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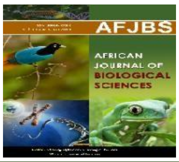

Research Paper Open Access

EVALUATE THE EFFICACY OF LASER PHOTOBIOMODULATION ON ORTHODONTIC TOOTH MOVEMENT IN CHILDREN: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Background and aim: the present study conducted with the aim of evaluating the efficacy of laser photobiomodulation on orthodontic tooth movement in children.

Method: In present systematic review and meta-analysis, information about orthodontic tooth movement in children in all articles published until the end of July 2023 through searching in databases PubMed, Scopus, Science Direct, ISI, Web of Knowledge, Elsevier, Wiley, and Embase and Google Scholar search engine were extracted using keywords and their combinations by two trained researchers independently. Data analysis was done using the fixed effects model in meta-analysis, by STATA (version 17); P-value less than 0.05 was considered significant.

Result: A total of eight studies were included in the meta-analysis process. Laser Photobiomodulation significantly increased the acceleration of orthodontic tooth movement compared to control group (MD: 0.29, 95% CI: 0.25, 0.34 ($p<0.01$).

Conclusion: low-level laser therapy is an effective approach for accelerating tooth mobility in orthodontic treatments.

Keywords: Orthodontic, Tooth Movement, Children, Laser Photobiomodulation, low-level laser therapy, Accelerating tooth mobility.

Introduction

Orthodontics is a time-consuming treatment and is generally performed within 24 to 36 months. Therefore, patients usually do not want orthodontics due to the long treatment time(1). On the other hand, based on the available evidence, it leads to complications such as root external analysis, caries and periodontal problems(2). Acceleration of orthodontic tooth movement (OTM) is very important in orthodontics(3); Various methods such as surgery, injection of biological substances (vitamin D3, prostaglandin E, parathyroid hormone, osteocalcin, etc.) are performed(4). One of the approaches that has resulted in good results is the use of low-level laser therapy (LLLT)(5).

The use of diode lasers is determined by two factors: 1- the type of absorption (average) and the wavelength that is responsible for the depth of penetration (inversely related). One of the advantages of using LLLT is to increase the proliferation of osteoblasts, quick recovery, accelerate bone regeneration, and reduce pain(6). In modern dentistry, the use of Photobiomodulation therapy has a wide application(7). Studies have shown that Photobiomodulation therapy accelerates tooth movement and reduces postoperative pain(8, 9). In in vitro studies, the rapid movement of teeth at the cellular level has been well reported. Non-invasive methods are the most popular methods with promising results.

Due to the differences in the findings of the studies, there is a need to conduct a comprehensive study in this field; And considering that early treatment of children's orthodontics can prevent jaw and teeth problems from facing more serious and long-term problems. Definitely, children's orthodontics has faster and better results than when the jaw and face are fully developed. Therefore, the present study was conducted with the aim of evaluating the efficacy of laser photobiomodulation on orthodontic tooth movement in children.

Method

Search strategy

In present study, in order to obtain scientific documents and evidence related to efficacy of laser photobiomodulation on orthodontic tooth movement in children, articles published in international databases such as PubMed, Web of Science, Scopus, Science Direct, Web of Knowledge, EBSCO, Wiley, ISI, Elsevier, Embase and Google Scholar search engine were used. The search process until July 2023 in PubMed database was done using MeSH keywords: (((("Index of Orthodontic Treatment Need"[Mesh] OR "Orthodontic Anchorage Procedures"[Mesh] OR "Orthodontic Appliances"[Mesh] OR "Orthodontic Appliances, Fixed"[Mesh]) AND "Tooth Movement Techniques"[Mesh]) AND "Low-Level Light Therapy"[Mesh]) OR ("Low-Level Light Therapy/adverse effects"[Mesh] OR "Low-Level Light Therapy/methods"[Mesh] OR "Low-Level Light Therapy/standards"[Mesh] OR "Low-Level Light Therapy/statistics and numerical data"[Mesh])) AND ("Child"[Mesh] OR "Adult Children"[Mesh] OR "Dental Care for Children"[Mesh] OR "Only Child"[Mesh]); and search process in other database was done until July 2023 using English keywords: Orthodontic, Orthodontic treatment, Orthodontic Tooth Movement, Tooth Movement, Laser Photobiomodulation, Low-Level Light Therapy, low-level laser therapy, LLLT, Children. In addition, the reference list of the obtained articles was checked to identify the used articles that were not obtained using the above methods. Databases were searched with high sensitivity. To avoid bias, the search was done by two researchers independently.

Study selection criteria

Inclusion criteria

use of the PECOS (patient/population, exposure, comparison, outcome, and study design) strategy to construct the research question is specified in Table 1; Human population, studies that reported accelerate the rate of OTM, studies that reported treatment time, LLLT of any wavelength. studies with incomplete results; in-vitro, in-vivo, animal studies, case studies; case reports and review articles were excluded.

Table1. PECO strategy.

PECO strategy	Description
P	Population: children
E	Exposure: low-level laser therapy
C	Comparison: Control group (non-LLLT)
O	Outcome: acceleration of OTM
S	Study design: Clinical, randomized controlled trials and cohort studies

Data collection

a checklist was designed based on the objectives, and information from the selected articles was entered into the checklist (Table 2).

Risk assessment

Cochrane Collaboration tool to assess risk of bias for randomized controlled trials. Bias is assessed as a judgment (high, low, or unclear)(10). The risk of bias tool covers six domains of bias: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other.

Data analysis

Meta-analysis was performed using mean differences with 95% confidence interval. To estimate the heterogeneity of the studies, the index I^2 (<25%: weak heterogeneity, 25-75%: moderate heterogeneity, and more than 75%: high heterogeneity) was used. The results were combined using the fixed effect model (Inverse–variance method) in meta-analysis. The publication bias was checked by Egger test and Beggs funnel plot and data analysis was done using STATA/MP. v17 software. A p-value of less than 0.05 was considered significant.

Result

After searching with related keywords, 379 studies were obtained. Endnote.X8 software was used to organize the studies. By using the mentioned software and reviewing the title and abstract of the articles, 39 duplicate studies were eliminated. Then the abstracts of 236 articles were examined by the researchers. 302 studies that did not meet the inclusion criteria or were excluded due to weak or unrelated relevance to the study objective (if after reading the title and abstract, it was not possible to make a decision about the article, the full text was referred to). The full text of 24 articles was carefully reviewed by two independent researchers, and 16 studies were excluded due to the inconsistency of study objectives; Finally, eight articles were selected (Figure 1).

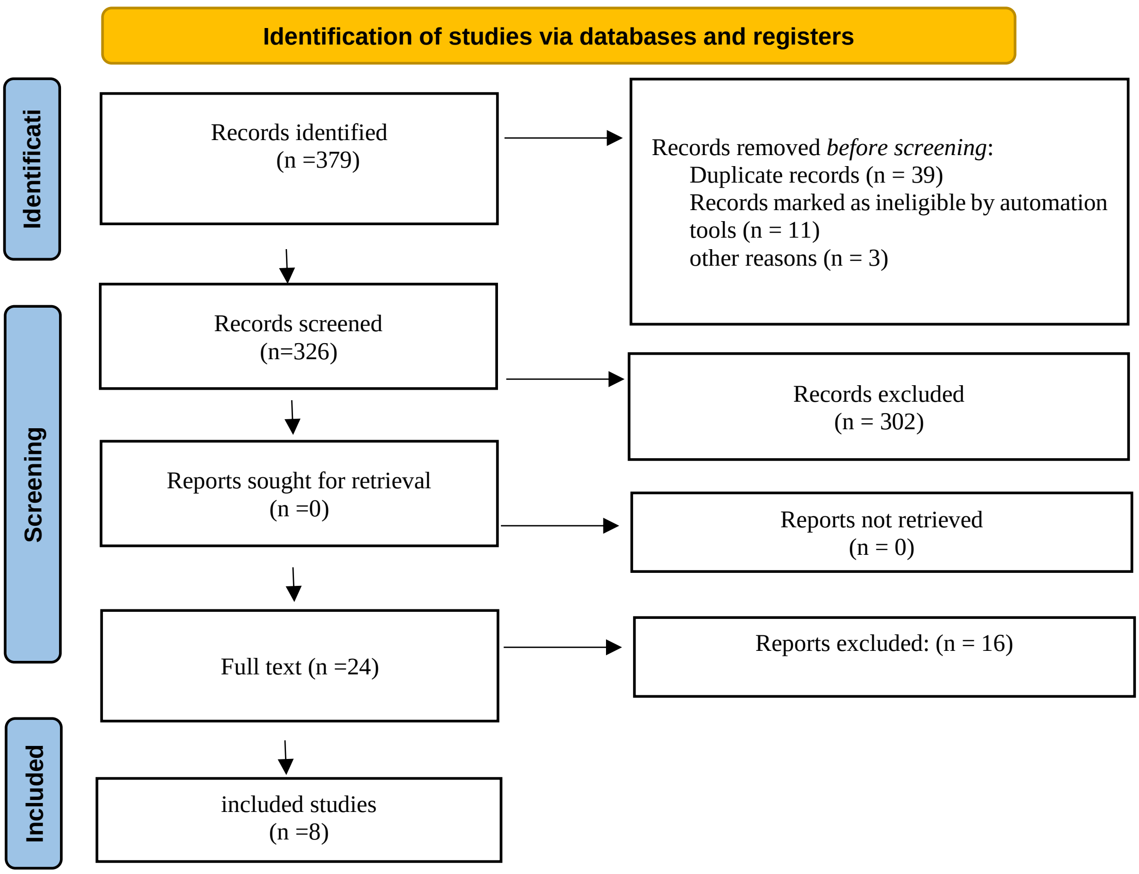

Figure 1. PRISMA 2020 Checklist.

Table 2. Characteristics and laser parameters of selected studies

Study. years	Study design	Number of patients	Renge of age (years)	Intervention site	Type of laser	Wavelength (nm)	Output power (mW)	Time (s)	Energy (J/cm^2)	follow-up session (days)
Alam et al., 2023 (11)	prospective	32	14-25	maxilla and mandible	gallium-aluminum-arsenide diode	810	100	3	7.5	
Le et al., 2022 (12)	RCT	16	12-35	Maxillary canines	gallium-aluminum-arsenide diode	810	100	10	5.1	0, 30, 60, 90
Farhadian et al., 2021 (6)	RCT	60	16-22	Maxillary and mandible canines	gallium-aluminum-arsenide diode	810	100	60	5	0, 3, 30
Matarese et al., 2018 (13)	RCT	40	10.5–20.2	Maxillary and mandible canines	gallium-aluminum-arsenide diode	810	100	90	8	3, 7 and 14
Kochar et al., 2017 (14)	RCT	20	16–24	Maxillary canines	gallium-aluminum-arsenide diode	810	100	80	5	3, 7, 21

Dalaie et al., 2015 (15)	RCT	12	16-22	maxilla and mandible	gallium-aluminum-arsenide diode	880	100	80	5	1, 3, 7, 30, 33, 37, 60, 63
Heravi et al., 2014 (16)	controlled clinical trial	10	16-22	Maxillary and mandible canines	gallium-aluminum-arsenide diode	810	200	40	80	0, 3, 7, 15
Sousa et al., 2011 (17)	RCT	26	16-22	Maxillary and mandible canines	gallium-aluminum-arsenide diode	780	100	60	8	0, 3, 7

Characteristics of patients

216 patients included in present study. Characteristics and laser parameters reported in Table 2.

Acceleration of OTM

mean differences was 0.29 (MD, 95% CI: 0.25, 0.34 (p<0.01); I^2 =97.70% (p=0.00), high heterogeneity); this result showed LLLT significantly increased the acceleration of OTM compared to control group (statistically significant level; p<0.01) (Figure 2).

The contour-enhanced funnel plot was used to assess publication bias among the included studies. acceleration of OTM from the included studies was located in a P-value of less than 0.01, indicating that the funnel plot asymmetry could be caused by the high heterogeneity of the included studies and publication bias (Figure 3). The Egger's test revealed minor study effects (P-value less than 0.001), indicating that some studies were missing from the meta-analysis.

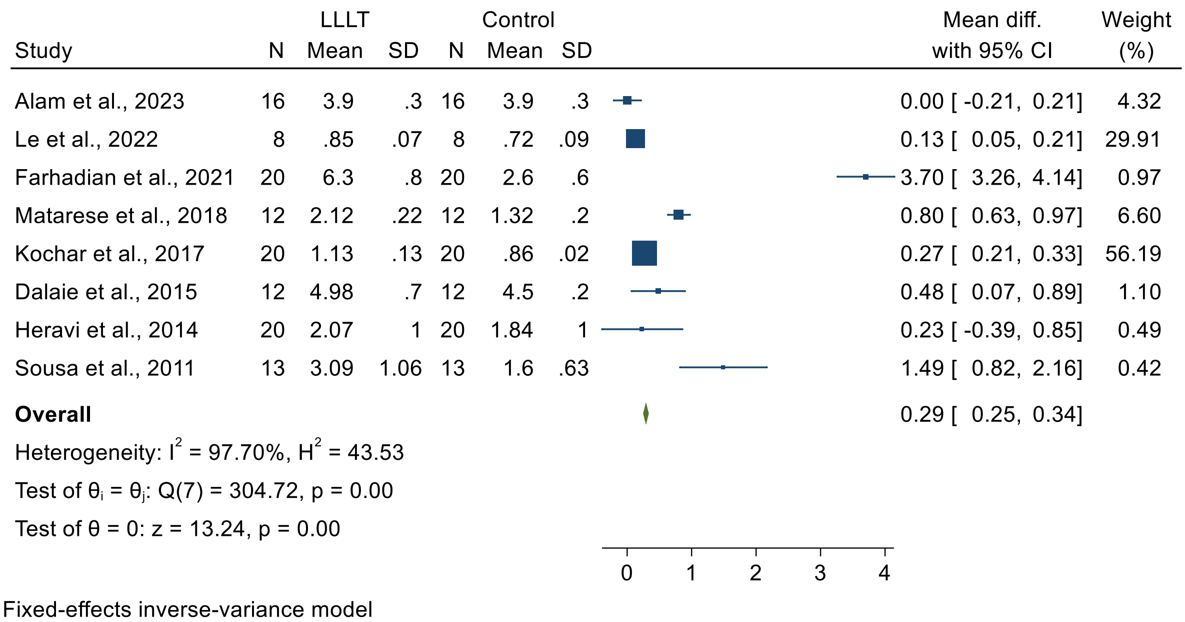

Figure 2. forest plot showed increase acceleration of OTM by LLLT group.

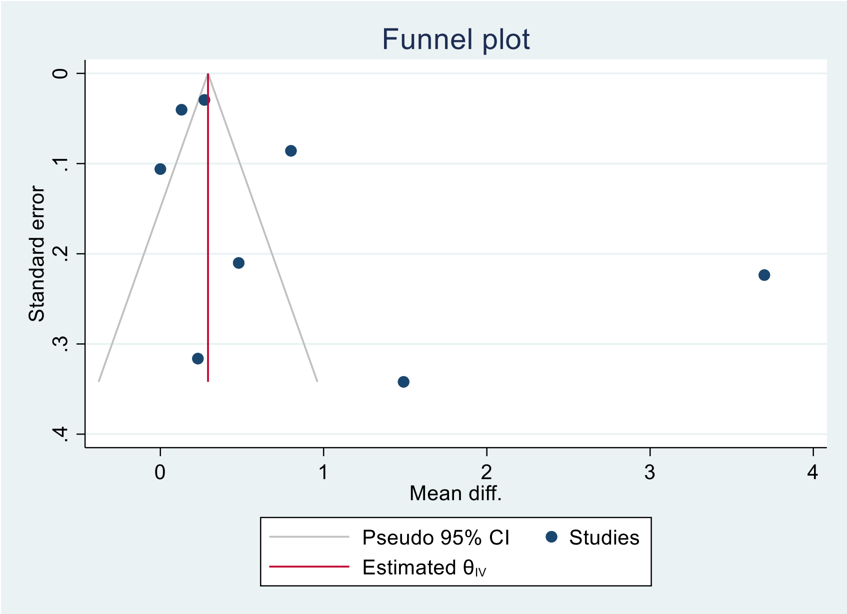

Figure 3. funnel plot was used to assess publication bias

Discussion

acceleration of OTM is very important in orthodontic treatment, especially in children. Based on the findings of the present meta-analysis, the use of LLLT compared to the control group could significantly accelerate OTM. In line with the results of the present study, a study showed that the OTM rate increases with the increase of time(18). Studies have shown that, during LLLT radiation, tooth movement was significantly higher than the control group(19). This can be due to the improvement of connective tissue circulation through increased expression of fibronectin and type I collagen, and it can also be attributed to the stimulation of osteoblast and osteoclast cell proliferation(20). A study showed that the use of laser increases the rate of OTM compared to the control group(21). In general, studies have reported that laser can accelerate the movement of teeth and reduce the treatment period(5, 12). The high heterogeneity between studies may be due to the fact that different doses of radiation were used.

Evidence suggests that using LLLT for three weeks has a double effect on OTM(11). Based on the findings of the studies, it can be stated that the dose calculations are not accurate and laser in some doses reduces the speed of dental movements and leads to treatment failure(11). Among the other causes of treatment failure in the use of laser, we can mention radiation and time of exposure to laser, factors related to dosimetry(22). In the studies, parameters such as the number and distance between treatments, time, wavelength, pulse, area and beam power should be examined with sufficient accuracy in order to provide better results. One of the recent studies (11) that included in present meta-analysis showed that there is no significant difference between the group receiving LLLT and the control group. Therefore, more studies are needed to confirm the evidence. Much studies have been conducted to assess the influence of LLLT on orthodontic tooth movement speed. The majority of published study data show that LLLT speeds up orthodontic tooth movement. while, two studies have concluded that the laser slows tooth mobility(23). In our study, there was an increase in tooth movement speed following LLLT irradiation. Many factors complicate a direct comparison of the current study and previous studies, including different laser irradiation parameters (wavelength, power, energy density, irradiation mode, time, and multiple exposures), different animal samples (dogs, rabbits, mice), and different canine retraction mechanisms, as well as the method used to measure tooth movement.

The present study had limitations such as the number of studies related to children is small and more studies need to be done, the parameters examined in the studies were variable, which should be investigated in future studies such as power, wavelength, frequency, energy density and number of teeth. The investigated should be well reported.

Conclusion

The present meta-analysis showed that the use of LLLT at a wavelength of 780 to 880 nm can have a positive effect on the acceleration of OTM; LLLT is an effective approach for accelerating tooth mobility in orthodontic treatments. However, due to the high heterogeneity between studies, the findings of the present study should be interpreted with caution.

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