



Efficiency of photobiomodulation in speeding up the tooth movement: A meta-analysis and systematic review

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KEYWORDS

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Abstract

Introduction- Orthodontic treatment is an effective way to cure aesthetic problems of teeth. With recent advanced, photobiomodulation (PBM) has become an important add-on in the orthodontic treatment. Current review aimed to evaluate the efficacy of PBM systematically on accelerating the alignment rate for further application in orthodontic treatment.

Material and Method- Articles were searched on Cochrane Library, ScienceDirect, PubMed, Scopus and Web of Science etc. Based on the guidelines of Cochrane Handbook for Systematic Reviews of Interventions and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) we included 6 articles in the current review. Abstract, case-reports, animal studies, studies including <10 subjects and studies without vital data were excluded. Data was collected and analysed using Review Manager 5.3. P-value<0.05 was considered to be statistically significant.

Result- After applying exclusion criteria, we were left with 6 articles from different geographical areas in our review. PRISMA guidelines were used for articles selection. Two of the articles showed a high risk of bias and four articles showed low risk. This systematic review observed that PBM significantly increased the orthodontic tooth movement (OTM) and with due course of time the rate of OTM further increased. PBM showed no difference in OTM in the 1st month but in the 2nd and 3rd months, a significant difference was seen. Variability/Heterogeneity among articles was significant.

Conclusion- PBM can increase the rate of OTM especially in the 2nd and 3rd month due to the accumulative effect of radiation. Therefore, PBM can be an important adjunct to the orthodontic treatment.



Introduction:

Malocclusion is a serious problem and can be treated by cosmetic dental treatment or orthodontic treatment which is an effective way to resolve the visible defect. As orthodontic field has advanced, a lot of adults and children are looking for cosmetic dental treatment. As per a previous documented study, conventional technique of fixed orthodontic appliances can take up to 1-2.5 years.^[1] The length of treatment procedure is the main reason for people to avoid such treatment. Long duration of treatment may also affect their daily work life apart from causing inconveniences in day to day activities. For orthodontists, long duration treatment also makes patients prone for higher complication rate due to associated gingivitis, root resorption, decay, and periodontal diseases.^[2] So, for a longtime the primary aim for the researchers was to search for methods which aim to enhance the speed of dental movement and reduce duration of orthodontic procedure. Various procedures have been explained as effective methods to increase rate of tooth movement, comprising of injections like prostaglandins & osteocalcin near alveolar socket, corticotomy, electric-current stimulation and pulsed electromagnetic field etc. Though these methods have number of evidences proving their efficiency but these methods are not comfortable for the patients due to pain experienced by them during these techniques.^[3] Additionally, finding these armamentarium and apparatus needed for such invasive procedures are not easy tasks for regular orthodontic procedures. Orthodontic practitioners are still trying to find an absolutely non-invasive and userfriendly technique which can reduce the treatment time.^[3] PBM has been introduced as one of the non-invasive technique into the field of orthodontics that uses light-emitting diodes (LEDs) or low-level lasers (LLs) with wavelength (λ) varying from 600-1000nm (range of red to near-infrared) to initiate a biostimulation reaction.^[3,4] The dissimilarity in LLs and LEDs is their light source as it is coherent for LLs and incoherent in LEDs.^[5] PBM is regarded as an efficient method for stimulating various processes of cell like proliferation of osteoclasts, osteoblasts, and fibroblasts of the dentoalveolar complex, angiogenesis,

cell turnover, mitochondrial metabolism improving the extent of healing of wound and bone, skin and nervous tissue remodelling and consequently accelerating tooth movement.^[6,7] Therefore, PBM can be an important adjunct to the orthodontic treatment.

Many researchers have found enhancement of tooth movement by PBM during space closure phase^[8] so that time of treatment is decreased. There are many meta-analyses which have observed the association between PBM and increased dental movement like **Imani et al.** and **Ge et al.** who have found in their studies that use of PBM with different wavelengths may decrease the duration of dental procedure, though the most favourable dose of PBM could not be determined till now.^[9,10] **Almeida et al.** observed contradictory results to the previous studies as tooth movement was not accelerated by PMB and also orthodontic treatment time was not reduced.^[11] So, as per these varied results, it is difficult to determine whether PBM accelerate tooth movements and decrease treatment time.

Many researchers in recent times have documented in their meta-analyses, observation of a link between tooth retraction and PBM in space closure phase. Out of all dental patients who went for alignment procedure, only 35-45% of them required extraction and <50% of them have went up to space closure phase.^[12-15] So, assessing the efficacy of PBM in decreasing the duration of orthodontic treatment may offer invaluable support for its wider in orthodontic care. Hence, for future consideration of PBM in orthodontic procedures, our review aimed to assess efficacy of PBM on speeding up the dental alignment rate.

MATERIALS AND METHODS:

The current systematic review was performed on the basis of guidelines of 'Cochrane Handbook for Systematic Reviews of Interventions and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)'.^[16]

Research question:

Is there any effect of PBM on the speed of OTM? 'PICOS ((patient, intervention, control, study design) format' was used for the research question.

Table 1: PICOS format protocol

Patient	Patients of any age and ethnic group who are undergoing for orthodontic procedure
Intervention	Photobiomodulation to accelerate dental movement
Control	Patients having traditional orthodontic treatment (without laser)



Outcome of interest	Rate of tooth movement, Overall alignment time
Study	Randomized or clinical control trial

Search strategy: The ‘Cochrane Library’ databases, ScienceDirect, ‘PubMed’, Scopus and ‘Web of Science’ etc., were used in this review for searching different studies. We used key words ‘Photobiomodulation’, ‘PBM’, ‘LLLT’, ‘laser therapy’, ‘laser irradiation’, or ‘tooth movement’, ‘dental movement’, and ‘orthodontic’. The search was restricted to human subjects from these sources. The search was restricted to articles of English language only.

Selection criteria:

Inclusion criteria:

1. English language based randomized or clinical control trials with no time and population boundation.
2. Studies on patients undergoing photobiomodulation for orthodontic tooth movement
3. Peer reviewed articles meeting PICOS criteria
4. Randomized or clinical control trials (RCT or CCT).
5. Photobiomodulation performed with low level laser/ LED equipment
6. Articles having individual characteristics and different parameters of PBM.

Exclusion criteria:

1. Abstracts, commentaries and case-reports
2. Animal studies
3. Studies including less than 10 subjects
4. Patients exposed to previous orthodontic treatment
5. Studies without vital data

Data extraction:

One of the authors of our study extracted data after searching all the articles and screening title and abstract of every article. Further together 2 authors then re-checked full texts of all the extracted articles. Collected data comprised sample size, authorship, year of publication, geographical area, study characteristics and

laser parameters like intervention sites on the tooth, frequency, mode of operation, wavelength and energy density.

Risk of different biases:

‘Cochrane Handbook for Systematic Reviews of Interventions’ was used for assessment of bias.^[17] Criteria seen were “(1)random sequence generation—selection bias, (2) allocation concealment—selection bias, (3) blinding of participants and personnel—performance bias, (4) blinding of outcome assessment—detection bias, (5) incomplete outcome data—attrition bias, (6) selective reporting—reporting bias.” If all the 6 domains were having low risk of bias then trial was said to be low risk. If ≥ 1 domains were having indistinct risk then it was said to be trial with unclear risk of bias. If ≥ 1 domains were having high risk of bias then trial was said to be of high risk.

Sample size, standard deviation and means were extracted to perform meta-analysis. ‘Review Manager 5.3 (RevMan 5.3, The Cochrane Collaboration, Oxford, United Kingdom)’ was used for doing meta-analysis by mean difference and 95% confidence interval (CI). ‘Cochrane’s test (I^2 test at $\alpha = 0.10$) and Chi-square test (χ^2)’ were used to evaluate heterogeneity between the estimates. ‘P-value <0.05 was considered to be statistically significant’. The unit of tooth movement was mm (millimeters)/time interval.

Results:

After searching all the articles we had 256 articles and after removal of duplication, we got 167 articles. On the basis of PICOS strategy which was used in our review article, six articles were finally included in this study after screening of title and abstract of every article. Out of 6 studies included, 2 were from UAE and 1 each from Syria, Italy, Iran and India. ‘Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA)’ was used for study selection as depicted in Figure number 1.

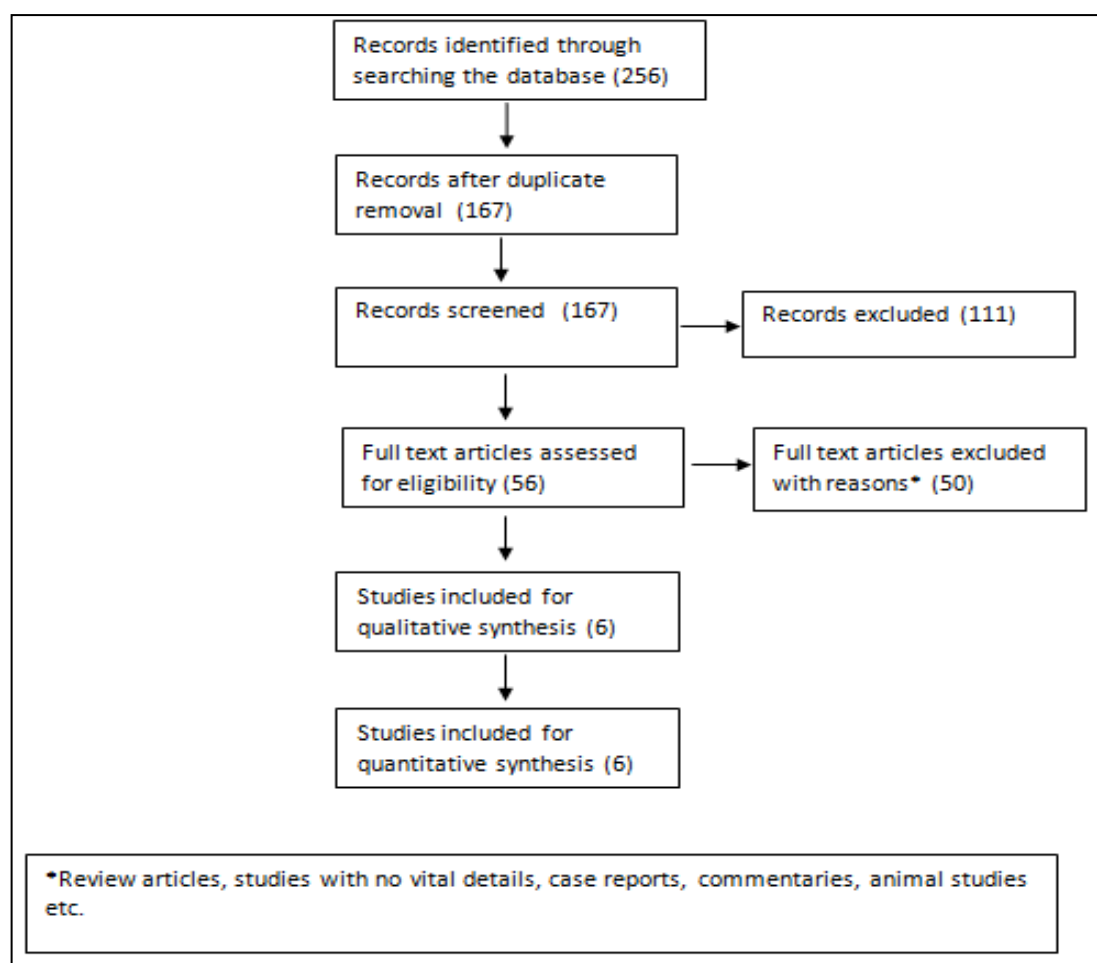


Figure 1: PRISMA flow chart for conducting systematic review and meta-analysis

By using 'Cochrane Collaboration's tool', we found that 2 of the trials depicted high risk of bias and 4 depicted low risk of bias. Every RCT showed a low risk of 'attrition bias (incomplete outcome data)'. Review about bias risk is shown in figure number 2.

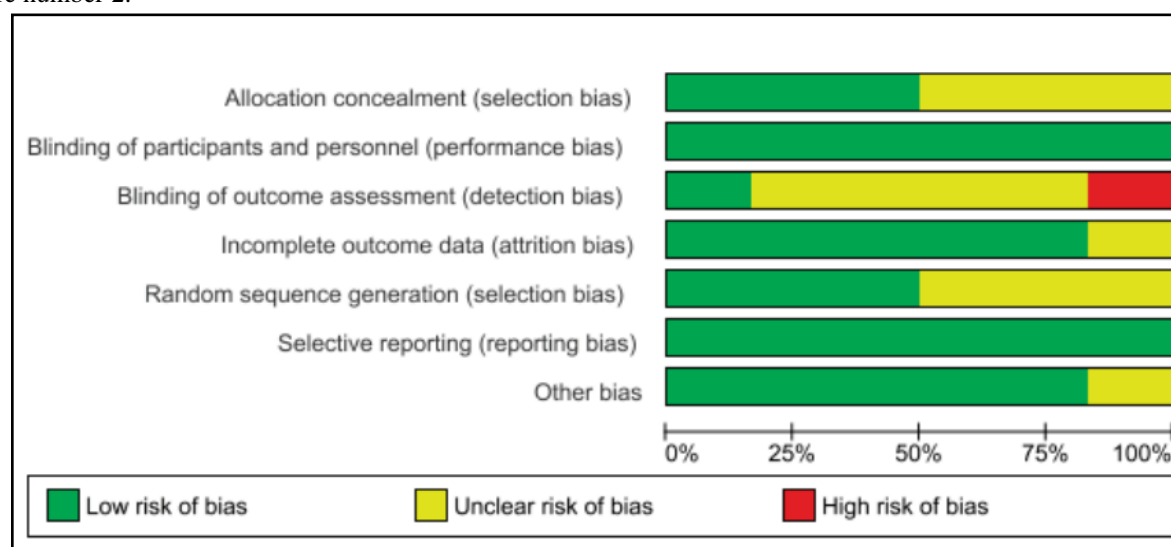


Figure2: Bias risk graph



Regarding PBM, it was given by LLLT in all studies, for which diode laser was used with wavelength from 618-940 nm. The trials evaluated the efficiency of PBM in speeding up the alignment & leveling, by speed of dental movement or overall treatment time needed for resolution of dental crowd.^[18,19,20] The extent of retraction in different tooth was evaluated by other trials which depicted statistically non-significant difference between patients receiving PBM and those not receiving PBM with WMD(weighted mean

difference) = 0.20; 95%CI(-0.09,0.51),p =0.26. Variability was found to be significant ($\chi^2=48.40$;p<0.001;I²=85%). But at 2nd months and 3rd months, trials showed greater tooth retraction with WMD = 0.50; 95%CI(0.29, 0.72),p <0.001. Variability was found to be significant ($\chi^2=188.36$; p < 0.001; I²=94%). At 3 months WMD was 0.49 with 95%CI(0.02,0.96),p=0.04. Variability/Heterogeneity was significant with chi-square 73.05 and p<0.001;I²=93%.^[21,22,23]

Table2: Characteristics of studies included (PICOS, follow-up period and main findings)

No.	Study	Intervention	Laser application schedule	Total energy dose/m	Comparison	Outcome	Design	Followup	Main findings
1	AlSayed et. al. 2017 Syria ^[18]	leveling and alignment, – conventional brackets, – GaAlAs laser 830 nm,	2 pts B, 2 pts Ln on each root of the 6 maxillary anterior teeth 30 s each pt the 1st month: on days 0, 3, 7, and 14, the 2nd month: every 15 days	72 J/tooth for the 1st month, then 36 J/tooth	OT + LLLT vs OT	– time for alignment – alignment improvement percentage	RCT parallel	till complete crowding resolution	LLLT accelerates OTM
2	Caccianiga et al. 2017 Italy ^[19]	alignment – self-ligating brackets – diode laser 980 nm, 1 W, 150 J/cm2 per session, continuous mode	the mandible divided into 6 dental segments, each segment containing 2 teeth: (36,35) (46,45) irradiated for 9 s, the remaining segments for 8 s; it was repeated 3 times at intervals of 2 min between the sessions a single monthly administration	150 J	OT + LLLT vs OT	treatment duration	RCT parallel	till complete crowding resolution	treatment duration was shorter in the LLLT group
3	Al-Okla et al. 2018 UAE ^[20]	– leveling and alignment – conventional brackets – OrthoPulse device, 850 nm, 65 mW, 0.065 J/cm2	5 min per arch daily	585 J per arch	OT + LLLT vs OT + sham	– RTM – root resorption	RCT parallel	6 months	– LLLT accelerates OTM – root length at a 6-month interval was shorter in the LLLT group
4	Dalaie et al. 2015 Iran ^[21]	– U + L canine retraction – conventional brackets + sectional closing loops – GaAlAs laser 880 nm, 100 mW, 5 J/cm2, continuous mode	4 pts B, 4 pts Ln on the canines 10 s each pt	Days of application were not mentioned	OT + LLLT vs OT	– RTM – pain experience	RCT SMD	67 days	no significant results for accelerating OTM or reducing pain
5	Nahas et al. 2017 UAE ^[22]	leveling and alignment – self-ligating brackets – extra-oral LED device (OrthoPulse) 850 nm, 90 mW/cm2, 108 J/cm2 on the surface of the cheek	20 min daily	3,240 J	OT + LLLT vs OT	RTM	RCT parallel	till complete alignment	LLLT accelerates OTM
6	Kochar et al. 2017 India ^[23]	– U + L canine retraction – conventional brackets + NiTi closed-coil springs – GaAlAs laser 810 nm, 100 mW, 5 J/cm2, continuous mode	5 pts B, 5 pts Ln on the canine 10 s each pt days: 0, 3 and 7 of force application	30 J	OT + LLLT vs OT + sham	– RTM – pain experience	RCT SMD	till complete tooth retraction	LLLT accelerates OTM and reduces pain experience

**Discussion:**

One of the major concerns among patients undergoing orthodontic treatment is its time taking nature and decreasing this duration needs tooth movement. Laser therapy is a noninvasive method that contributes to pain relief and reduces inflammation, parallel to the enhanced healing and tissue repair processes. PBM as one of the laser therapy can induce cell proliferation and enhance stem cell differentiation. Although the specific mechanism of action of PBM is not yet fully known, it is believed to be due to stimulating effect on the proliferation of osteoclasts, osteoblasts, and fibroblasts by amplifying the extent of bone remodeling and consequently accelerating dental movement.^[6,7] In this study we tried to assess efficacy of PBM on speeding up the dental alignment rate thereby decreasing the duration of orthodontic treatment. Our systematic review observed that PBM noticeably accelerated the rate of tooth movement and with due course of time, the speed of tooth movement further increased. In present study, all the included articles were having different frequency and wave length of lasers used for management. Overall duration of treatment, density of energy used and output of power also varied in different articles taken in this study.

Present systematic review comprised of 6 different RCTs from different parts of the world, which assessed effect of PBM on tooth movement on patients undergoing orthodontic treatment. The review suggested that PBM showed no difference in OTM at the end of 1 month but in the 2nd and 3rd months, a significant difference was seen. The results of our study are in accordance with few studies on animal.^[24,25,26,27]

It might be due to cumulative effect of radiation. So it can be said that, it needs a minimum of 1 month duration for biostimulation effect for increased OTM.^[28] It has also been found in other study that low level laser if used at an interval of 3 weeks can accelerate the OTM by 200%.^[8]

Total energy dose applied per time period is a better parameter as compared to total energy/cm² as it provides better tool to compare different protocols & it also limits complexity. Out of these clinical trials **Nahas et al.** from UAE^[22] and **Kochar et al.** from India^[23] used energy density per unit time.

The dissimilarity found in the outcomes of different studies may be due to different dose of radiation employed in different studies.^[28]

The methodology of the orthodontic treatment is also very important to limit the attrition bias. Laser therapy often involves multiple sittings, so it is very difficult to achieve patient's compliance which is a must for better results. Researches focussing on increased OTM with longer duration of study are further needed to assess optical characters of destroyed tissues, output of power, frequency, dose and wave length of laser.^[28,29] The strength of our study is that we did extensive search of articles and used Cochrane Collaboration tool for assessment of bias.

Limitation of the study: This systematic review involved only 6 studies. Other limitation was use of different frequency and λ of laser used for management, different overall duration, density of energy and output of power in various articles taken in the current study. Heterogeneity of studies was other limitation.

Conclusions:

This review article concluded that PBM can increase the speed of OTM especially in the 2nd and 3rd month due to the accumulative effect of radiation. Therefore LLLT can represent an important add-on therapy in patients needing orthodontics procedure. Additional research is yet needed focussing on properties of laser used which will support the results of this systematic review. An effective and standard PBM protocol for accelerating OTM and speeding up recovery of the patients is still needed.

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Conflict of interest: None.

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