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Assessing the impact of photo-biomodulation on expediting orthodontic tooth movement: A comprehensive systematic review

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Abstract

Introduction: Orthodontic procedures offer an efficient solution for addressing dental aesthetic issues. Photo-biomodulation (PBM) has recently gained prominence as an important auxiliary method in orthodontic treatment.

Material and Method: The investigators utilized various databases in their search, including Cochrane Library, ScienceDirect, PubMed, Scopus, and Web of Science. Adhering to the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions and PRISMA standards, the team identified and incorporated 6 studies into their systematic review. They eliminated abstracts, case reports, animal studies, research with fewer than 10 participants, and investigations lacking essential data. The team utilized Review Manager 5.3 for data compilation and analysis.

Result: Following the application of exclusion criteria, our review encompassed 6 studies from diverse geographical regions. The selection process adhered to PRISMA guidelines. Among the selected articles, two exhibited a high risk of bias, while four demonstrated a low risk; however, substantial differences emerged in the second and third months. The studies displayed considerable variability and heterogeneity in their findings.

Conclusion: The rate of OTM can be enhanced by PBM, particularly during the second and third months, due to the cumulative effects of radiation exposure. Consequently, PBM may serve as a valuable complementary treatment in orthodontics.

Keywords: Photo biomodulation, LLLs, low-level lasers, Orthodontic tooth movement,

Introduction

Misaligned teeth pose a significant issue that can be addressed through either cosmetic dentistry or orthodontic procedures, both of which effectively correct visible dental irregularities. According to previously published research, the traditional method of using fixed orthodontic devices typically requires between 1 and 2.5 years to complete treatment.[1] The primary reason individuals avoid certain treatments is the extended duration of the procedure. Not only can lengthy treatments disrupt their regular work schedule, but they can also interfere with everyday activities, causing significant inconvenience.

Longer orthodontic treatment durations can heighten the likelihood of patient complications. These potential issues include gum inflammation, deterioration of tooth roots, dental caries, and problems

affecting the tissues surrounding the teeth. Such complications are more prone to develop when orthodontic care is extended over a prolonged period.[2] For an extended period, researchers primarily focused on discovering techniques to accelerate tooth movement and shorten the duration of orthodontic treatment. Scientists have discovered multiple successful techniques for accelerating the movement of teeth. These strategies include injecting substances like prostaglandins and osteocalcin in proximity to the alveolar socket, conducting corticotomy procedures, employing electric current stimulation, and using pulsed electromagnetic fields, as well as other techniques. Although many patients find them unpleasant due to the discomfort experienced during their implementation.[3]

Moreover, obtaining the necessary tools and equipment for these invasive techniques is challenging in routine orthodontic practice. Orthodontists continue to search for a completely non-invasive and user-friendly method that can shorten the duration of treatment.[3] Photobiomodulation (PBM) has emerged as a non-invasive method in orthodontics. These instruments function in a wavelength (ג) spectrum of 600-1000nm, encompassing light, to elicit a biostimulatory response.[3,4,5] Research has shown that PBM is an effective method for improving various cellular functions in the dentoalveolar complex. This technique has been found to stimulate the growth of osteoclasts, osteoblasts, and fibroblasts, while also enhancing blood vessel formation, cellular renewal, and mitochondrial activity. These outcomes lead to enhanced wound and bone healing, regeneration of skin and nerve tissues, and ultimately, accelerated tooth movement. [6,7] As a result, PBM has the potential to be a significant complementary technique in orthodontic therapy.

However, the optimal dosage of PBM remains undetermined at present. [8,9,10] Contrary to previous research, Almeida et al. found that PMB did not expedite tooth movement or shorten orthodontic treatment duration.[11] Given these conflicting outcomes, it remains unclear whether PBM effectively accelerates tooth movement and reduces overall treatment time.

Several comprehensive reviews conducted by researchers have demonstrated a connection between photo biomodulation (PBM) and tooth movement during space closure procedures. In orthodontic treatments involving dental alignment, extractions were required for only 35-45% of cases. Furthermore, fewer than half of those who underwent extraction reached the space closure phase. [12-15] Assessing how well PBM shortens orthodontic treatment duration could offer vital insights for its wider to explore its potential applications in future orthodontic treatments.

Materials and methods

The researchers conducted this systematic review in accordance with the protocols described in the 'Cochrane Handbook for Systematic Reviews of Interventions' and in compliance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[16]

PICOS format protocol

This review employed several databases, including ScienceDirect, PubMed, Scopus, and Web of Science, to gather information. The search used terms like "Photo biomodulation," "PBM," "LLLT," "laser therapy," "laser irradiation," "tooth movement," "dental movement," and "orthodontic." The review was limited to human studies and articles published in English. These criteria were applied across all sources.

Selection criteria:

1. Randomized or clinical control trials in English, without restrictions on time or population.

2. Research focusing on orthodontic tooth movement using photo biomodulation.
3. Peer-evaluated publications that satisfy PICOS criteria.
4. RCTs or CCTs.
5. Photo biomodulation administered using low-level laser or LED devices.
6. Studies presenting specific characteristics and varied parameters of PBM.

Criteria for exclusion:
1. Summaries, opinion pieces, and individual case studies
2. Research conducted on non-human subjects, Research lacking essential information
3. Investigations involving fewer than 10 participants
4. Individuals who have undergone prior orthodontic procedures

Data extraction:
In our research, a single author initially extracted data by reviewing titles and abstracts of all articles. Subsequently, two authors collaboratively performed a second check, scrutinizing the full texts of selected articles. The collected data encompassed various aspects, including the number of participants, study authors, year of publication, and geographical setting. Additionally, details about study characteristics were recorded, along with specific laser parameters. These parameters included the areas of the tooth targeted for intervention, the laser's frequency and operational mode, its wavelength, and the energy density applied.

The present study received ethical approval from the Institutional Ethics Committee of Vinayaka Mission University (Ref No: VMU/IEC/2023/68325). A detailed Participant Information Sheet was provided to all participants, and written informed consent was obtained prior to their participation in the study.

Results

Our initial search identified 256 articles, which were subsequently reduced to 167 after removing duplicates. We then employed the PICOS approach to examine the titles and abstracts of all remaining articles, ultimately selecting six for inclusion in our study.

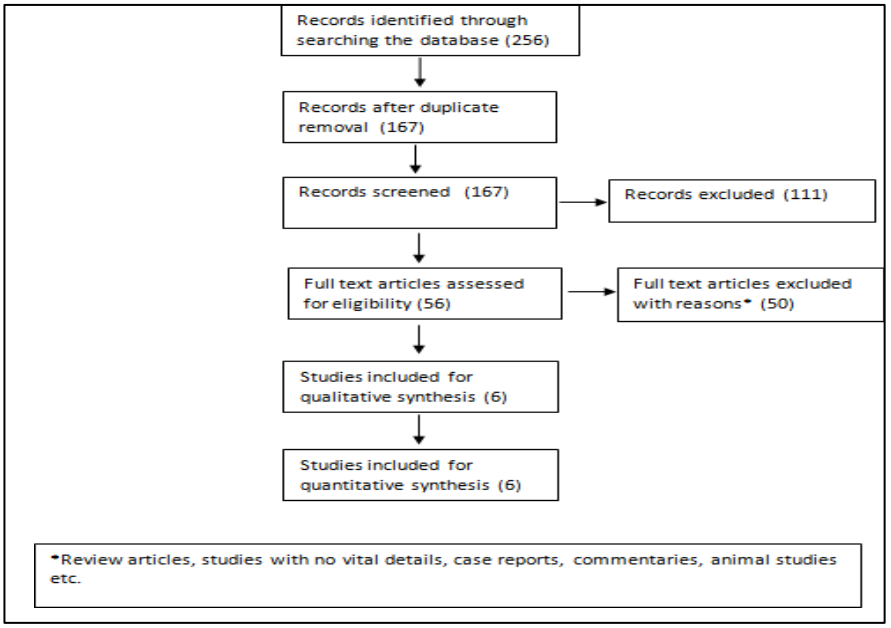

Figure 1: PRISMA flow chart for conducting systematic review and meta-analysis

Across all investigations, photo-biomodulation (PBM) was delivered via Low-Level Laser Therapy (LLLT), utilizing diode lasers with wavelengths between 618 and 940 nm. The study investigated the impact of PBM on expediting tooth alignment and leveling, evaluating its efficacy through the speed of tooth movement or the overall length of treatment needed to correct dental overcrowding. [18-20] Additional studies examined the extent of tooth movement during retraction, finding no statistically significant difference between subjects who underwent PBM and those who did not. The calculated weighted mean difference (WMD) was 0.20, with a 95% confidence interval (CI) ranging from -0.09 to 0.51 and a p-value of 0.26.

Discussion

In orthodontics, low-level laser therapy (LLLT) has emerged as a promising technique for accelerating tooth movement and reducing overall treatment duration. Increasing interest has been shown in evaluating its effectiveness as an adjunct to conventional orthodontic therapy, particularly with respect to alignment efficiency.

Alsayed et al [17] investigated the effect of LLLT on leveling and alignment using GaAlAs laser therapy (830 nm) and reported significantly improved alignment and reduced crowding resolution time compared to conventional orthodontic treatment alone. Similarly, Caccianiga et al [18] evaluated a diode laser (980 nm) in combination with self-ligating brackets and concluded that laser therapy positively influenced orthodontic alignment outcomes.

Al Okla et al [19] examined the use of a photobiomodulation device (OrthoPulse, 850 nm) applied for five minutes per arch daily and observed accelerated orthodontic tooth movement with faster alignment. However, they also reported evidence of root resorption after six months, emphasizing the need for cautious clinical monitoring. In contrast, Dalaie et al [20] evaluated the effects of GaAlAs laser therapy (880 nm) during canine retraction and found no statistically significant improvement in tooth movement or pain reduction, suggesting that LLLT may not be effective across all orthodontic mechanics.

Nahas et al [21] reported enhanced decrowding of the lower anterior segment using an extraoral photobiomodulation device, whereas Kochar et al [22] demonstrated that LLLT accelerated canine retraction and reduced pain perception, indicating that laser therapy may offer both biomechanical and analgesic benefits.

Collectively, these studies indicate that LLLT can contribute to reduced orthodontic treatment duration; however, its effects on pain control remain inconsistent. Variations in outcomes may be attributed to differences in laser wavelength, energy density, dosage, frequency of application, and study design. Despite these inconsistencies, LLLT remains a promising adjunctive modality, particularly for alignment and leveling phases of orthodontic treatment.

Prolonged treatment duration is a major concern for orthodontic patients. Photobiomodulation, a non-invasive laser-based technique, has been shown to reduce inflammation, alleviate pain, and promote tissue healing. Nimeri et al [7] and Miles et al [9] suggested that PBM stimulates osteoblasts, osteoclasts, and fibroblasts, thereby enhancing bone remodeling and accelerating tooth movement. Although the exact biological mechanisms are not fully understood, cumulative laser exposure appears

to be an important factor in achieving clinical benefits.

This systematic review analyzed six randomized controlled trials evaluating the effect of PBM on orthodontic tooth movement. The findings demonstrated no significant effect during the first month of treatment; however, significant acceleration was observed during the second and third months. These results are consistent with animal studies reported by Garcez et al [24], Yoshida et al [25], Duan et al [26], and Carvalho-Lobato et al [27], suggesting a cumulative biostimulatory effect. Heravi et al [28] reported that a minimum of one month of laser exposure is required to observe enhanced orthodontic tooth movement, while Qamruddin et al [10] demonstrated that laser application at three-week intervals could increase tooth movement by up to 200%.

Among the clinical trials, Nahas et al [21] and Kochar et al [22] utilized energy density per unit time, which may explain variations in treatment outcomes. Differences in radiation dosage, frequency, and laser parameters remain critical factors influencing clinical effectiveness.

Patient compliance is essential for optimal outcomes, as laser therapy often requires multiple sessions. Further research is needed to standardize laser parameters such as wavelength, power output, dosage, and application frequency to improve consistency across studies and evaluate long-term effects [28]. The primary strength of the present review lies in its comprehensive literature search and systematic risk-of-bias assessment using the Cochrane Collaboration tool.

Limitations of this review include the small number of included studies and heterogeneity in laser protocols, treatment duration, energy density, and outcome measures, which may limit the generalizability of the findings.

Conclusions

The findings of this review article suggest that photo biomodulation (PBM) can accelerate orthodontic tooth movement (OTM), particularly during the second and third months of treatment. This acceleration is attributed to the cumulative effects of repeated radiation exposure. As a result, low-level laser therapy (LLLT) may be considered an effective adjunctive treatment for orthodontic patients. Nevertheless, additional research is required to examine the particular laser characteristics that corroborate these systematic review findings. Additionally, there is still a requirement to develop a standardized and efficient PBM protocol that can improve OTM and accelerate patient recuperation.

Conflict of interest: Nil

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