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The Role of 'Photobiomodulation (PBM) Therapy' in Prosthodontics: A Structured Review.

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ABSTRACT

Background: Previously referred to as low-level laser treatment (LLLT), photobiomodulation therapy (PBM) uses non-ionizing light sources, usually in the red or near-infrared spectrum, to increase tissue repair and cellular activity. With applications in fixed, removable, implant, and maxillofacial prosthodontics, its function in prosthodontics has expanded beyond postoperative care.

Objective: To explore and summarize the current and emerging roles of PBM therapy in various branches of prosthodontics, highlighting its biological benefits, clinical indications, and recent advancements.

Methods: A literature review was conducted using databases such as PubMed, Scopus, and Google Scholar. Studies from 2000 to 2024 were included, focusing on PBM applications in prosthodontic disciplines. Keywords included "photobiomodulation", "low-level laser therapy", "prosthodontics", "dental implants", "fixed prostheses", and "maxillofacial prosthetics".

Results: PBM has demonstrated clinical advantages in a variety of prosthodontic applications. supports soft tissue recovery around crowns and bridges and lessens post-preparation sensitivity. reduces stomatitis associated with dentures, speeds up mucosal healing, and enhances full and partial denture adaption. improves osseointegration, and boosts early implant stability. enhances tolerance to obturators and face prosthesis, aids in the management of mucositis, and promotes tissue repair after radiation or surgery.

Conclusion: PBM is a useful addition to prosthodontics, providing biologically sound and non-invasive advantages that improve patient comfort and treatment results. Its function will probably be further refined by ongoing study and technological advancement, making it a crucial part of contemporary prosthodontic treatment.

Keywords: *Photobiomodulation therapy (PBM), Prosthodontics, Low-level laser therapy (LLLT), Osseointegration, Tissue healing, Dental implants, Removable dentures*

1. INTRODUCTION

Low-level light, typically in the red or near-infrared spectrum, is used in Photobiomodulation therapy (PBM Therapy), a non-invasive treatment, to increase cellular activity. Cold laser therapy and low-level laser therapy (LLLT) are other names for it. [1,2]

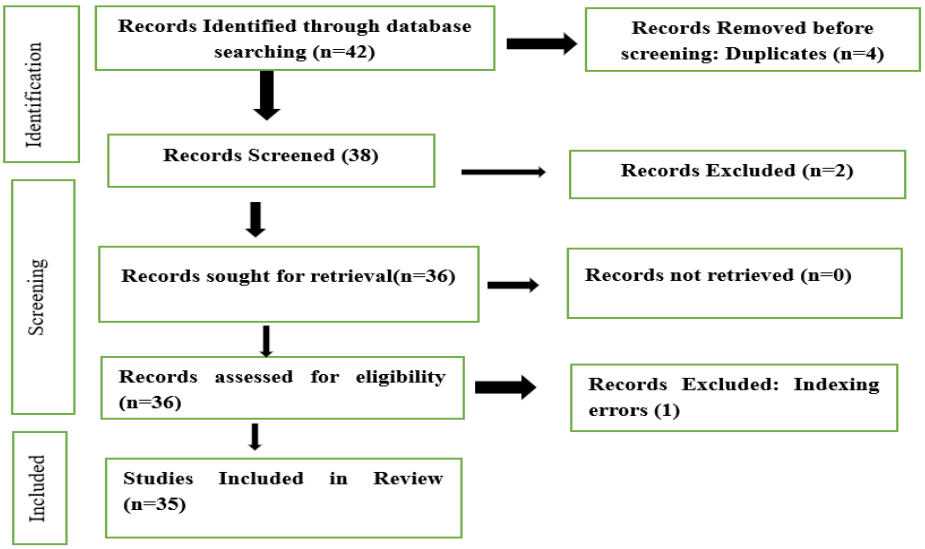
Mode of Action of PBM:

PBM therapy functions by exposing tissues to particular light wavelengths, which are then absorbed by mitochondria. This lessens oxidative stress, increases cellular energy production (ATP synthesis), and facilitates healing. PBM is a non-thermal, non-surgical light therapy that lowers pain and inflammation, alters immune responses, and encourages tissue regeneration and healing, according to the American Dental Association. Its effectiveness is supported by scientific research, particularly in the areas of tissue repair and pain management. PBM therapy is a promising adjunctive treatment in prosthodontics and other dental specialties, as studies have shown that it can significantly reduce post-operative discomfort and inflammation. [3,4]

2. METHODOLOGY

A comprehensive review of the literature was conducted on the application of PBS in dentistry in general and prosthodontics in particular. Using databases like Google Scholar, Wiley Online Library, EBSCOhost, Science Direct, and Medline via PubMed, articles published between March 2000 and March 2025 were located. Following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA), the following keywords were used: Photobiomodulation therapy (PBM), Prosthodontics, Low-level laser therapy (LLLT), Osseointegration, Tissue healing, Dental implants and Removable dentures. A total of 35 articles were included in the systematic review, including case reports, original studies, and reviews that discussed the use of PBM in various prosthodontic treatments. [Figure 1]

Figure 1: PRISMA Flow chart for the selection of Articles



3. RESULTS

An examination of the selected literature reveals a number of significant applications of photo biomodulation therapy in prosthodontics. PBM reduces pain and inflammation, helps to lessen post-operative swelling, enhances osseointegration, which in turn increases implant stability, treat peri-implantitis, lessens some TMJ disorders and tooth sensitivity, all of which reduce treatment time, patient discomfort, and oral lesion management. Decreases post-operative discomfort and inflammation. The clinical application of PBM is being broadened by emerging technologies including as AI-guided PBM dosing, smart healing abutments, and integration with digital prosthodontics.

Sufficient number of studies on the effectiveness of PBM therapy are lacking, and there are no standardized protocols or Randomized Controlled Trials (RCTs) in the literature. In the literature, only a small number of prosthodontic treatments are covered about the PBM applications. These include Removable Dentures in 05 papers, MFP in 06, FPD in 06, Implants in 10 and other treatments in 08. [Figure-2]

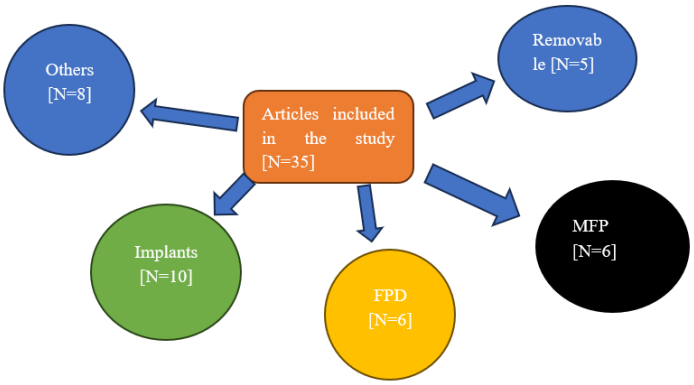


Figure 2: Treatment wise distribution of Articles

4. DISCUSSION

In prosthodontics, PBM therapy is a promising tool, but when incorporating it into clinical practice, its limitations must be taken into account. To maximize its efficacy and create standardized treatment protocols, more research is required. PBM's therapeutic benefits have a scientific foundation thanks to its mechanism, which includes mitochondrial stimulation and cellular regeneration. The applications of PBM therapy in other specialties of dentistry proved its existence with positive results, which includes:

PBM therapy has drawn interest in dentistry because it can: [5,6]

1. Reduce inflammation and pain (for example, in TMJ disorders, post-extraction healing), speed up the healing of wounds (for example, following implant placement or oral surgeries)

2.Improve the osseointegration of dental implants.

3.lessen the sensitivity of the dentin

4.Enhance the movement of orthodontic teeth (reducing treatment time and discomfort)

5.Treat radiation or chemotherapy-induced oral mucositis.

6.Periodontal Therapy: By promoting cell proliferation and differentiation, PBM improves tissue regeneration and promotes healing in periodontal treatments.

7.Management of Oral Lesions: PBM has proven useful in reducing pain and hastening the healing process for oral lesions like herpes simplex infections and aphthous ulcers.

8. Orthodontic Treatment: PBM may speed up tooth movement and lessen discomfort related to orthodontic procedures, which could shorten treatment times.

9. Disorders of the Temporomandibular Joint (TMJ): PBM has been used to help patients with TMJ disorders feel better and function better.

10. Dentin Hypersensitivity: PBM helps patients with dentin hypersensitivity by lessening tooth sensitivity.

11.Postoperative Healing: After dental procedures, PBM encourages tissue healing and lessens postoperative pain and inflammation.

12. Implantology: PBM has been demonstrated to improve dental implant success rates by promoting osseointegration and lowering peri-implant inflammation.

13. Pediatric Dentistry: PBM is regarded as a safe and efficient treatment option for a number of ailments in young patients, such as pain control and accelerated healing.

Role of PBM in Removable Prosthodontics

1. Management of Denture-Related Stomatitis (DRS)- In DRS, PBM has demonstrated encouraging outcomes in lowering erythema, irritation, and Candida albicans colonization. It improves microcirculation, stimulates tissue healing, and increases mitochondrial activity. PBM can be particularly beneficial for patients with recurrent stomatitis or those who do not comply with antifungal treatment. [7]

2. Pain Relief during Denture Adjustment Phase- In the early stages of denture wear, PBM helps to lessen mucosal irritation

and pain. enables faster denture adaption and increases patient comfort.[8]

3. Acceleration of Healing After Preprosthetic Surgery- Use Case: PBM is applied after surgery (such as frenectomy or alveoloplasty) to promote soft tissue recovery prior to denture delivery. a quicker return to function and less pain and inflammation following surgery. [9]

4. PBM in Residual Ridge Resorption (RRR)- There is interest in using PBM to modify bone metabolism, which may help slow the progression of RRR in those who wear complete dentures.[10]

5. Management of Traumatic Ulcers- are frequently caused by poorly fitted dentures. PBM reduces pain and speeds up epithelial regeneration without the need for medication. [11]

Wavelengths typically used: 630–980 nm. PBM is non-invasive and has minimal side effects. Contraindications, cancerous lesions, pregnancy (precautionary), direct retinal exposure

Role of PBM in Maxillofacial Prosthodontics

In maxillofacial prosthodontics, photobiomodulation therapy (PBM) is supportive yet clinically important, especially because of its analgesic, anti-inflammatory, and wound-healing properties. PBM is a useful complement in maxillofacial prosthodontics since it frequently involves surgical procedures, irradiated tissues, and complex oral-facial abnormalities.

1. Enhancing Healing After Maxillofacial Surgery- used post-operatively following procedures such as orbital enucleation, maxillectomy, and mandibulectomy. speeds up the healing of surgical and transplant areas by lowering inflammation and encouraging angiogenesis and fibroblast proliferation. [12]

2. Management of Oral Mucositis in Cancer Patients- frequently seen in individuals receiving chemotherapy and radiation treatment for head and neck malignancies. Mucositis is less severe and lasts less time when PBM is used, enabling prompt prosthesis recovery. [13]

3. Treatment of Osteoradionecrosis (ORN) and Improving Vascularity- In irradiated tissues, PBM is utilized as an adjuvant to promote angiogenesis and improve perfusion, particularly prior to the implantation of osseointegrated implants or prostheses. In irradiated bone and soft tissues, PBM stimulates neovascularization and endothelial cell activity. [14]

4. Pain Control in Patients with Complex Defects- Nerve injury or fibrosis frequently causes neuropathic or post-operative discomfort in people using maxillofacial prosthetics. PBM is a non-pharmacological treatment for post-operative discomfort and trigeminal neuralgia, among other chronic pain conditions. [15]

5. Facilitating Osseointegration of Craniofacial Implants - Implant survival is lower in irradiated or rebuilt areas. Osteoblast activity is stimulated, early bone growth surrounding implants is improved, and implant success in damaged bone may be increased. [16]

6. Scar and Fibrosis Management- Unsightly scars and contracture are common side effects of maxillofacial surgery. PBM improves prosthesis fit and appearance by regulating collagen synthesis and decreasing the growth of fibrotic tissue. [17]

Role of PBM in Fixed Prosthodontics

In fixed prosthodontics, photobiomodulation therapy (PBM) is also helpful but is becoming more and more important, especially in implantology, soft tissue management, and pain management. PBM optimizes the biological milieu, which can lead to better clinical results, even though it has no direct effect on the mechanical or material components of fixed prostheses.

1. Post-Preparation Gingival and Pulpal Inflammation Control - Pulpal inflammation or gingival damage may result after tooth preparation for crowns or bridges. PBM helps in tissue healing, hemorrhage control, and inflammation reduction. improves tissue health and impression accuracy prior to prosthesis cementation. [18]

2. Management of Tooth Sensitivity After Tooth Preparation - Dehydration or dentin exposure can cause post-operative discomfort in patients. modifies nerve response and promotes reparative dentin development to lessen dentinal hypersensitivity. [19]

3. Soft Tissue Healing Around Crown Margins - particularly helpful when using retraction cords or preparing the subgingival margin. Better prosthesis fit and healthier tissue margins result from PBM's ability to speed up epithelium regeneration and lower inflammation. [20]

4. Peri-Implant Soft Tissue Management (Implant-Supported Crowns/Bridges)- Implant-supported fixed prostheses need stable, well-healed peri-implant soft tissue. enhances the soft tissue integration surrounding implant abutments and encourages quicker post-operative recovery. [21]

5. Enhancing Osseointegration of Implants- Implants supporting fixed prostheses frequently depend on good osseointegration. PBM speeds up implant recovery, improves bone growth, and increases osteoblastic activity. [22]

6. Cementation Comfort & Soft Tissue Recovery - can be used following the final cementation of a crown or bridge,

particularly in patients who have tissue trauma or sensitivity. facilitates soft tissue adaption and offers instant comfort. [23]

Role of PBM in Implant prosthodontics

Since its biologic effects such as improving osseointegration, encouraging soft tissue healing, lowering pain and inflammation, and possibly increasing implant survival—can result in better functional and aesthetic outcomes, photobiomodulation therapy, or PBM, has attracted a lot of interest in implant prosthodontics.

1. Enhancement of Osseointegration -Mechanism: At the implant–bone contact, PBM promotes angiogenesis, collagen formation, and osteoblast proliferation. Result: Better primary and secondary implant stability and quicker bone healing. PBM improved implant osseointegration in compromised, irradiated bone. [24]

2. Improving Early Implant Stability- For immediate or early loading regimens, early stability is essential. PBM promotes remodeling and bone turnover surrounding the implant, which raises the Implant Stability Quotient (ISQ) values during the early stages of healing. Early-stage bone formation and mineralization were significantly improved with PBM. [25]

3. Post-Surgical Pain and Inflammation Reduction - Following implant insertion, patients may experience pain, discomfort, or oedema. PBM reduces oedema and pain perception by modulating inflammatory mediators (such as IL-1 and PGE2). PBM reduced post-operative pain and improved patient comfort without pharmaceuticals. [26]

4. Soft Tissue Healing Around Implant Abutments - Both biological seal and aesthetics depend on healthy peri-implant soft tissue. For quicker healing, PBM promotes the migration of epithelial cells and the proliferation of fibroblasts. Both soft and hard tissue response around implants was positively influenced by PBM. [27]

5. Management of Peri-Implantitis (Adjunctive Therapy)- PBM can help with tissue repair and inflammation resolution, but it cannot take the place of purification. enhances the immunological response and modifies cytokine activity. PBM as an adjunct helped reduce inflammation and improve clinical outcomes when combined with mechanical treatment. [28]

6. Healing in Irradiated or Medically Compromised Patients - Patients with systemic illnesses or those with irradiated bone have lower implant success rates. Even in tissues that are already damaged, PBM increases angiogenesis, lowers oxidative stress, and encourages bone regeneration. Cellular bioenergetics are upregulated by PBM, supporting regeneration even under stress. [29]

The latest advancements of PBM in Prosthodontics

Recent developments in prosthodontics demonstrate how Photobiomodulation Therapy (PBM) has developed from a simple means of promoting wound healing to a precise, protocol-driven approach that improves biological results and patient satisfaction. Improvements in clinical research, digital workflow integration, and laser/light delivery devices are the main drivers of these developments.

1. Integration with Digital Prosthodontics and CAD/CAM Workflows- PBM is utilized both before and after digitally guided procedures (such as CAD/CAM crown preps or guided implant insertion). PBM enhances peri-implant tissue conditioning, speeds up healing, and makes rapid or early loading regimens easier. [30]

2. Targeted PBM Using Laser Biostimulation with Fiber Optics- Highly localised PBM is made possible by new fiber-optic delivery devices, which are particularly helpful in confined spaces like the gingival sulcus or the mucosa around implants. more accurate soft tissue care around subgingival edges or fixed prostheses. [31]

3. PBM for Accelerated Soft Tissue Contouring Before and After Prosthesis Placement- These days, PBM is used to modify soft tissue profiles, particularly around full-arch prostheses and implant crowns in the aesthetic zone. enhanced pink aesthetics, decreased inflammation, and a better emergence profile. [32]

4. Customized Wavelength and Dosage Protocols (Photonic Dosing Algorithms)- The best PBM dose and wavelength are being determined by testing AI-driven platforms based on: Tissue thickness, Target depth, and Type of prosthesis (removable vs. fixed). Personalize PBM therapy for maximum efficiency and safety. [33]

5. PBM as a Prehabilitation Tool Before Implant Placement- Preconditioning the bone and soft tissue with PBM days or weeks prior to surgery is a new practice. increased osteogenic potential and angiogenesis, which are particularly beneficial for patients who are irradiated or have other health issues. [34]

6. PBM-Integrated Healing Abutments - Following implant implantation, several research teams are creating healing abutments with embedded PBM diodes that constantly emit low-level light. photobiomodulation that lasts without additional clinic visits. [35]

7. Adjunctive PBM in Peri-implantitis and Mucositis Treatment Protocols- PBM is currently included in standardized procedures that combine antibacterial and mechanical treatments. In at-risk situations, improved soft tissue repair and decreased inflammation increase implant survival. [36]

8. Use in Immediate Loading and Provisionalization Protocols- in situations where immediate temporization is envisaged,

such as full-mouth rehabilitations or aesthetic zone cases. During the preliminary period, PBM reduces soft tissue collapse and preserves tissue health. [37]

According to recent developments, PBM is evolving from a supporting therapy to a crucial part of advanced prosthodontic care, particularly in patients with medical compromise, complex implant cases, and aesthetic zone maintenance. It fits in nicely with the movement towards patient-centered, minimally invasive, and digitally integrated prosthodontics.

5. CONCLUSION

Due to its capacity to promote tissue regeneration, lessen pain and inflammation, and speed up healing, photobiomodulation therapy (PBM) has become a prominent supplementary treatment in prosthodontics. It is used in all areas of prosthodontics, including maxillofacial, implant, fixed, and removable prosthodontics, where it enhances patient satisfaction and clinical results. PBM improves prosthetic function and comfort, supports osseointegration, facilitates mucosal and soft tissue healing, and controls prosthesis-related problems, especially in tissues that have been compromised or exposed to radiation. PBM is gradually evolving from supportive care to a crucial part of full prosthodontic therapy with to developments in laser delivery devices and customized treatment plans. Its place in evidence-based prosthodontic practice will be further cemented by further studies and clinical standardization.

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