ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 08 | August - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

PHOTOBIOMODULATION IN TREATMENT OF HYPERSENSITIVITY IN MOLAR INCISOR HYPOMINERALISATION: A SYSTEMATIC REVIEW

Dentistry

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ABSTRACT

Background Molar Incisor Hypomineralisation (MIH) related hypersensitivity is a complex problem that affects both the quality of life and dental health of young patients. Photobiomodulation (PBM) offers a promising approach to treating this condition by reducing sensitivity, strengthening teeth and providing a child-friendly alternative to more invasive procedures. The present systematic review aims to evaluate the utility of PBM in managing hypersensitivity in children & adolescents with MIH, contributing to a better understanding of its effectiveness and potential benefits for children suffering from this condition.**Methods** A comprehensive search was conducted across electronic databases including PubMed, PsycINFO, Cochrane Library, and Embase, covering studies from 2000 to 2024. Studies included randomized controlled trials (RCTs), non-randomized controlled trials, prospective cohort studies and comparative observational studies focusing on children and adolescents upto 16 years of age who were receiving treatment for MIH. Outcome measures included reductions in hypersensitivity assessed through pain scores e.g. Visual Analog Scale [VAS], Numeric Rating Scale [NRS] or sensitivity thresholds. The Cochrane Collaboration's Risk of Bias tool and Newcastle-Ottawa Scale were used for quality assessment. Data were synthesized narratively and systematic review was performed **Results** Four studies met the inclusion criteria, with studies conducted in various countries including China, Brazil and Italy. Sample sizes ranged from 39 to 120 participants. The primary intervention evaluated in these studies was Photobiomodulation, including LLLT and LED therapy, often combined with conventional treatments. The majority of studies found significant hypersensitivity reduction in PBM-treated groups compared to control groups. In studies where PBM was combined with fluoride varnish or other desensitizing agents, an enhanced reduction in sensitivity was observed, often surpassing the effects of standalone treatments.**Conclusion**Photobiomodulation, particularly when combined with conventional desensitizing agents such as fluoride varnish or CPP-ACPF mousse, significantly reduces hypersensitivity, offering both immediate and sustained relief among children and adolescents. This technique offers a minimally invasive, safe and effective alternative for managing hypersensitivity in MIH-affected teeth, improving the quality of life for pediatric patients. Further research is needed to establish definitive clinical guidelines and optimize PBM application for MIH-related hypersensitivity.

KEYWORDS

MIH, LASER therapy, hypersensitivity, fluoride varnish, LLLT

INTRODUCTION

Molar-Incisor Hypomineralisation (MIH) is a developmental condition affecting the enamel of molars and incisors, causing enamel defects that compromise tooth structure and function.[1] First recognized in 2001, MIH has become a significant focus in dentistry due to the challenges it presents in treatment and long-term management.[2] The condition arises from disruptions in enamel formation during the early years of life, often linked to factors such as illnesses, medications, or other systemic issues in early childhood. Teeth affected by MIH typically show distinct opacities, ranging in color from white to yellow-brown and the enamel is often soft and prone to rapid breakdown under chewing forces. This leaves the teeth vulnerable to decay, fractures and heightened sensitivity.[3]

Hypersensitivity in MIH-affected teeth is a major issue because the loss of enamel exposes the underlying dentin, which contains nerve endings connected to the pulp. This exposure causes discomfort or pain, particularly when eating or drinking hot, cold, or sweet foods.[4] For children, this sensitivity can make routine dental care and oral hygiene difficult, further complicating the condition. Standard treatments like Fluoride varnishes, desensitizing agents, or fillings can reduce symptoms but often fail to address the underlying problems or provide lasting results.[5] The search for a more effective treatment has led to interest in photobiomodulation (PBM), a therapy that uses light energy to stimulate natural healing processes in tissues.[6]

PBM, also known as Low-Level LASER Therapy, uses specific wavelengths of light to activate biological changes in tissues. When the light is absorbed by cells, particularly in the mitochondria, it can enhance cellular energy production, reduce inflammation and promote tissue repair.[7] In dental applications, PBM has shown promise in reducing pain by calming the nerves and encouraging the formation of new dentin. It also helps seal dentinal tubules, which are small channels in the dentin that can transmit pain signals.[8] By addressing the causes of hypersensitivity and promoting repair, PBM offers a targeted and gentle approach to managing this condition. PBM has particular advantages for children with MIH. The treatment is non-invasive and painless, making it easier to perform on patients who may feel anxious or uncooperative during traditional dental procedures.[9] Unlike some other treatments, PBM does not involve drilling or chemical agents that could damage the already weakened tooth structure.[10] Instead, it works by strengthening the tooth and reducing pain without causing additional trauma. This makes it an attractive option for treating young patients with sensitive teeth.

Recent developments in PBM technology, including portable and affordable devices, have made it easier to integrate this treatment into dental practices.[11] Research has shown that PBM can reduce hypersensitivity quickly and help strengthen the dentin over time, potentially offering a long-lasting solution.[12] However, while early studies are encouraging, more research is needed to confirm the best ways to use PBM for MIH and to establish consistent treatment protocols.

Overall, MIH-related hypersensitivity is a complex problem that affects both the quality of life and dental health of young patients.[13] PBM offers a promising approach to treating this condition by reducing sensitivity, strengthening teeth and providing a child-friendly alternative to more invasive procedures.[14] The present systematic review aims to evaluate the utility of PBM in managing hypersensitivity in patients with MIH, contributing to a better understanding of its effectiveness and potential benefits for children suffering from this condition.

METHODS

The present systematic review investigated the effectiveness of Photobiomodulation (PBM) therapy in managing dental hypersensitivity in children and adolescents with Molar Incisor Hypomineralisation (MIH). The primary objective of this systematic review was to assess the effectiveness of PBM in MIH affected teeth compared to conventional desensitizing treatments in children and adolescents.

SEARCH STRATEGY

A comprehensive search strategy was developed to identify relevant studies published in English language without any restriction for the date of publication. Electronic databases including PubMed, PsycINFO, Cochrane Library and Embase were systematically searched The search strategy combined keywords and controlled vocabulary terms related to "Photobiomodulation," "Low-Level LASER Therapy," "LED Therapy," "Dental Hypersensitivity," "Molar Incisor Hypomineralisation," "MIH," "Hypomineralized Molars," "Enamel Hypomineralization," and "LASER Therapy". Additionally, reference lists of included studies and relevant review articles were hand-searched for additional studies.

SELECTION OF THE ARTICLES

Studies were included if they met the following criteria:

- Participants: Children aged upto 16 years
- Intervention: Photobiomodulation therapy, including Low-Level LASER Therapy (LLLT) or LED therapy, specifically targeted to manage dental hypersensitivity.
- Comparator: Studies with conventional desensitizing agents (fluoride varnish, desensitizing toothpastes), placebo treatments or no treatment.
- Outcomes: Studies reporting outcomes related to hypersensitivity reduction in MIII..
- Study Design: Randomized controlled trials (RCTs), non-randomized controlled trials, prospective cohort studies and comparative observational studies were included.

Studies were excluded if they focused on adults or population outside the specified age range or those with dental hypersensitivity unrelated to MIH or studies that did not report quantitative measures of hypersensitivity reduction or outcomes. Animal-based studies, case reports, narrative reviews, editorials and conference abstracts were also excluded.

Two independent reviewers screened titles and abstracts of identified studies against the inclusion criteria. Full-text articles of potentially eligible studies were then assessed for inclusion. Any discrepancies were resolved through discussion or consultation with a third reviewer.[15]

DATA EXTRACTION

A standardized data extraction form was developed to extract relevant information from included studies. Data extracted included study characteristics (e.g., author, year, study design), participant demographics, details of the intervention and comparator (if applicable), outcome measures and results related to dental hypersensitivity reduction in MIH.

QUALITY ASSESSMENT

The methodological quality of the included studies was assessed using appropriate tools depending on the study design. For RCTs, the Cochrane Collaboration's Risk of Bias tool was used, while the Newcastle-Ottawa Scale was employed for observational studies. Quality assessment was conducted independently by two reviewers, with any discrepancies resolved through discussion or consultation with a third reviewer.

DATA SYNTHESIS

Data synthesis involved a narrative synthesis of study findings, summarizing the effectiveness of PBM therapy in reducing hypersensitivity among children upto age 16 years. Comparisons between PBM and conventional interventions were highlighted, along with the duration of hypersensitivity relief.

RESULTS:

A total of four randomized clinical trials were identified from the years 2000 to 2024 [16-19] The PRISMA Flow diagram indicating the selection process of the studies included in the present systematic review is delineated in Figure 1. Of the four studies, two were conducted in China, one in Brazil and one was carried out in Italy. The sample sizes varied significantly. ranging from 39 to 120 children, with age groups spanning 6 to 16 years. Most studies included children diagnosed with MIH based on established criteria, such as the European Academy of Paediatric Dentistry (EAPD) guidelines or specific MIH diagnostic protocols n=1 study employed LLLT, n=2 studies employed Er:YAG LASER therapy, No studies exclusively used LED therapy. The PBM protocols involved diode LASERS (808 nm, 980 mm), Er:YAG LASERS and other light-based therapies, with varying energy densities, power settings and application frequencies. Comparator treatments included fluoride varnish (n=1), CPP-ACPF mousse (n=1)and GLUMA desensitizing agents (n=1). Some studies also assessed PBM as a standalone treatment, while others evaluated its effectiveness in combination with traditional desensitizing agents. The primary outcome assessed was hypersensitivity reduction, measured using validated scales such as the Visual Analog Scale (VAS) (n=2), the Face Scale (n=1) and the Wong-Baker Faces Pain Rating Scale (WBFPRS) (n=1).

Across studies, statistical analyses confirmed that PBM significantly improved hypersensitivity outcomes. n=1 study reported statistically significant reductions in sensitivity with p-values <0.05, demonstrating meaningful improvements compared to baseline measurements. The extent of hypersensitivity reduction varied based on the PBM modality, energy dose and duration of application, with some studies highlighting the superiority of diode LASER-based PBM over Er:YAG LASER-based interventions. The systematic review provides evidence supporting the efficacy of PBM therapy in reducing hypersensitivity in MIII-affected teeth. PBM, particularly when used in conjunction with conventional desensitizing treatments, offers rapid, significant and sustained relief from hypersensitivity, with no reported complications.

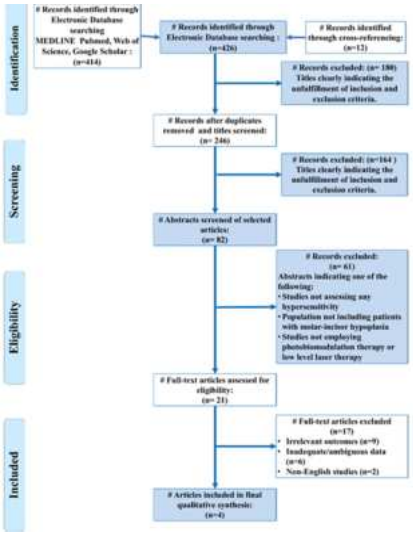

Figure 1: PRISMA Flow diagram indicating the selection process of the studies included in the present systematic review

Risk of Bias Assessment

Figure 2: Traffic light plot indicating the risk of bias in the studies included in the present systematic review

Figure 3: Summary plot indicating the overall risk of bias of the studies included in the present systematic review

Two studies (n=2) were rated as having a low overall risk of bias, suggesting strong methodological quality and reliable findings. The remaining two studies (n=2) had some concerns, primarily due to

limitations in the randomization process, outcome measurement and reporting transparency

DISCUSSION:

The findings of this systematic review highlight the potential of PBM as a promising treatment for managing hypersensitivity in children with MIH. The included studies consistently demonstrated a reduction in hypersensitivity, supporting the efficacy of PBM in alleviating discomfort in affected teeth.

The geographic distribution of the included studies spanned China, Brazil and Italy, indicating that PBM therapy is gaining global recognition in pediatric dentistry.[20] Given that MIH prevalence varies worldwide, differences in genetic susceptibility, environmental factors, dietary habits and fluoride exposure may influence the clinical effectiveness of PBM.[21] Future studies should aim to include multicenter trials from varied populations to validate these findings.

One of the most significant observations in this review was the enhanced efficacy of PBM when combined with conventional desensitizing agents such as fluoride varnish or CPP-ACPF mousse. The study from Brazil reported a remarkable 93% reduction in hypersensitivity when PBM was used alongside fluoride varnish, compared to 87% for fluoride varnish alone and 79% for PBM alone.[16] This suggests a synergistic effect, where PBM enhances the action of conventional desensitizing agents by accelerating tissue repair, reducing nerve excitability and promoting dentin formation.[22] This finding aligns with previous studies in broader dental research, where PBM has been shown to enhance wound healing and reduce post-operative discomfort in various dental procedures.

The variation in PBM modalities across studies presents an important factor influencing treatment outcomes. The included studies utilized different PBM sources, including Low-Level LASER Therapy (LLLT) (n=1) and Er:YAG LASER therapy (n=2), while none used LED therapy exclusively. This discrepancy raises questions about which PBM modality is most effective for MIH-related hypersensitivity. The Brazilian study, which employed diode LASER (808 nm, 100 mW, 1 J per point), showed a statistically significant reduction in hypersensitivity, while the Italian study, using a 980 nm diode LASER at 4W, also demonstrated considerable pain reduction ($p<0.0001$). However, the studies that used Er:YAG LASER therapy (n-2) showed mixed results, with one reporting significant pain relief while another indicated that PBM was equally effective as conventional desensitizing treatments but not superior. These differences may stem from variations in wavelength, energy density, duration of exposure and treatment frequency.

The mechanism of action of PBM in reducing MIH-related hypersensitivity appears to be multifaceted.[21] At a cellular level, PBM is believed to stimulate mitochondrial activity, leading to increased production of adenosine triphosphate (ATP). This boost in cellular energy promotes the repair of enamel and dentin, thereby reducing hypersensitivity.[23] Additionally, PBM is known to modulate inflammatory cytokines, thereby decreasing inflammation and pain perception. Another significant mechanism is the stimulation of odontoblast activity, which promotes secondary dentin formation and helps seal exposed dentinal tubules, thereby reducing pain transmission.[24] These biological effects may explain why PBM provides both immediate and long-term relief from hypersensitivity.[25]

The included studies utilized different hypersensitivity measurement tools, which adds another layer of complexity to interpreting the results. Among the included studies, n=2 used the Visual Analog Scale (VAS), n=1 used the Facial Image Scale and n=1 used the Wong-Baker Faces Pain Rating Scale (WBFPRS). While all these tools provide valuable patient-reported outcomes, the lack of standardization makes direct comparisons across studies difficult.[16-19]

The follow-up durations in the included studies varied significantly, ranging from 4 weeks to 52 weeks. This discrepancy is important because hypersensitivity relief may fluctuate over time, with some treatments providing only temporary relief while others yield more sustained effects. Studies with shorter follow-up periods may overestimate the long-term benefits of PBM, while those with longer durations can better capture its sustained effects.[16,18] The study with the longest follow-up (52 weeks) reported continued hypersensitivity reduction, indicating that PBM may have long-lasting benefits.[19] However, it remains unclear whether repeated PBM applications are required to maintain these effects over time.

A critical aspect of this review was the safety profile of PBM therapy. Among the included studies, n=3 explicitly reported no adverse events, confirming that PBM is a non-invasive and well-tolerated intervention, Unlike some conventional desensitizing treatments that may cause temporary irritation or require multiple applications, PBM does not pose risks of enamel erosion, pulpal irritation, or allergic reactions.[16-19] This makes it particularly suitable for pediatric patients who may have difficulty tolerating conventional therapies. However, despite the favorable safety profile, there is still a need for more long-term studies to ensure there are no delayed adverse effects associated with PBM exposure.

The clinical implications of these findings are significant. PBM provides a non-invasive. painless and child-friendly alternative to conventional treatments for MIH-related hypersensitivity.[26] Given that MIH is often associated with dental anxiety and increased treatment difficulty in children, PBM could be an effective solution that enhances patient compliance and comfort.[27] Moreover, PBM may reduce the need for restorative interventions. thereby preserving the integrity of MIH-affected teeth for longer.[28]

Despite the promising findings, this systematic review has several limitations. Firstly, the total number of included studies was relatively small (n=4), which limits the generalizability of the findings.[16-19] Additionally, while all studies demonstrated a reduction in hypersensitivity, n=1 study reported only marginally better results with PBM compared to conventional treatments, indicating that PBM may not be superior in all cases.[18] The heterogeneity in study designs, PBM protocols and outcome measures further complicates the ability to draw definitive conclusions. Another limitation is the lack of data on long-term cost-effectiveness, as PBM devices can be expensive and it remains unclear whether the benefits justify the cost in routine pediatric dental care.

Future research should focus on conducting large-scale, multicenter RCTs with standardized PBM protocols. Additionally, studies should investigate combination therapies, comparing PBM with various desensitizing agents to determine the most effective approach. It would also be beneficial to explore the molecular mechanisms of PRM in Mili, camining how it influences odontoblast function, dentin regeneration and enamel remineralization.

CONCLUSION:

The present systematic review provides compelling evidence supporting the effectiveness of PBM therapy in managing hypersensitivity in children with MIII The findings suggest that PBM, particularly when combined with conventional desensitizing agents such as fluoride varnish or CPP-ACPF mousse, significantly reduces hypersensitivity, offering both immediate and sustained relief. Despite the promising results, variations in PBM protocols, study methodologies and follow-up durations highlight the need for standardization in treatment parameters. If validated through future research, PBM could serve as a minimally invasive, safe and effective alternative for managing hypersensitivity in MIH-affected teeth, improving the quality of life for pediatric patients.

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