



Home-use Photobiomodulation for Pain Management and Recovery after Lower Third Molar Extraction: A Pilot Split-Mouth Study

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Abstract

Introduction: The extraction of lower third molars often results in pain, swelling, and trismus, significantly impacting recovery. Conventional pharmacological treatments, though effective, pose risks like systemic side effects. Photobiomodulation (PBM) therapy is a promising non-invasive alternative, known for its anti-inflammatory and healing properties. This study evaluates the efficacy of home-use PBM devices in postoperative recovery, emphasizing accessibility and patient adherence.

Methods: A split-mouth pilot study was conducted with 12 participants (18–45 years old) undergoing bilateral third molar extractions. One side was treated with daily PBM therapy using a low-level light device (four wavelengths: 940 nm, 850 nm, 660 nm, 630 nm) for seven days, while the other side served as a placebo. Recovery metrics, including pain (VAS scale), swelling, trismus, and medication use, were assessed daily. Statistical analysis utilized the Kruskal-Wallis and Mann-Whitney U tests.

Results: The PBM group showed significantly reduced pain (Day 3: $P=0.001$), swelling (Day 7: $P=0.001$), and trismus (Day 4: $P=0.037$), with sustained improvements through Day 7. Analgesic use was significantly lower in the PBM group (Day 4: $P=0.001$), demonstrating PBM's analgesic and anti-inflammatory effects.

Conclusion: Home-use PBM therapy effectively manages postoperative complications, accelerating recovery and reducing medication dependence. It offers a practical, non-invasive alternative to clinic-based treatments, enhancing accessibility and adherence. Further studies are recommended to validate these findings and optimize PBM protocols.

Keywords: Photobiomodulation; Low-level laser therapy; Third molar extraction; Postoperative pain; Swelling; Trismus; Medication use.



Introduction

The extraction of the lower third molar is a standard dental procedure. The procedure frequently leads to significant postoperative complications, such as pain, swelling, and trismus. These symptoms can significantly impact a patient's quality of life and prolong recovery, making effective management essential.¹ Traditionally, conventional pain management relies heavily on pharmacological treatments, including corticosteroids, analgesics, and anti-inflammatory drugs.² Even though these methods help control symptoms, they come with a lot of risks, such as allergic reactions, problems with platelets, stomach ulcers, and problems with the kidneys or heart.³

Many medical fields, including dentistry, have demonstrated the effectiveness of PBM therapy. It provides a non-invasive way to lessen pain and speed

up healing, especially after complicated procedures like dental extractions. However, accessing PBM therapy in clinical settings can pose logistical challenges for some patients, such as travel difficulties or time constraints.^{4,5}

Home PBM devices have shown promise as safe and effective ways to treat various conditions, such as chronic pain, wounds, diabetic foot ulcers, and side effects of cancer treatment, by speeding up the healing process.⁶ PBM therapy operates at a cellular level by stimulating mitochondrial activity, particularly cytochrome c oxidase, to enhance ATP synthesis and promote tissue repair. Additionally, it modulates oxidative stress and inflammatory pathways, reducing cytokine levels such as interleukin-6 and tumor necrosis factor-alpha, further aiding recovery.⁷

This study focuses on evaluating the feasibility of incorporating home-use PBM devices into the

postoperative care plan for third molar extractions to enhance accessibility and recovery outcomes. Specifically, it investigates their role in reducing pain, swelling, and medication use while addressing accessibility issues inherent in clinic-based treatments. The broader goal is to establish PBM therapy as a safe, effective, and accessible dental postoperative care option, aligning with global efforts to promote non-pharmacological pain management and address the opioid crisis.

Material and Methods

Study Sample

Twelve healthy participants (five males, seven females) aged 18 to 45 years, with a mean age of 24.67 ± 4.48 , were recruited for this study between April 2022 and March 2023. All participants presented with bilaterally impacted mandibular third molars that required surgical extraction. The patients were selected based on the bilateral similarity of third molar impaction classification, specifically utilizing the criteria established by Pell and Gregory's classification⁸ (Figure 1). People who had systemic diseases or medical conditions that were not under control, had a history of cancer or photosensitivity disorders, were pregnant or breastfeeding, or were taking medications that could change how they felt pain or how quickly their wounds healed were not allowed to participate in the study.

This pilot clinical study utilized a non-randomized, intra-patient controlled design. The initial surgical site was determined by patient preference and symptom severity, with the contralateral side undergoing surgery one month later. Regarding the PBM treatment, the sham PBM therapy was applied to the first surgical site, while the active PBM therapy was delivered to the second. This sequential administration was a deliberate strategy to ensure complete participant blinding to the active PBM intervention, particularly given the use of a sham device that blocked therapeutic light.

The patients were informed of the nature and potential risks of the proposed surgical procedures, and

they reviewed and signed an informed consent form. The Declaration of Helsinki guidelines were followed throughout the study. The study was approved by the Scientific Research and Graduate Studies Council, the Faculty of Dental Medicine, Damascus University, Damascus, Syria. The ethical approval for this study was granted under the code (328/S.M).

Surgical Procedure

The same surgeon performed all surgical procedures, adhering to a standardized protocol. The surgeon extracted the patient's preferred side of the first third molar. We administered local anaesthesia using Ubistesin 1/200,000 (3M ESPE AG, Germany). We elevated a full-thickness triangular mucoperiosteal flap and performed bone removal or tooth sectioning as needed. Lower third molars were extracted, and the mucoperiosteal flap was repositioned, and the surgical wound was closed with a 5-0 polyglactin suture.

Postoperatively, the patients received detailed verbal and written instructions. A prescription for 1000 mg amoxicillin-clavulanic acid twice daily, 0.12% chlorhexidine gluconate rinses twice daily, and 400 mg ibuprofen as needed was provided. One month later, we scheduled the surgical extraction of the contralateral third molar.

PBM Treatment

Following surgery, the patients were instructed to self-administer PBM therapy once daily from the first to the seventh postoperative day. A low-level light device emitting light at four different wavelengths (940 nm, 850 nm, 660 nm, 630 nm) was used (PBMPro, Oral IQ™, USA) (Figure 2). PBM therapy was applied at specific anatomical locations in the surgical side, including the submandibular lymph nodes and the angle of the lower mandible. PBM therapy was also directed at the intraoral surgical site directly to the extraction wound (Figure 3). The first surgical site received the placebo PBM treatment, while the second site received PBM therapy.

The PBM light was utilized in both external areas for

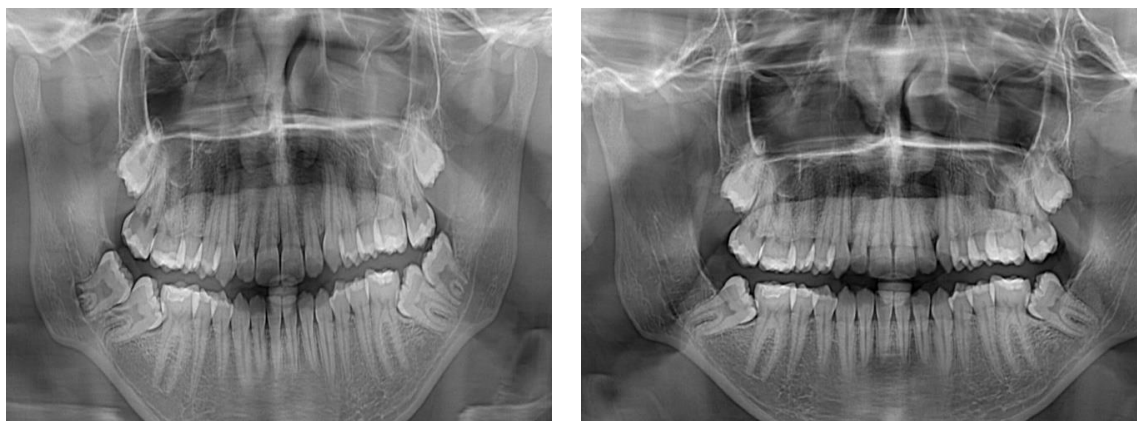


Figure 1. Panoramic radiographs showing (a) bilateral impacted lower third molars and (b) post-surgical extraction of lower third molars

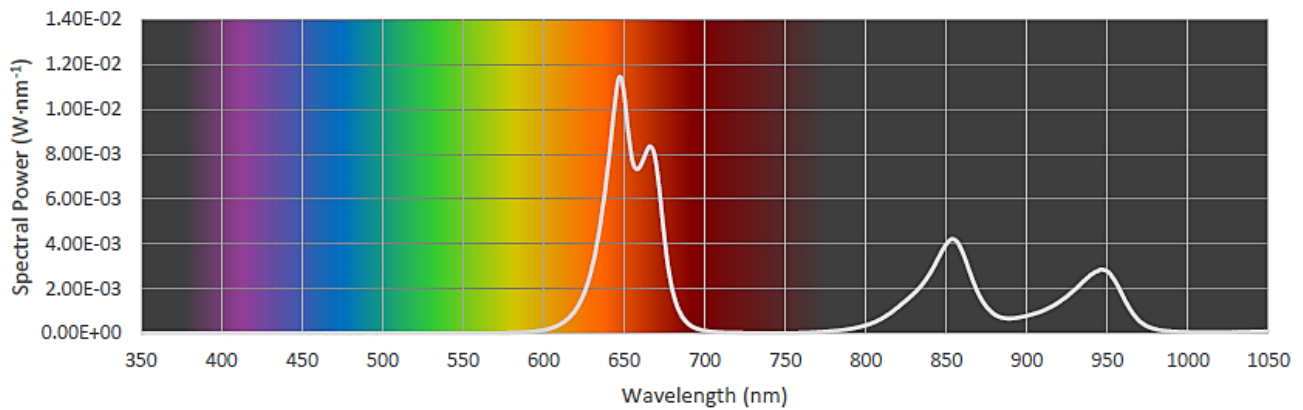


Figure 2. Spectral power distribution of PBM wavelengths for effective therapy

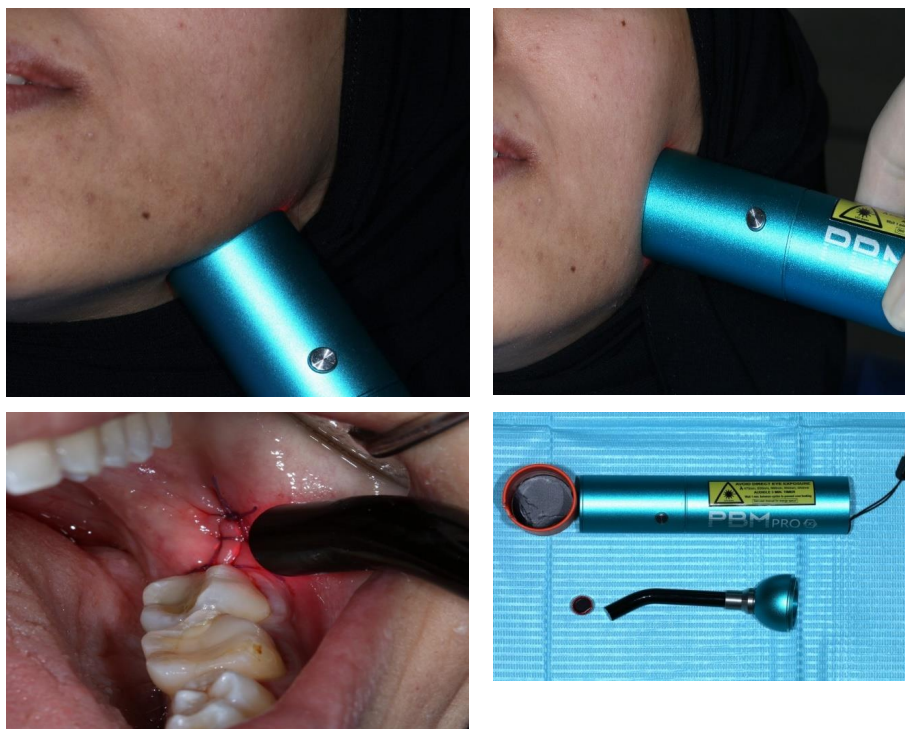


Figure 3. Application of PBM therapy at (a) the submandibular lymph node, (b) the angle of the mandible, and (c) to the extraction site with a wand curved attachment. (d) Mimicking the laser application procedure with light occlusion

120 seconds for each site, with an average power density of 134.3 mW/CM² and a total energy dose of 16 J/cm². A wand curved attachment was used to apply the light to the internal surgical area for 60 seconds, with an average power density of 134.3 mW/CM² and a total energy dose of 8 J/cm². Each session lasted around 5 minutes for the three sites. The placebo treatment followed the same procedure using a sham device. The therapeutic light was blocked by custom black paper integrated into the device and tip cover, as shown in Figure 3. This protocol ensured the standardization of treatment and control conditions for evaluating the efficacy of PBM therapy. The patients were instructed to wear protective eyewear during PBM device application.

Outcome Measures

Postoperative recovery metrics included the assessment of pain, swelling, trismus, and medication usage through patient-reported scales. These assessments were conducted daily for seven days following the surgical procedure. Pain levels were rated on a 1-to-5 scale, an emoji-based pain scale ranging from “No Pain” to “Severe Pain,” enabling patients to accurately indicate their discomfort. Swelling was evaluated subjectively by patients using a 5-point scale (0 = no swelling, 5 = severe swelling).⁹

The difficulty in opening the mouth (trismus) was assessed through a functional scale, spanning from “No Problem” to “Extreme,” providing insights into recovery-related functional limitations. Pain medication usage was self-reported and documented to evaluate reliance

on analgesics during the recovery period. These metrics provided a holistic view of the postoperative experience and recovery trajectory (Figure S1).

Statistical Analysis

The statistical analysis was conducted to evaluate the differences between the PBM and placebo groups. The mean Visual Analog Scale (VAS) scores were analysed using the Kruskal-Wallis test to assess overall differences between the groups. Data analysis was performed using computer software (SPSS v.17.0, IBM, Chicago, IL).

Pairwise comparisons were performed using the Mann-Whitney U test to determine significant differences between the two independent groups. Statistical significance was set at $P < 0.05$.

Results

Pain Assessment and Reduction Trends

The study included twelve patients who underwent bilateral lower third molar extraction. All patients completed the study protocol. Pain scores were assessed daily using the VAS scale, demonstrating a consistent reduction in the PBM group compared to the control group across the first postoperative week. On Day 3, the PBM group showed the most significant reduction in pain scores, with a mean rank difference of 17.00 for the control group versus 8.00. Table 1 displays the PBM group ($P = 0.001$).

Day 1 ($P = 0.003$), Day 2 ($P = 0.005$), and Day 4 ($P = 0.003$) all showed significant reductions, demonstrating the efficacy of PBM therapy. The difference remained statistically significant on Day 6 ($P = 0.035$), with marginal significance observed on Day 7 ($P = 0.053$), reflecting the therapy’s sustained benefits.

Figure S2 illustrates the pain reduction trends measured on the VAS scale across the first postoperative week. The most notable differences were observed on Day 3, with the steady and cumulative reduction in pain over the week highlighting the therapeutic impact of PBM therapy.

Swelling Level Analysis

Swelling levels were assessed daily using a subjective

5-point scale, and the data revealed a consistent downward trend in the PBM group compared to the control group throughout the first postoperative week. The PBM group showed significant reductions in swelling on multiple days. Notably, Day 4 exhibited a statistically significant difference ($P = 0.024$), as the mean rank for the PBM group (9.63) was considerably lower than that for the control group (15.38). Similarly, Day 5 showed a pronounced difference ($P = 0.007$), with the PBM group maintaining a mean rank of 9.00 compared to 16.00 in the control group. By Day 7, swelling scores in the PBM group were markedly lower, achieving a significant difference ($P = 0.001$) (Figure S3). This shows that PBM therapy is better at controlling inflammatory responses after surgery. Table 2 presents a detailed comparison of swelling levels between the PBM and control groups, clearly demonstrating statistically significant differences across multiple days. These findings support the conclusion that PBM therapy effectively reduces swelling during the postoperative period.

Trismus Data Analysis

Trismus, or difficulty in opening the mouth, was evaluated daily throughout the first postoperative week. The PBM group consistently demonstrated improved mouth-opening abilities compared to the control group. Notable improvements were observed on several days, particularly on Day 4 ($P = 0.037$), when the mean rank for the PBM group was significantly lower (9.71) than that for the control group (15.29).

Other significant differences were recorded on Day 2 ($P = 0.013$) and Day 3 ($P = 0.017$), further highlighting the efficacy of PBM therapy in alleviating trismus. These improvements persisted through Day 6 ($P = 0.014$), showcasing the therapy’s cumulative effect. Although no significant differences were found on Day 1 ($P = 0.244$) or Day 7 ($P = 0.167$), the overall trend favored the PBM group in accelerating recovery. Table 3 provides a comprehensive summary of the difficulty in opening the mouth as measured by the Mann-Whitney U test, emphasizing the statistically significant differences between the two groups during the recovery period (Figure S4).

Table 1. Postoperative Pain Scores (VAS) – Comparison Between PBM and Control Groups

Day	Mean Rank (Control)	Mean Rank (PBM)	Mann-Whitney U	P-value
Day 1	16.42	8.58	25	0.003*
Day 2	16.33	8.67	26	0.005*
Day 3	17	8	18	0.001*
Day 4	16	9	30	0.003*
Day 5	15.75	9.25	33	0.016*
Day 6	15.38	9.63	37	0.035*
Day 7	15.13	9.88	40	0.053

*The mean difference is significant at the 0.05 level.

Table 2. Swelling Levels Between PBM and Control Groups

Day	Mean Rank (Control)	Mean Rank (PBM)	Mann-Whitney U	P-value
Day 1	15.38	9.63	37.5	0.035*
Day 2	15.33	9.67	38	0.04*
Day 3	15.92	9.08	31	0.011*
Day 4	15.38	9.63	37.5	0.024*
Day 5	16	9	30	0.007*
Day 6	16	9	30	0.008*
Day 7	16.58	8.42	23	0.001*

*The mean difference is significant at the 0.05 level.

Table 3. Difficulty Opening the Mouth – Comparison Between PBM and Control Groups

Day	Mean Rank (Control)	Mean Rank (PBM)	Mann-Whitney U	P-value
Day 1	13.92	11.08	55	0.244
Day 2	15.83	9.17	32	0.013*
Day 3	15.63	9.38	34.5	0.017*
Day 4	15.29	9.71	38.5	0.037*
Day 5	15.63	9.38	34.5	0.017*
Day 6	15.63	9.38	34.5	0.014*
Day 7	14.08	10.92	53	0.167

*The mean difference is significant at the 0.05 level.

Medication Use Analysis

Medication usage was evaluated daily across the postoperative week to compare the PBM and control groups. The PBM group consistently required fewer pain medications than the control group, with statistically significant differences observed on several days. On Day 2, the PBM group demonstrated a significant reduction in medication usage ($P=0.001$), with a mean rank of 7.96 compared to 17.04 for the control group. This trend continued on Day 3 ($P=0.011$) and became more pronounced on Day 4 ($P=0.001$), when the PBM group maintained a lower mean rank of 7.83 compared to 17.17 for the control group. On Day 5, the PBM group again showed significantly reduced medication dependency ($P=0.008$).

By Day 6, a significant difference remained ($P=0.018$), underscoring the sustained efficacy of PBM therapy in reducing the need for pain medications. By Day 7, the gap between the groups narrowed, reflecting reduced medication needs across both groups. Table 4 and Figure S5 illustrate the downward trend in medication usage, emphasizing the significant reductions observed in the PBM group compared to the control group over the first postoperative week.

Discussion

The present study evaluated the efficacy of PBM therapy in managing postoperative complications following lower third molar extraction, emphasizing its potential as a non-invasive adjunct to traditional postoperative care. The results demonstrated PBM's effectiveness in reducing pain, swelling, and trismus, while minimizing the need for pain medications. Supporting these observations, Farhadi et al highlighted the specific mechanisms behind PBM's analgesic effects, noting that the therapy leads to nociceptor desensitization and a reduction in inflammatory mediators.⁵ These processes contribute significantly to the reduction of postoperative pain, underscoring the dual benefit of PBM in managing both pain perception and underlying inflammation. This supports the analgesic properties observed in our study and further validates PBM as an effective non-

Table 4. Pain Medication Usage Between PBM and Control Groups

Day	Mean Rank (Control)	Mean Rank (PBM)	Mann-Whitney U	P-value
Day 1	13	12	66	0.546
Day 2	17.04	7.96	17.5	0.001*
Day 3	15.96	9.04	30.5	0.011*
Day 4	17.17	7.83	16	0.001*
Day 5	16.17	8.83	28	0.008*
Day 6	15.75	9.25	33	0.018*
Day 7	15.04	9.96	41.5	0.061

*The mean difference is significant at the 0.05 level.

pharmacological treatment option for postoperative pain management. These findings align with previous research, confirming PBM's role in promoting healing and reducing inflammation. The PBM group exhibited significantly reduced pain levels compared to the control group, as evidenced by daily VAS assessments.

The sustained improvements observed over the week suggest that PBM therapy's effects accumulate with consistent application, contributing to accelerated recovery timelines. These benefits are likely due to PBM's ability to block pain receptors and reduce inflammatory chemicals like bradykinin. Reduced pain levels also suggest a potential to decrease reliance on medications, mitigating concerns about side effects associated with traditional painkillers. Limeback et al emphasized PBM's ability to decrease reliance on opioids and NSAIDs, providing a safer alternative for managing postoperative pain. This highlights the practical benefits of PBM in minimizing pharmacological dependency and enhancing patient safety, aligning with the revised focus on safety and accessibility.¹⁰

PBM's anti-inflammatory effects are attributed to its ability to modulate cytokines such as tumor necrosis factor-alpha and interleukin-6. This modulation of inflammatory markers plays a critical role in minimizing postoperative swelling and inflammation, thereby enhancing recovery outcomes. Conversely, discrepancies observed in findings may relate to differences in wavelength application and assessment timing.¹¹ Trismus improved significantly in the PBM group by Day 2, with sustained improvements until Day 6. D'avi et al highlighted the efficacy of PBM in reducing muscle tension and enhancing mitochondrial activity, supporting these findings.¹² Medication usage trends further underscored PBM's benefits, with the PBM group requiring fewer pain medications than the control group. Ma et al corroborated this, emphasizing PBM's role in reducing reliance on opioids and NSAIDs.¹³

This study uniquely highlights the role of home-use PBM devices in addressing accessibility challenges, empowering patients to actively manage their recovery. Results emerging as early as Day 2 reinforce the feasibility of patient-driven therapy. The frequency of

PBM treatment sessions is a critical factor influencing outcomes. Evidence suggests that repeated sessions produce cumulative effects, enhancing pain relief over time. Consistent PBM sessions have demonstrated sustained benefits in various conditions, highlighting the importance of regular application for optimal outcomes.¹⁴ Consistent application of higher energy densities (10–15 J/cm²) may better address inflammatory conditions, while lower densities (2–5 J/cm²) are optimal for healing and prevention. These insights reinforce the versatility and effectiveness of PBM therapy in managing postoperative complications.

The present study had limitations inherent to its pilot nature, including a small sample size and the reliance on subjective patient-reported assessments for pain and swelling, which introduced variability and potential bias. Additionally, the focus on short-term postoperative outcomes limited the evaluation of long-term efficacy. The variability in PBM therapy outcomes with different treatment protocols further underscores the need for optimization. For instance, Koparal et al found that single-dose PBM therapy was insufficient for significant reductions in postoperative pain and swelling, highlighting the importance of multisession applications for achieving cumulative effects.¹⁵

At-home Photobiomodulation (PBM) devices offer convenience but present several limitations. Patient compliance with treatment protocols (frequency, duration, and application) can be inconsistent, affecting therapy effectiveness. Variability in user application technique, such as device placement, distance, and pressure, can lead to inconsistent light delivery and suboptimal results without professional guidance. Finally, significant differences in technical specifications and calibration among commercial home-use devices make it difficult to standardize and ensure a therapeutically effective dose.

This limitation in our approach suggests that further research is needed to determine optimal PBM dosing schedules. Future studies should validate these findings with larger, randomized controlled trials and incorporate objective measures, such as imaging for swelling and functional recovery metrics, to enhance the robustness and generalizability of the results.

Conclusion

PBM therapy has emerged as a promising adjunctive treatment for managing postoperative complications following lower third molar extraction. This study highlights the efficacy of home-use PBM devices in accelerating recovery by reducing pain, swelling, trismus, and dependence on pain medications.

The findings emphasize the potential of home-use PBM devices to improve accessibility and adherence, offering patients a practical and effective way to manage

their postoperative recovery. Home-use PBM promises to reshape healthcare by decentralizing care, reducing burdens, cutting costs, decreasing in-clinic visits, and expanding access for underserved populations, fostering a more efficient and equitable future healthcare system. By empowering patients to take an active role in their care, PBM therapy provides a non-invasive and accessible alternative to clinic-based treatments.

Authors' Contribution

Conceptualization: Walid Altayeb, Islam Kassem.

Data curation: Walid Altayeb.

Formal analysis: Omar Hamadah.

Investigation: Walid Altayeb.

Methodology: Walid Altayeb, Islam Kassem.

Project administration: Walid Altayeb.

Resources: Omar Hamadah.

Software: Omar Hamadah.

Supervision: Tosun Tosun.

Validation: Walid Altayeb, Islam Kassem, Omar Hamadah, Tosun Tosun.

Visualization: Omar Hamadah, Islam Kassem.

Writing—original draft: Walid Altayeb, Omar Hamadah.

Writing—review & editing: Tosun Tosun.

Conflict of Interests

The authors declare that there are no conflicts of interest relating to this work.

Ethical Approval

The Declaration of Helsinki guidelines were followed throughout the study. The study was approved by the Scientific Research and Graduate Studies Council, the Faculty of Dental Medicine, Damascus University, Damascus, Syria. The ethical approval for this study was granted under the code (328/S.M).

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Supplementary Files

Supplementary file 1 contains Figures S1–S5.

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