykinin, histamine, and prostaglandin E2 release. This inhibits afferent pain fibers and modulates neurotransmission. Due to reversible changes in membrane permeability, therapeutically applied photons stimulate cell proliferation, decrease C and A delta fiber activity, improve nerve regeneration, decrease inflammatory cytokines, and prompt the proliferation of fibroblasts and macrophages. These effects are supported by systematic reviews and meta-analyses, as well as a clinical feasibility trial conducted by Hanna et al.[9], which showed that near-infrared (NIR) laser photobiomodulation was effective in modulating oral pain. Additionally, PBM can neutralize the effects of inflammatory cytokines on gingival fibroblast functions, thereby enhancing oral mucosal healing.[10]

Rationale for conducting the present study

Although one of the goals of laser-assisted therapy in endodontics is to achieve optimal root canal disinfection, the efficacy of various irrigants and laser treatment protocols has been investigated in several unstandardized, scattered studies. Therefore, this complex case report aimed to evaluate the efficacy of using a 980-nm diode laser to activate NaOCl as an adjunctive therapy for decontaminating the root canal system. The objectives were as follows: 1) achieving an optimal clinical outcome based on long-term follow-up, 2) alleviating POEP, and 3) proposing optimal treatment protocols for root canal system decontamination.

Materials and methods

Study design

A prospective, interventional, clinical case report study evaluated the efficacy of a 980-nm laser in activating sodium hypochlorite when used as an adjunctive therapy to root canal instrumentation. The goal was to optimize the restorability outcomes of challenging teeth. The study was conducted in accordance with the Declaration of Helsinki. Informed written consent was obtained from the patient after she received a full explanation of the proposed treatment options, benefits, and drawbacks.

Study's participant and case description

A 57-year-old female presented with a toothache in her lower left and right second premolars (LL5 and LR5, respectively). She experienced a sharp, shooting pain in LR5 that worsened when she chewed. She also complained of tooth sensitivity, bad breath, and recurrent infections over the past two years. Multiple courses of oral antibiotics had been prescribed for these issues. A prosthetic restoration had been constructed in the LR5-LR7 area over 20 years ago, and the patient had experienced discomfort while chewing ever since. She had an infection in LR5 for three weeks prior to her appointment, during which time she was prescribed multiple courses of antibiotics. The LL5 tooth had undergone root treatment over 10 years ago.

Clinical examination

An intraoral examination revealed a three-unit bridge prosthesis from LR5 to the lower right second molar (LR7), with LR6 serving as a pontic. LR5 was tender to percussion (++), and there was mild gingival inflammation **(Fig. 1A)**. The tooth exhibited Grade III mobility, a negative vitality test, and evidence of a buccal sinus tract **(Fig. 1B)**. LR5 exhibited secondary caries, Grade III mobility, and tenderness upon percussion (++).

At baseline (T0), bleeding on probing (BOP) and periodontal pocket depth (PPD) at all six sites of both affected teeth are shown in **Table 1**.

Imaging investigation

Long-cone periapical views (paralleling technique) of LR5 **(Fig. 2A)** and LL5 **(Fig. 2B)** showed large periapical areas for both teeth, with vertical and horizontal bone loss.

The definitive diagnosis

Taking the patient's symptoms, clinical examination, and radiographic findings into consideration, the definitive diagnosis for LR5 and LL5 was a residual periodontal abscess.

Treatment options

The operator thoroughly explained the management op-

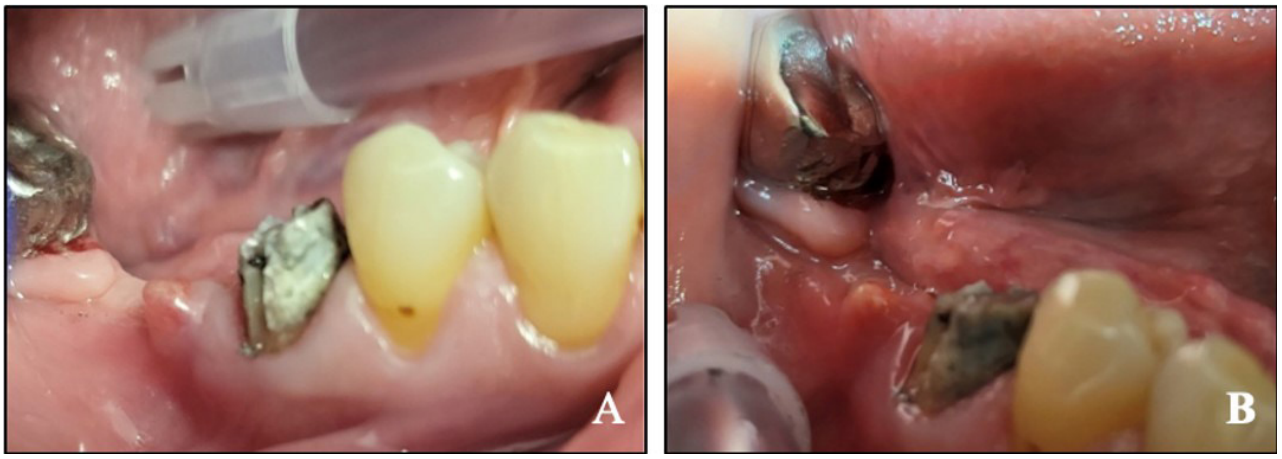


Figure 1. Clinical photos of LR5 after removal of 3-unit prosthesis at T0. Both **(A)** and **(B)** show evidence of gingival inflammation and buccal sinus tract.

Folia Medica

tions to the patient, including their respective benefits, advantages, and drawbacks. The options were as follows: 1) conventional endodontic decontamination (CED); 2) adjunctive therapy with a 980-nm laser to activate the NaOCl in conjunction with CED; and 3) dental extraction.

Table 1. Periodontal pocket depth measurements at six sites of LR5 and LL5 where the values were in millimeters (mm) at T0

Periodontal parameters	Affected tooth	Tooth site					
		MB	B	DB	ML	L	DL
BOP	LR5	4	4	5	4	4	5
	LL5	6	4	4	5	3	4
PDP	LR5	4	4	5	4	4	5
	LL5	6	4	4	5	3	4

LR5: lower right second premolar; LL5: lower left second premolar; MB: mesiobuccal; B: buccal; DB: distobuccal; MB: mesiobuccal; L: lingual; DL: distolingual

Rationale of combined mechanical debridement and laser-activated irrigant (LAI)

Considering that both teeth had Grade III mobility according to the Miller Mobility Scale[11], the prognosis for treatment was potentially challenging, and extraction would typically be the preferred management option. However, the patient chose to keep the teeth. Therefore, NaOCl activated by a 980-nm diode laser as an adjunct to CED was selected.

Decontamination dosimetry of 980 nm diode laser

Table 2 shows the dosimetry and treatment protocols for the photoactivation of 5.25% NaOCl with a 980-nm diode laser. This protocol is based on the deep penetration of 980-nm photonic energy, which enables the activation of NaOCl deeper within the root canal. To minimize thermal effects during laser-assisted irrigation (LAI), the laser fiber was moved in a continuous circular motion with a 1 mm withdrawal from the apex toward the coronal part of the tooth.

Photobiomodulation dosimetry of the 980 nm diode laser

We applied transmucosal 980-nm laser photobiomodulation to the buccal mucosa of both teeth to alleviate post operative extraction pain (POEP), reduce gingival inflammation, and heal the buccal sinus tract of LR5. **Table 2** illustrates the PBM dosimetry and treatment protocol based on our previous clinical study, which demonstrated immediate pain relief and significant wound healing.[11]

Outcome assessment tools

Visual Analogue Scale (VAS) with Numeric Pain Intensity Scale (NPIS)

The patient's self-reported pain intensity was recorded using the Visual Analogue Scale (VAS), the current gold standard for qualitative pain assessment. This corresponds to the Numeric Pain Intensity Scale (NPIS), which ranges from 0 to 10, with 0 indicating "no pain," and 10 represent-

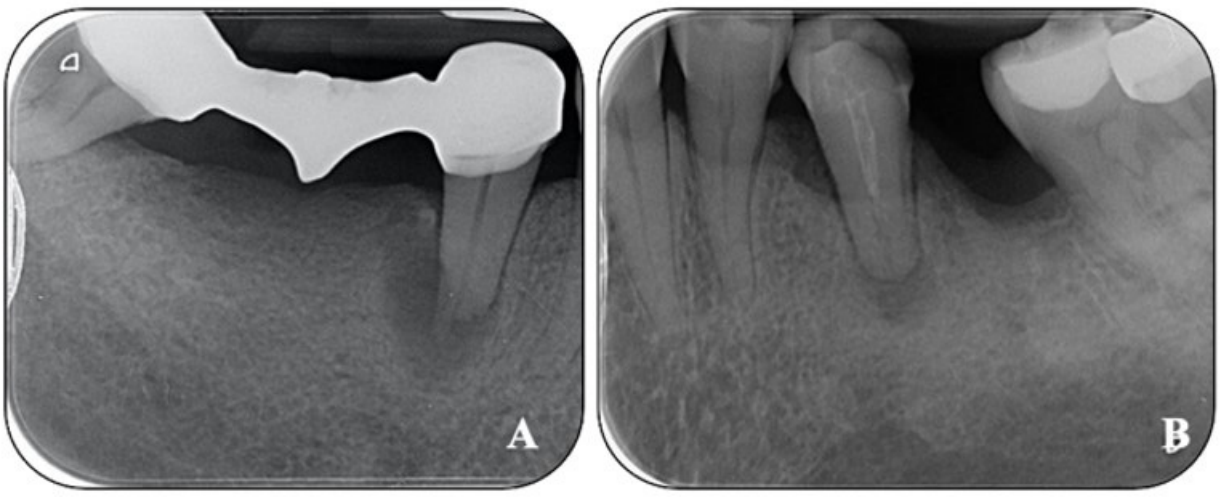


Figure 2. Long-cone periapical views of both LR5 **(A)** and LL5 **(B)**. **(A)**. LR5 is an abutment of a 3-unit bridge (LR5-LR7). A well circumscribed periapical radiolucency associated with vertical and horizontal bone loss. **(B)**. LL5 with incomplete root canal treatment (RCT), apical radiolucency, and associated vertical and horizontal bone loss.

Table 2. Laser-assisted irrigant (LAI) and photobiomodulation (PBM) treatment protocols

Device specifications/Dosimetry/Treatment protocols		LAI	PBM
Device specifications	Manufacturer	Lambda, Italy	Lambda, Italy
	Model identifier	Wiser 2	Wiser 2
	Emitters type	Diode laser	Diode laser
	Medical/laser class	IV	IV
	Beam delivery system	Fiber	Fiber
	Probe design	Single	Single
	Beam profile	Gaussian	Flattop
Irradiation parameters	Wavelength (λ)	980 nm	980 nm
	Therapeutic peak output power	1.5 W	300 mW
	Emission mode	Superpulsed	Continuous
	Duty cycle (s)	Ton 10 , Toff 10	-
	Average of therapeutic power output	0.75 W	-
	Size of endodontic optic fibre	200 μm	1 cm^2
	Energy (J) per canal	3.75	18
	Total energy (J) per canal	11.25	-
	Irradiation time	5	60
	Total irradiation time (s) per canal	15	-
Treatment protokol	Application technique	Spiral in clockwise	Static
	Number of consecutive irradiations in a single session/canal	3	1st week: Twice a week [3 days (72 h)]; 2nd week: one application

ing "the worst possible pain." The patient's pain intensity was recorded at the following timepoints: baseline (T0); immediately after the conventional SRP (T1); three days after T1 and the first endodontic treatment session (T2); seven days after T2 (T3); three months (T4); six months (T5); and 12 months (T6).

Clinical evaluation

The clinical variables, assessment tools, and timepoints for evaluation were as follows: 1) Tooth mobility was assessed using the Miller index classification at T0 and T2-T6: Grade 0: No mobility; Grade I: Slight mobility with minor horizontal or lateral movement; Grade II: <1 mm in the buccolingual direction; Grade III: >1 mm in the buccolingual direction, with depression; 2) Infection (buccal sinus tract) was assessed at T0-T3; 3) PPD and BOP were assessed and recorded in the periodontal chart at T0 and at follow-ups from T4-T6. To eliminate potential bias, intra-examiner calibration was performed at T0 and at various follow-up time points. Three repeated measurements were taken, and the mean value was recorded.

Radiographical examination

Radiographic examinations were scheduled at T0 and T4-T6 to evaluate the outcomes. A periapical health assessment using a reference radiograph (RR) was crucial for evaluating endodontic success. The RR has three possible scores for radiographic healing[12]: Score 1: Complete healing (normal periodontal space); Score 2: Incomplete healing (the lesion did not change in size or reduced without returning to normal periodontal space); Score 3: Failed healing (periapical lesion increased in size). Additionally, a Periapical Index (PAI) scoring system was used to reinforce the outcome assessment: score 1 indicates a normal periapical structure, score 2 indicates a mild alteration in bone structure, score 3 indicates an alteration in bone structure with a less pronounced onset, score 4 indicates a well-defined radiolucent area, and score 5 indicates an extensive lesion with diffuse edges. PAI scores of 1 or 2 represent "healed" or "minimally inflamed" tissue, while scores of 3–5 indicate "diseased" tissue. Since this tool is subjective, three calibrated examiners interpreted and evaluated the images until reliable consistency and consensus were reached.

Pre-endodontic treatment

At T0, the following variables were recorded: pain intensity, tooth mobility, buccal sinus tract, infection, edema, and periodontal parameters (BOP and PPD). The 3-unit bridge of LR5-LR7 was removed, and the buccal sinus tract of LR5 was drained. BOP and PPD were re-evaluated. The conventional periodontal treatment steps for both teeth were as follows: 1) the patient rinsed her mouth with 0.12% CHX for 60 seconds; 2) supra- and subgingival SRP of affected teeth was performed with an ultrasonic scaler by one experienced operator who also performed LAI and endodontic obturation; 3) manual instrumentation was performed from the end of the periodontal pocket to the coronal part of the tooth, followed by irrigation with 3% H2O2; 4) PPD and BOP were measured, recorded, and calibrated by two independent clinicians; and 5): at the end of treatment (T1), the first PBM irradiation with a 980 nm laser delivered with a flattop beam profile was transmucosally applied for 60 seconds **(Table 2)**.

Step-by-step LAI and endodontic therapy for LR5 and LL5

Management of a periapical lesion

The first endodontic session (T2) took place three days after the periodontal session. Although the endodontic treatment for both teeth was performed on separate occasions, the steps were as follows: 1) No local anesthetic was administered, and a rubber dam was placed to isolate both teeth; 2) Pulp access cavities were prepared, and necrotic intracanal pulp tissue was removed from LR5 using a NiTi file. Then, intracanal irrigation was performed with 5.25% NaOCl; 3) The old root canal filling of LL5 was removed; 4) The working length (WL) for LR5 and LL5 was determined to be 15 mm and 16 mm, respectively **(Figs 3A, 3B)**. A silicone stop was placed on the file and an apex locator **(Fig. 3C)** was used to confirm the working length. A digital reading of "00" on the device indicates that the file has reached the apical foramen. The measured file length was adjusted by 0.5 mm; 5) Mechanical debridement was performed with NiTi files for canal preparation and shaping until reaching the apical foramen using the "Step Back" technique at "ISO 40" for LR5 and "ISO 35" for LL5; 6) The canals were irrigated with 5.25% NaOCl and dried with a paper point to the initial measured WL. The canals were filled with Ledermix using a NiTi file ISO 35 for LR5 and ISO 30 for LL5, and were left sealed for seven days; 7) Glass ionomer cement was used to seal the access cavities, and the second PBM session was performed.

Management of periapical lesion, 2nd session (T3)

This session occurred seven days after the first endodontic treatment (mechanical debridement and PBM therapy) for both teeth. During the clinical re-evaluation, we assessed the following: reported pain intensity, evidence of gingival inflammation, LR5 buccal sinus tract, and teeth mobility. Significant improvements were observed, including a great reduction in tooth mobility, improved gingival health, and decreased sensitivity to percussion (both vertically and transversally) for LR5. Both teeth were isolated with a rubber dam, caries removed, and cavity access was obtained. The antibiotic paste was removed with NiTi file ("ISO 35" for LR5 and "ISO 30" for LL5) at the previously measured WL. 5.25% NaOCl was introduced passively with a fine 30-gauge needle with a silicone stopper placed 2 mm from the measured WL to minimize the risk of peri-radicular extrusion. The canals were then dried for 30 seconds. The sequence of the root canal decontamination with 980 nm diode laser irradiation was as follows: 1) the canals were irrigated with 5.25% NaOCl; 2) WL for LR5 (14 mm) and LL5 (15 mm) was transferred to the laser optical fiber and secured with a silicone stopper; 3) LAI dosimetry **(Table 2)** was employed; 4) the optical fiber was inserted inside each wet canal without activation, 1 mm shorter than WL. The fiber was then activated and moved in a spiral motion clockwise from the apical to coronal part of each canal; 5) after completing the first laser irradiation session, the canals were irrigated with 5.25% NaOCl. The second and third irradiation sequences followed at 5 seconds irradiation time for each sequence. The canals were irrigated with 5.25% NaOCl between each irradiation sequence and dried to previously determined WL; 6) the canals were obturated with "lateral cold condensation" technique using gutta-percha (GP). The GP size and WL for LR5 and LL5 were ISO

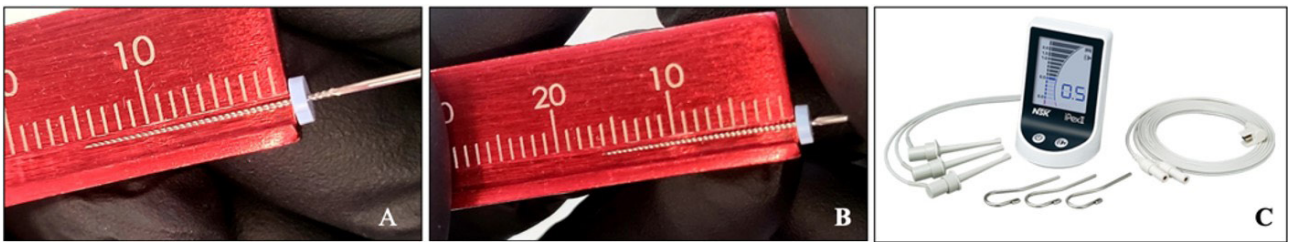


Figure 3. Working length (WL) measurements. **(A)**. LR5: 15 mm; **(B)**. LL5: 16 mm; **(C)**. Apex locator.

40 and ISO 35, and 15 mm and 16 mm, respectively. EverX Flow was used to seal the access cavities; 7) third PBM session was performed.

Results

Evaluation of patient's self-reported pain intensity

The results of self-reported pain intensity, measured using NPIS at T0-T6 for both teeth, are shown in **Table 3.** The patient reported no need for analgesic intake throughout the treatment period.

Clinical outcomes assessment

Infection and tooth sensitivity

The clinical examination revealed no evidence of inflammation, and the buccal sinus tract had resolved at T3 **(Fig. 4A, B)**. Healthy buccal mucosa was evident at this stage.

Tooth mobility assessment

The results of the tooth mobility evaluation at T0-T6 are shown in **Fig. 5**. Notably, LR5 mobility at T5 and T6 were not applicable due to the presence of a 3-unit bridge. Tooth mobility was Grade 0 for LR5 and Grade I for LL5 at T5, while both teeth exhibited Grade 0 at T6.

Periodont al parameters

A significant reduction in PPD reduction **(Fig. 6)** was observed at six sites of both teeth at T4-T6, as well as a reduction in BOP at six sites of both teeth from T2-T6 **(Table 4)**.

Assessment of the periapical healing rate

Utilisation of LAI as an adjunct to SPR, combined with successful root canal obturation, optimized the periapical healing rate for both teeth at T4-T6. For LR5 periapical healing **(Fig. 7)**, there was a significant improvent at T4 with scores 1 on RR and score 4 on PAI compared to T0, where the scores were 3 on RR and 5 on PAI. The healing continued to improve at T5, with scores of 1 on RR, and 2 on PAI, indicating a successful outcome. For LL5 periapical healing **(Fig. 8)**, there was a significant improvemnt at T4 where the scores were 1 on RR and 3 on PAI, compared to 3 on RR and 4 on PAI at T0. The healing continued to improve with scores of 1 on RR and 2 on PAI at T5 and T6.

Table 3. Reported pain intensity on NPIS. At rest, a significant reduction in pain intensity at T2 compared to T0 and T1, and maintained a score of 0 at T3-T6. At rest, pain intensity for LL5 was 1 at T0 and T2, whereas it was 0 at T3-T6. During eating, severe pain intensity was felt at T0 and T1, but significantly reduced to >50% at T2, and 0 at T3-T6

Activity	Tooth	Pain intensity scoring at various timepoints						
		T0	T1	T2	T3	T4	T5	T6
At rest	LR5	7	7	1	0	0	0	0
	LL5	1	1	1	0	0	0	0
At eating	LR5	9	9	3	0	0	0	0
	LL5	5	5	3	0	0	0	0

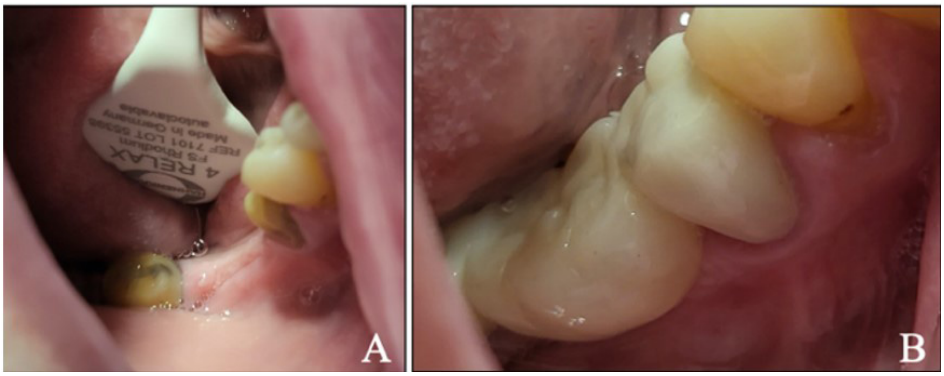


Figure 4. Clinical photos of LR5 **(A)**. shows buccal sinus tract resolved completely with no evidence of inflammation at T3. **(B)**. final restoration of the 3-unit bridge constructed at T4.

Folia Medica

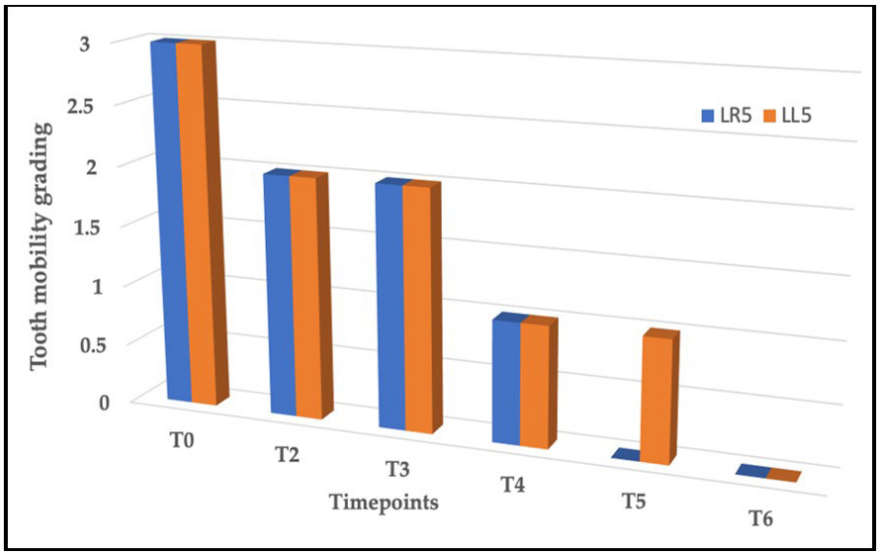


Figure 5. Mobility of LR5 and LR5 at T2-T6 compared to T0. A great reduction in teeth mobility, Grade II, at T2 compared to Grade III at T0. Further reduction in tooth mobility to Grade I was observed at T4.

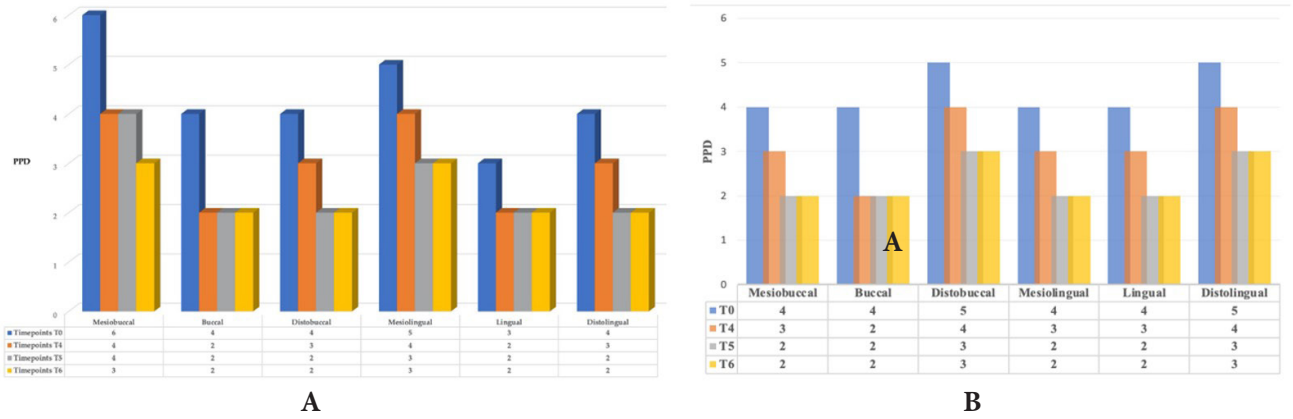


Figure 6. The results of PPD measured at six sites of each tooth at T4-T6 compared to T0. **(A)**. LL5 and **(B)**. LR5.

Table 4. Bleeding on probing (BOP) for each tooth at six sites at T0, T2-T6. A significant improvement in BOP at T2 and continued to improve at T3, and absence of BOP at all six sites of both teeth at T4-T6

Timepoint	LR5						LL5					
	MD	B	DB	ML	L	DL	MD	B	DB	ML	L	DL
T0	x	x	x	x	x	x	x	-	-	x	x	x
T1	-	x	x	-	x	x	x	-	-	x	-	-
T2	-	-	x	-	-	x	x	-	-	x	-	-
T3	-	-	-	-	-	-	-	-	-	-	-	-
T4	-	-	-	-	-	-	-	-	-	-	-	-
T5	-	-	-	-	-	-	-	-	-	-	-	-
T6	-	-	-	-	-	-	-	-	-	-	-	-

Discussion

The rationale behind conventional periodontal therapy (SRP)

Conventional SRP was an essential therapeutic approach prior to endodontic treatment to stabilize periodontal health and reduce tooth mobility. The results of this study showed a significant improvement in BOP at six sites of both teeth at T3, with continued improvement and no symptoms at T4-T6. There was also a significant reduction in PDP at T4, with continued improvement at T5 and T6 **(Figs 7, 8)**. The reduction in tooth mobility followed the pattern of Grade III at T0; Grade II at T2 and T3, Grade I at T4, Grade 0 for LR5, and Grade 1 for LL5 at T5, and Grade 0 for both teeth at T6. PBM likely added further value to SRP and LAI by restoring BOP and PPD, and reducing tooth mobility at T1-T3, likely due to its anti-inflammatory and regenerative effects.[10,13]

Evaluation of periapical healing

Periapical healing was assessed using the PAI with five scores and RR with three scores at T0 and T4-T6. The positive results indicate effectively employed decontamination protocols. NaOCl activated with a 980 nm laser for 5 seconds in each canal for three sequences after SRP, helped eradicated root canal MOS and contributed to significant periapical healing by T6. PBM likely played a vital role in accelerating the healing of buccal sinus tract and improving the periapical healing rate.[7,8] A recent systematic review showed a lack of robust assessment tools for evaluating periapcial healing, leading to inconclusive results.[14] In the present study, both quantitative and qualitative assessment tools were employed to overcome this limitation.

PBM effects on POEP

POEP is reported to affect a high number of patients with prevalence rates reaching up t o 58%.[5] For LR5, pain intesntiy at rest was initially 7 at T0 and T1, but droped to 1 at T2. This significant reduction in POEP continued, with a pain score of 0 by T3 (after the third PBM session) and remained at zero at T4-T6. During eating, a similar pattern of pain alleviation was observed at T4-T6 for both teeth, despite severe pain reproted at T0 and T1. This suggests that the 980 nm PBM laser with flattop beam profile[10] was effective in alleviating POEP, which aligns with findings from a recent systematic review[15].

Study limitations and future research direction

Although this study employed robust methodology and assessment tools and included a 12-month follow-up, it had some limitations. Future studies should consider incorporating microbiological profiling, salivary analysis, and 3D

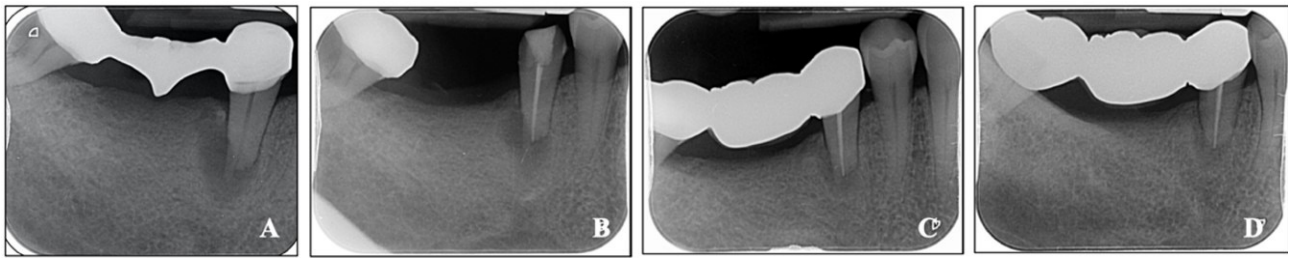


Figure 7. Periapical views of LR5 illustrating the periapical healing area at different timepoints. **(A)**. at T0, an extensive radiolucency scoring 3 and 5 on RR and PAI scores respectively, and external root resorption >50% vertical and horozontal bone loss; **(B)**. at T4: a significant reduction in periapical area, bone regeneration distallly with no external root resorption and homogeneity indicating healing; **(C)**. at T5, further reduction in periapical area and continued to improve at T6 **(D)**.

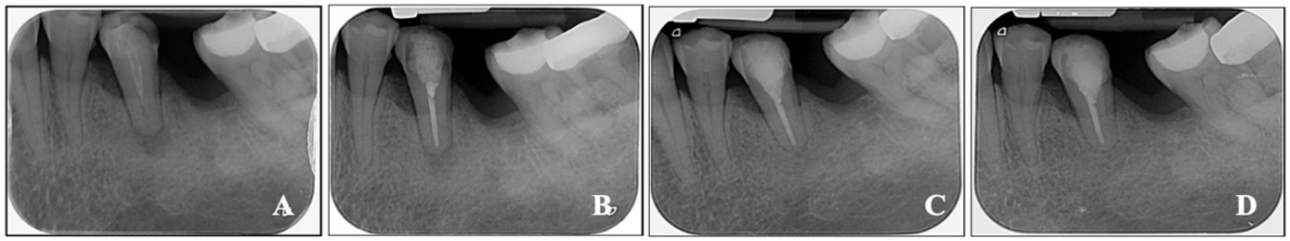


Figure 8. Periapical views of LL5 illustrating periapical healing rate at different timepoints. **(A)**. at T0, scores of the radiolucency area were 3 and 5 on RR and PAI, respectively, >50% bone loss; **(B)**. at T4, periapical area significantly reduced and evidence of regenerative bone distally; **(C)**. at T5, no periapical area as well as at T6 **(D)**.

imaging. Additionally, comparing different laser activation techniques (e.g., sonic methods) or evaluating the effects of no activation could provide further insight into optimal root canal disinfection strategies.

Conclusions

The use of NaOCl activation with a 980-nm laser as an adjunctive therapy to scaling and root planing (SRP) for root canal disinfection has proven valuable in optimizing periapical healing rates and maintaining restored periodontal parameters over a 12-month period. Furthermore, 980-nm laser photobiomodulation was effective in alleviating the post-operative edema and pain. Further studies with larger data sets and longer follow-up periods are needed to confirm these findings and explore additional treatment protocols.

Author contributions

Conceptualization: I.C.M. and R.H.; methodology: I.C.M. and R.H.; software: I.C.M.; validation: R.H.; formal analysis: I.C.M. and R.H.; investigation: I.C.M.; resources: R.H., I.C.M., and S.B.; data curation: R.H.; writing–original draft preparation: R.H.; writing–review and editing: R.H.; visualization: R.H.; supervision: R.H.; project administration: I.C.M. and S.B. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.
Not applicable.

Informed Consent Statement

An informed written consent was obtained from the patient.

Data Availability Statement

All the data are available in the text.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. Bordea IR, Hanna R, Chiniforush N, et al. Evaluation of the outcome of various laser therapy applications in root canal disinfection: A systematic review. Photodiag Photodyn Ther 2020; 29:101611.
2. Morsy DA, Negm M, Diab A, et al. Postoperative pain and antibacterial effect of 980 nm diode laser versus conventional endodontic treatment in necrotic teeth with chronic periapical lesions: a randomized control trial. F1000Res 2018; 7:1795.
3. Mehta N, Gupta A, Mahesh S, et al. Comparative evaluation of antibacterial efficacy of Allium sativum extract, aqueous ozone, diode laser, and 3% sodium hypochlorite in root canal disinfection: An in vivo study. J Conserv Dent 2020; 23:577–82.
4. Kaplan T, Sezgin GP, Sönmez KS. Effect of a 980-nm diode laser on post-operative pain after endodontic treatment in teeth with apical periodontitis: a randomized clinical trial. BMC Oral Health. 2021; 21:41–9.
5. Alí A, Olivieri JG, Duran-Sindreu F, et al. Influence of preoperative pain intensity on postoperative pain after root canal treatment: A prospective clinical study. J Dent 2016; 45:39–42.
6. De Freitas LF, Hamblin MR. Proposed mechanisms of photobiomodulation or low-level light therapy. IEEE J Sel Top Quantum Electron 2016; 22(3):348–64. doi: 10.1109/JSTQE.2016.2561201
7. Hanna R, Dalvi S, Tomov G, et al. Emerging potential of phototherapy in management of symptomatic oral lichen planus: A systematic review of randomized controlled clinical trials. J Biophotonics 2023; 16(7):e202300046.
8. Hanna R, Dalvi S, Bensadoun RJ, et al. Role of photobiomodulation therapy in neurological primary burning mouth syndrome. a systematic review and meta-analysis of human randomized controlled clinical trials. Pharmaceutics 2021; 13:1838.
9. Hanna R, Bensadoun RJ, Beken SV, et al. Outpatient oral neuropathic pain management with photobiomodulation therapy: a prospective analgesic pharmacotherapy-paralleled feasibility trial. Antioxidants 2022; 11:533.
10. Hanna R, Miron IC, Benedicenti S. A novel therapeutic approach of 980 nm photobiomodulation delivered with flattop beam profile in management of recurrent aphthous stomatitis in pediatrics and adolescents–a case series with 3-month follow-up. J Clin Med 2024; 13:2007.
11. Wu CP, Tu Y-K, Lu S-L, et al. Quantitative analysis of Miller mobility index for diagnosisof modeate to severe periodontittis- A cross-sectional study. J Dent Sci 2018; 13:43–47.
12. Zanini M, Decerle N, Hennequin M, et al. Revisiting Orstavik's PAI score to produce a reliable and reproducible assessment of the outcomes of endodontic treatments in routine practice. Eur J Dent Educ. 2021; 25:291–298.
13. Hanna R, Dalvi S, Benedicenti S, et al. Photobiomodulation therapy in oral mucositis and potentially malignant oral lesions: a therapy towards the future. Cancers 2020; 12:1949.
14. Meire M, De Moore RJG. Principle and antimicrobial efficacy of laser-activated irrigation: A narrative review. Int Endo J 2024; 57(7):841–60.
15. Kadam AS, Merwade S, Kumar KN, et al. Effect of laser photobiomodulation on postoperative pain in endodontics: a systematic review. Photobiomodul Photomed Laser Surg 2024; 42:11–19.