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Review Article

Effects of Low Laser Therapy in Fixed Orthodontic Treatment: Systematic Review

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ABSTRACT

Objective: to determine how low-level laser therapy affects patients' early pain thresholds and the level of tooth movement brought on by orthodontic treatments.

Study Design: Systematic review.

Methodology: Various electronic databases (Google Scholar 145, PubMed = 534, NCBI = 18, and Cochrane = 42) were searched for 743 papers for this purpose. Ten publications were chosen for the systematic review of our topic of interest.

Results: Seven of the ten studies examined for evidence had strong evidence, while just three included moderate evidence. Four of the seven studies with strong evidence had statistically significant conclusions. Three studies with intermediate evidence have shown significant results. LLLT may thereby promote orthodontic tooth movement, according to the evidence.

Conclusion: According to a thorough evaluation of the scientific literature, there is no evidence that LLLT by diode laser increases immediate orthodontic discomfort, although it does encourage orthodontic tooth movement. Limited laser treatment is also helpful for treating discomfort and relieving pain.

Keywords: Limited laser therapy, Orthodontic tooth movement, Photo bio-modulation.

How to Cite This Article: *Kumar K, Hussein A, Qamruddin I, Khatri T Alam MK. Effects of Low Laser Therapy in Fixed Orthodontic Treatment: Systematic Review. Pak Armed Forces Med J 2025; 75(2): 413-420. DOI: https://doi.org/10.51253/pafmj.v75i2.9513*

INTRODUCTION

A laser is a beam of light with a single wavelength (or color) that traverses a collimated tube and gives a focused energy source. Based on the treated tissue (optical), scattering, absorption, and transmission may happen after the laser. Dental procedures may use photo-thermal laser-tissue interactions, including ablation, hemo-stasis/coagulation, and incision/excision, by altering laser parameters like beam width and exposure length.[1] Photo-bio-modulation, often termed low-level laser treatment (LLLT), is modifying biological activity by non-thermal photons. The primary therapeutic applications of LLLT include the relief of pain and injury, the acceleration of tissue healing, and the promotion of the recovery of various tissues and nerves to prevent tissue damage. Low-level laser therapy is utilized in orthodontics to reduce discomfort further.[2,3] Orthodontic treatment (OT) is vital for functional and cosmetic recovery. Orthodontic force and tooth mobility generate an immediate inflammatory response induced by inflammatory cytokines. The tissue response involves early vascular alterations, the generation of cytokines, prostaglandins, and growth factors, and the activation of tissue remodeling. Although other research suggests it cannot, LLLT may aid pain management in orthodontic patients. A laser's ability to reduce orthodontic discomfort is controversial.[4]

According to the study, 20 patients with Class I bi-maxillary protrusion were treated with a test tooth mobility and discomfort. The study result indicated that laser therapy is an excellent way to move orthodontic teeth, and LLLT may shorten fixed orthodontic treatment. LLLT and LIPUS may promote bone remodeling and enhance expression for optical tissue.[5] Fujita *et al*., indicate that by increasing RANK/RANKL and c-FMmC/macrophage colony activating factors, low-dose laser treatment increases osteoclast development and tooth movement on the bone's pressure-bearing side.[6] According to studies, every patient, regardless of age, feels uncomfortable throughout treatment. Analgesics are often used to treat pain. Numerous studies indicate that these painkillers may reduce OTM by reducing prostaglandin action and suppressing osteoclast activity.[7] Using a face pain scale, LLLT lowered pain perception during the first two days compared to the control group.[8]

Because low-level lasers promote bone remodeling without causing damage to the

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Received: 19 Nov 2022; revision received: 13 Feb 2023; accepted: 31 Jan 2024

surrounding tissue, they may hasten orthodontic tooth movement.[9] However, several examinations found conflicting results and no variation in reduced discomfort stages.[10] Therefore, this review has been conducted to evaluate the effects of LLT on orthodontic discomfort and mobility.

METHODOLOGY

The primary goal of the study is to examine the impact of low-level laser therapy on orthodontic mobility and pain in original articles. For this purpose, 743 publications were searched on different electronic databases (Google Scholar=145, PubMed=538, NCBI=18, and Cochrane=42). Figure 01 illustrates the approach of the selected 10 articles.

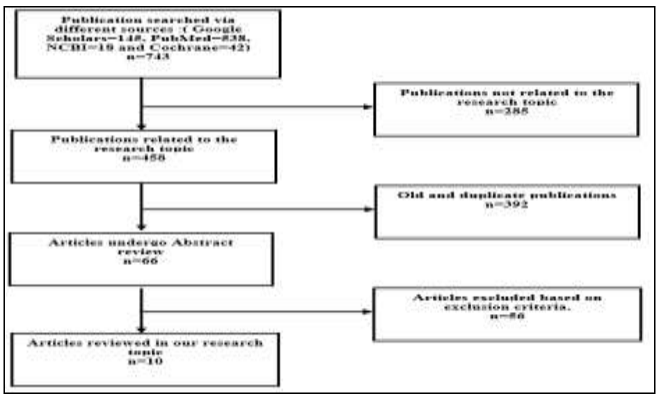

Figure: Literature Flow

Inclusion Criteria: Studies about the use of low-level laser therapy (LLLT) to shift teeth in orthodontic treatment for people, research on result indicators such as laser type and wavelength, tooth movement frequency during LLLT, prospective randomized clinical studies and controlled clinical trials (CCTs), a laser with emission of continual wavelength; and energy calculation requirements were included.

Exclusion Criteria: The studies are based on animal research, case report reviews, and outdated studies. Research of applications reporting laser of orthodontic tooth movement of canines and molars; duplicate studies, literature on patients with cancer or other systemic diseases, and literature on the use of high-level laser were excluded.

Data were filtered to exclude items that were not relevant after the authors reviewed the whole text for theoretically relevant titles and abstracts. The author name, Year of publication, country, study design, laser type, power output, wavelength/energy density, frequency of laser treatment, exposure time, type of emission, application technique, effectiveness on pain relief and tooth movement, follow-up period, and method of assessment were all collected for each study. Figure illustrates the methodology for choosing articles.

Problem Specification

This study is based on evidence from the literature indicating that LLLT is efficient in orthodontic tooth movement in humans. Is there any evidence that LLLT is more effective in reducing pain? Is there any evidence that a particular laser wavelength affects the LLLT in OTM? A methodical extraction of essential article information [reference of all articles], their sampling details (Table-I), statistical outcomes of clinical study outcome (Table-II), LLLT effect in orthodontic tooth movement and pain reduction (Table-III), laser type, its characteristics and frequency of laser treatment (Table-IV) were done.

RESULTS

Seven of the ten studies reviewed for evidence included substantial evidence, while three contained moderate evidence. Four of the seven studies with strong evidence had statistically significant findings, whereas three did not. Three studies with moderate evidence showed substantial outcomes. Consequently, there is evidence that LLLT accelerates orthodontic tooth movement. Table-II shows highly significant studies showing that LLLT accelerates orthodontic movement in humans, while non-significant studies showed no differences. One research study indicated that when performed with the specified settings, it is an approach for speeding orthodontic tooth movement in situations of dental crowding (I).

Study Selection

The Figure shows an article selection flowchart procedure for each level of the review. The search returned 743 results. After removing duplicates and examining titles and abstracts, the complete texts of 458 relevant articles were examined. Eventually, 392 old and obsolete studies were excluded, and 10 were identified as potentially acceptable for our research topic. Eight of them were RCTs, and two of them were blind studies and split-mouth designs.

Study Characteristics

Table-I examines the study parameters. This study analyzes whether adequate information was provided in each of the chosen literature sources for their calculation.

Table-I: Details of the Extracted Study

Efficacy of LLT in OTM	Effective	Effective	Not effective	Effective	Effective	Effective	failed to identify	Effective	Effective	Effective
Method of measuring	Manual	digital	digital	digital calliper	manual		digital calliper	digital	digital calliper	Digital
Follow-up period		every month	28 days	every 15 days	Four months	Four days	Two months	Monthly	not mentioned	Three months
Reduce Pain	Yes	Yes	Yes	yes	yes	yes	not at all	Yes	yes	Yes
Application technique	Direct contact	Direct contact	Direct contact	Direct contact		Direct contact		Direct contact	Direct contact	Direct contact
Emission Type	Continuous	Continuous	Continuous and pulse modes both	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Frequency of laser treatment	Days 0, 3, 7, and 14 of each month and for two months	One day, one week, one month, nine-week	0, 1, 2, 3, 7, 14, and 21 days	3, 7, and 14 days	days 0 to 14	12, 24, 36, 48, 72, and 96 h	day 1 to 2 month	Not mentioned	day (0,3,7,14); first month Every 15 days; the second month	21,42,63,84 days
Exposure time	15-16 s	60 s	9 s	15 s	10 s	340 s	80 s	50 s	15 s	100 s
Power output	800 mW	80 mW	180 mW	1000 mW	100mW	160 mW	Not mentioned	160 mW	150 mW	20 mW
Energy density		8.6 J/cm^2	1.6 J	8 J/cm^2	5 J/cm^2 at 10 point	54.4 J	5 J/cm^2 at 10 point	12 J/cm^2	2.25 J/cm^2	5 J/cm^2
Wavelength	940 nm	940 nm	808 nm	810 nm	810nm	650 nm	880 nm	632.8 nm	830 nm	820 nm
Type of Laser	Diode laser intraorally,	Single GaAs	Ga-Al-As diode laser	Ga-Al-As diode laser	Diode laser	Single GaAs	Ga-Al-As diode laser	Ga-Al-As diode laser	Ga-Al-As	Ga-Al-As diode laser
No.of patients	20	27	20	71	20	120	12	45	94	15
Study design	randomized study design	RCT	RCT	RCT	Single-blind study.split-mouth design	RCT	double-blind study	RCT	RCT	RCT
Country/City	Iraq	China	Australia,	Italy	India	Italy	Iran	Italy	Damascus	Italy
First author, Year	Baydaa Flayyih Hamzah,2019	Chong Ren,2019	Doreen Ng, 2018	Gaetano Isola,2019	Gagan Deep Kochar, 2017	Ida Marini,2015	Kazem Dalai,2015	Mark Cronshaw,2019	Mohammad Moaffak A.,2017	Üretürk,2017

Elastomeric Separators

One investigation showed that therapy reduced the duration of the induced pain. The therapeutic significance of the current data supports the chances of employing SLLLT in routine orthodontic procedures as part of a randomized trial design.[16] To make secure laser irradiation with the proper dosage a regular therapy for orthodontic pain, additional research is necessary to develop a comprehensive protocol for simple implementation and practical use.

Archwire Placement

Mohammad Moaffak, Gaetano, and Ida Marini examined the analgesic influence of the following three experiments. The quality management techniques for each of the following four-time intervals: before installing the first archwire, after the installation of the first archwire, after the insertion of

Table-II: Details of Statistical Significance and Clinical Outcomes of Selected Study

First Author, Year	*p*-value	Statistical Significance	Clinical Outcome
Baydaa Flayyih Hamzah,2019 (11)	p=0.001	Highly Significant	In the second group, there was a considerable discrepancy in the evaluations of discomfort.
Chong Ren,2019 (12)	p=0.84	Non-Significant	On every measure, there was no significant disparity in the laser and groups treated.
Doreen Ng, 2018 (13)	p=0.823	Non-Significant	There is no discernible difference between the continuous mode and the pulsed method of delivering LLLT.
Gaetano Isola,2019 (14)	p<0.001	Highly Significant	a substantial decrease in the total amount of time required for space closure
Gagan Deep Kochar, 2017 (15)	p<0.05	Significant	Both of them showed statistically significant differences from one another.
Ida Marini,2015 (16)	p=0.021	Significant	substantial differences were seen between the groups receiving laser treatment and those receiving placebo, as well as those receiving control.
Kazem Dalai,2015 (17)	p=0.45	Non-Significant	No difference between both sides
Mark Cronshaw,2019 (18)	p=0.012	Significant	Statistically significant
Mohammad Moaffak A.,2017 (19)	p<0.001	Highly Significant	In the 2 categories, statistically relevant variability was seen.
Üretürk,2017 (20)	p=0.001	Highly Significant	40% faster on the laser side

Table-III: Details of Study Regarding Effect of LLLT on Pain Reduction and Orthodontic Tooth Movement

First author, Year	Country/City	Study design	No.of Patients	LLLT Reduces Pain	Efficacy of LLT in OTM	Follow-up period
(Wu et al., 2018)	China	randomized study design	40	Yes	Effective	
(Ren et al.,2019)	China	RCT	27	Yes	Effective	Every month
(Ng et al.,2018)	Australia'	RCT	20	Yes	Not effective	28 days
(Gaetano, Sebastiano, and Ernesto,2019)	Italy	RCT	71	Yes	Effective	Every 15 days
(Kochar et al., 2017)	India	Single-blind study. Split mouth design	20	Yes	Effective	Four months
(Marini et al.,2015)	Italy	RCT	120	Yes	Effective	Four days
(Dalaie et al.,2015)	Iran	double-blind study	12	Not at all	failed to identify	Two months
(Mark, Steven. Eugenia and Edward,2019)	Italy	RCT	45	Yes	Effective	Monthly
(Hasan, Moaffak, Sultan, and Ajaj,2019)	Damascus	RCT	94	Yes	Effective	Not mentioned
(Üretürk et al.,2017)	Italy	RCT	15	Yes	Effective	Three months

the second archwire, and after the insertion of the third archwire. This was done to determine the outcome measurements.[14] Another research indicates SLLLT should be used. Particularly at the start of the procedure and at the time the archwire must be changed.[16]

Effectiveness of LLT in Reducing Orthodontic Pain

The pain measures and key conclusions vary across the included research. Eight studies demonstrated pain reduction of orthodontic tooth movement; the dominant study observed no change in tooth movement or discomfort between irradiated and non-irradiated sides. (p>0.05), Moreover, one study failed to provide solid evidence. In the research, Kochar *et al*.[15] discovered a dependable method and a successful mechanism for treating pain in parameter settings. (Gagan Deep). Furthermore, according to Wu *et al*., (2018), treating LLLT alleviates tooth and gum discomfort and sensitivity associated with orthodontic treatment. Besides that, Hasan, Moaffak, Sultan, and Ajaj's findings indicate that low-level lasers have successfully alleviated pain.[21]

After installing the 0.014-inch thermal NiTi and the 0.016-inch thermal NiTi, respectively, pain on the laser side significantly decreased 1 day (p=0.04), 1 week (p=0.03), and 1 week (p=0.02) later, according to Ren *et al*.[12] (Table-II). The first three months of orthodontic therapy saw a considerable reduction in discomfort following a stable trend (p=0.01). Weekly and monthly declines on the laser side were smaller (p=0.02 at one week and p=0.04 at one month, respectively). Numerous studies have also examined the efficacy of diode LLLT for orthodontists' pain management LLLT testing, whereas other studies have

Table-IV: Details of Laser and its Characteristics

First Author, Year	*p*-value	Statistical Significance	Clinical Outcome	First Author,Year	*p*-value	Statistical Significance	Clinical Outcome	First Author, Year
(Wu et al., 2018)	GaAlAs Laser Diode	810nm	2 J/cm2	400mw	The 20s	Two h, 24 h, 4 d, and seven day	Continuous	Direct contact
(Ren et al.,2019)	Single GaAs	940 nm	8.6 J/cm^2	80 mW	60 s	One day, one week, one month, nine-week	Continuous	Direct contact
(Ng et al., 2018)	Ga-Al-As diode laser	808 nm	1.6 J	180 mW	9 s	0, 1, 2, 3, 7, 14, and 21 days	Continuous and pulse modes both	Direct contact
(Gaetano, Sebastiano, and Ernesto,2019)	Ga-Al-As diode laser	810 nm	8 J/cm^2	1000 mW	15 s	3, 7, and 14 days	Continuous	Direct contact
(Kochar et al., 2017)	Diode laser	810nm	5 J/cm^2 at 10 point	100mW	10 s	days 0 to 14	Continuous	Direct contact
(Marini et al.,2015)	Single GaAs	650 nm	54.4 J	160 mW	340 s	12, 24, 36, 48, 72, and 96 h	Continuous	Direct contact
(Dalaie et al.,2015)	Ga-Al-As diode laser	880nm	5 J/cm^2 at 10 point	Not mentioned	80 s	day 1 to 2 month	Continuous	Direct contact
(Mark, Steven. Eugenia and Edward,2019)	Ga-Al-As diode laser	632.8 nm	12 J/cm^2	160 mW	50 s	Not mentioned	Continuous	Direct contact
(Hasan, Moaffak, Sultan, and Ajaj,2019)	Ga-Al-As	830 nm	2.25 J/cm^2	150 mW	15 s	day (0,3,7,14); first month Every 15 days; the second month	Continuous	Direct contact
(Üretürk et al.,2017)	Ga-Al-As diode laser	820 nm	5 J/cm^2	20 mW	100 s	21,42,63,84 days	Continuous	Direct contact

concluded that it is effective for orthodontic pain relief.[10]

Effect of Wavelength of Laser in LLLT

Table IV describes the details and characteristics of the laser type used in the studies. Among the ten studies in Table 01, two worked with the wavelength 940nm, 02 with 630-650nm, and six worked with 800-880nm. Our study found no effect of particular wavelength on orthodontic movement, although the Diode laser is an efficient therapy for enhancing orthodontic tooth movement. All studies are carried out using a defined parameter. Different authors described the laser characteristics and its efficacy. 940-nm wavelength has been documented as helpful for orthodontic pain relief, periodontal inflammatory regulation, and bone remodeling[22]

DISCUSSION

This systematic review evaluated that LLLT is a successful technique for accelerating tooth movement in orthodontic treatment, except for one study. Following the finding that lasers may quicken wound healing and reduce patient suffering, the concept of utilizing lasers to accelerate tooth movement emerged.[23] Local injections of prostaglandins, osteocalcin, and activated vitamin D3 are only a few of the techniques mentioned by researchers as possible strategies to accelerate tooth movement.[14]

This study conducted numerous clinical trials and animals on this issue.[24] Various studies emphasize that the amount of irradiation received during laser treatment defines its stimulatory effects. In healthy patients, increasing the dose of diode laser irradiation from 0.7-8 J over cm^2 increased tooth movement.[25,26] Using a low-grade diode laser gallium-aluminium arsenide (output power: 20 mW, wavelength: 780 nm, energy dose: 5 J/cm^2) in 10 s at 0, 3, 7, and 14-day intervals every two months, Cruz *et al.*,[24] discovered that canine retraction increased significantly more quickly the irradiated group exhibited a higher rate of movement (1.49 mm) than the non-irradiated group. Therefore, it has been observed in this study that in the previous studies, many laser variables have been used, and inconsistent outcomes depend on laser energy dosages and irradiation times; adverse effects have been recorded.

Furthermore, this study's findings indicate that low-level laser treatment (LLLT) has an inhibitory impact, indicating that it restricts the frequency of various irradiation treatments (daily irradiations and exposure duration for treatment increased the number of blood vessel numbers in rats, but in the rats (100 mW, 830 nm, total energy of 54 J). Furquim *et al*., have demonstrated through a recent survey the influence of the number of relapses in dogs.[27] Following the force applied, the GaAlAs in 200 milliwatts, 810 nanometers, and 2 joules per session were determined to be the most effective way of irradiation for this application. However, it was discovered that the overall laser energy dosage (2J/session: 32 J/cm^2/point) was inadequate for promoting rotational tooth movement and minimizing relapse for up to three months after laser irradiation. It was noticed that this was the case.

The literature describes various wavelengths for reducing discomfort during orthodontic treatment. Lim, Lew, and Tay discovered that LLLT did not give instant pain relief but successfully lowered discomfort 24 to 48 hours after deploying GaAlAs laser-irradiated elastic separators. (30 mW,830 nm, 59.7 mW/cm^2).[28] Bicakci *et al*., argue that LLLT in Orthodontics was used. In this study, the mean levels significantly increased but declined progressively between groups. Twenty-four hours were highly appropriate therapy for the first four days following treatment, but there was no substantial difference across the studies.[29] This finding was verified by the second research, in which the pain intensity specified conditions (100 mW, 830 nm laser, 5 J/cm^2) alleviated patients' discomforts after inserting rubber orthodontic separators.[30]

Considerable data indicated that laser therapy might accelerate bone remodeling and tooth mobility while reducing the pain associated with orthodontic treatment.[22] Consistently, patients express concern over the pain caused by tooth movement. Due to its intrinsically subjective nature, pain perception is notoriously difficult to assess in scientific studies.[2] Despite this, some investigations have failed to irradiate and uneradicated sides of the mouth.[31]

The lack of a substantial difference between the irradiated and non-irradiated areas led us to infer that the low energy delivered was most likely criticized.[32] In addition, this study indicates that no one wavelength had a substantial effect on the OTM. According to Furquim,[27] roughly fifty percent of lasers with a power of sixty milliwatts may penetrate human cortical bone to a depth of one millimeter. The experiments employed a power and achieved favorable results. Few investigations revealed that light-emitting diode lasers might speed tooth movement in humans, hence significantly reducing treatment time.[33]

Studies indicate that low-level laser treatment stimulates bone remodeling without hurting the periodontium and maybe a very effective method for accelerating tooth movement. In experiments with rats, 800 nm increased bone metabolism, accelerated ossification, and accelerated tooth movement. In a recent clinical investigation, a laser with 0.25 mW output and an 800 nm wavelength in continuous wave mode enhanced tooth movement by 1.3 times that of the control.[34]

LIMITATIONS OF THE STUDY

This poses a restriction because both male and female patients were included in the study. It is well known that there are considerable disparities in the sensitivity to pain between the sexes. On the other hand, a mixed group is advantageous since the findings may be applied to a larger population. Patient subjectivity in describing pain is another drawback. However, our study used the VAS score to overcome this constraint. Although an extensive age range (18-55) is a weakness, it is an advantage since it allows us to apply our findings to future treatment recommendations broadly.

CONCLUSIONS

A systematic evaluation of research demonstrates that LLLT by diode laser increases orthodontic tooth movement and that there is no evidence that LLLT accelerates acute orthodontic discomfort. Instead, low-level laser irradiation demonstrates advantages in pain alleviation and inflammatory management. It has been evaluated that elastomeric separators significantly impact the severity and duration of experimental orthodontic discomfort and that wavelength ranges with regulated parameters. In conclusion, the laser expedites tooth movement and may minimize the therapy time.

Conflict of Interest: None.

Funding Source: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

KK & AH: Data acquisition, critical review, approval of the final version to be published.

IQ & TK: Conception, study design, drafting the manuscript, approval of the final version to be published.

MKA: Data analysis, data interpretation, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Niemz M. Laser-Tissue Interactions: Fundamentals and Applications. Springer Cham; 2019. https://doi.org/10.1007/978-3-030-11917-1
2. Youssef M, Ashkar S, Hamade E, Gutknecht N, Lampert F, Mir M, et al. The effect of low-level laser therapy during orthodontic movement: A preliminary study. Lasers Med Sci 2008; 23: 27-33. https://doi.org/10.1007/s10103-007-0449-7
3. Turhani D, Scheriau M, Kapral D, Benesch T, Jonke E, Bantleon HP et al. Pain relief by single low-level laser irradiation in orthodontic patients undergoing fixed appliance therapy. Am J Orthod Dentofacial Orthop 2006; 130(3): 371-377.https://doi.org/10.1016/j.ajodo.2005.04.036
4. Garlet TP, Coelho U, Silva JS, Garlet GP. Cytokine expression pattern in compression and tension sides of the periodontal ligament during orthodontic tooth movement in humans. Eur J Oral Sci 2007; 115(5): 355-362. https://doi.org/10.1111/j.1600-0722.2007.00469.x
5. Alazzawi M, Husein A, Alam M, Hassan R, Shaari R, Ahmad A, et al. Effect of low level laser and low intensity pulsed ultrasound therapy on bone remodeling during orthodontic tooth movement in rats. Prog Orthod 2018; 19. https://doi.org/10.1186/s40510-018-0208-2
6. Fujita S, Yamaguchi M, Utsunomiya T, Yamamoto H, Kasai K. Low-energy laser stimulates tooth movement velocity via expression of RANK and RANKL. Orthod Craniofac Res 2008; 11(3): 143-155. https://doi.org/10.1111/j.1601-6343.2008.00423.x
7. Sobouti F, Khatami M, Chiniforush N, Rakhshan V, Shariati M. Effect of single-dose low-level helium-neon laser irradiation on orthodontic pain: a split-mouth single-blind placebo-controlled randomized clinical trial. Prog Orthod 2015; 16: 32. https://doi.org/10.1186/s40510-015-0102-0
8. Guram G, Reddy RK, Dharamsi AM, Ismail PM, Mishra S, Prakashkumar MD et al. Evaluation of Low-Level Laser Therapy on Orthodontic Tooth Movement: A Randomized Control Study. Contemp Clin Dent 2018; 9(1): 105-109. https://doi.org/10.4103/ccd.ccd_864_17
9. Seifi M, Shafeei HA, Daneshdoost S, Mir M. Effects of two types of low-level laser wave lengths (850 and 630 nm) on the orthodontic tooth movements in rabbits. Lasers Med Sci 2007; 22(4): 261-264. https://doi.org/10.1007/s10103-007-0447-9
10. Kreisler MB, Al Haj H, Noroozi N, Willershausen B, D'Hoedt B. Efficacy of low level laser therapy in reducing postoperative pain after endodontic surgery—A randomized double blind clinical study. Int J Oral Maxillofac Surg 2004; 33(1): 38-41. https://doi.org/10.1054/ijom.2002.0449
11. Hamzah B. The effect of low-level laser therapy after simple tooth extraction. Journal of International Oral Health. 2019: 18; https://doi.org/10.4103/jioh.jioh-288-18
12. Ren C, McGrath C, Gu M, Jin L, Zhang C, Sum F, et al. Low-level laser-aided orthodontic treatment of periodontally compromised patients: a randomised controlled trial. Lasers Med Sci 2020; 35(3): 729-739. https://doi.org/10.1007/s10103-019-02923-0
13. Ng D, Chan AK, Papadopoulou AK, Dalci O, Petocz P, Darendeliler MA et al. The effect of low-level laser therapy on orthodontically induced root resorption: a pilot double blind randomized controlled trial. Eur J Orthod 2018; 40(3): 317-325. https://doi.org/10.1093/ejo/cjx065
14. Isola G, Ferlito S, Rapisarda E. Low-level laser therapy increases interleukin-1β in gingival crevicular fluid and enhances the rate of orthodontic tooth movement. Am J Orthod Dentofac Orthop 2019; 155(4): 456-457.https://doi.org/10.1016/j.ajodo.2019.01.004
15. Kochar GD, Londhe SM, Varghese B, Jayan B, Kohli S, Kohli VS et al. Effect of Low-level Laser Therapy on Orthodontic Tooth Movement. J Indian Orthod Soc 2017; 51(2): 81-86. https://doi.org/10.4103/jios.jios_200_16
16. Marini I, Bartolucci ML, Bortolotti F, Innocenti G, Gatto MR, Alessandri Bonetti G et al. The effect of diode superpulsed low-level laser therapy on experimental orthodontic pain caused by elastomeric separators: a randomized controlled clinical trial. Lasers Med Sci 2015; 30(1): 35-41. https://doi.org/10.1007/s10103-013-1345-y
17. Dalaie K, Hamedi R, Kharazifard MJ, Mahdian M, Bayat M. Effect of Low-Level Laser Therapy on Orthodontic Tooth Movement: A Clinical Investigation. J Dent 2015; 12(4): 249-256.
18. Cronshaw M, Parker S, Anagnostaki E, Lynch E. Systematic Review of Orthodontic Treatment Management with Photobiomodulation Therapy. Photobiomodul Photomed Laser Surg 2019; 37(12): 862-868. https://doi.org/10.1089/photob.2019.4702
19. Alsayed Hasan MM, Sultan K, Hamadah O. Low-level laser therapy effectiveness in accelerating orthodontic tooth movement: A randomized controlled clinical trial. Angle Orthodont 2017; 87. https://doi.org/10.2319/062716-503.1
20. Üretürk SE, Saraç M, Fıratlı S, Can Ş B, Güven Y, Fıratlı E. The effect of low-level laser therapy on tooth movement during canine distalization. Lasers Med Sci 2017; 32(4): 757-764. https://doi.org/10.1007/s10103-017-2159-0
21. Coombe AR, Ho CT, Darendeliler MA, Hunter N, Philips JR, Chapple CC, et al. The effects of low level laser irradiation on osteoblastic cells. Clin Orthod Res 2001; 4(1): 3-14. https://doi.org/10.1034/j.1600-0544.2001.040102.x
22. Heravi F, Moradi A, Ahrari F. The effect of low level laser therapy on the rate of tooth movement and pain perception during canine retraction. Oral Health Dent Manag 2014; 13(2): 183-188.
23. AlSayed Hasan MMA, Sultan K, Ajaj M, Voborná I, Hamadah O. Low-level laser therapy effectiveness in reducing initial orthodontic archwire placement pain in premolars extraction cases: a single-blind, placebo-controlled, randomized clinical trial. BMC Oral Health 2020; 20(1): 209. https://doi.org/10.1186/s12903-020-01191-7
24. Cruz DR, Kohara EK, Ribeiro MS, Wetter NU. Effects of low-intensity laser therapy on the orthodontic movement velocity of human teeth: a preliminary study. Lasers Surg Med 2004; 35(2): 117-120. https://doi.org/10.1002/lsm.20076
25. Genc G, Kocadereli I, Tasar F, Kilinc K, El S, Sarkarati B. Effect of low-level laser therapy (LLLT) on orthodontic tooth movement. Lasers Med Sci 2013; 28(1): 41-47. https://doi.org/10.1007/s10103-012-1059-6

26. Sousa MV, Scanavini MA, Sannomiya EK, Velasco LG, Angelieri F. Influence of low-level laser on the speed of orthodontic movement. Photomed Laser Surg 2011; 29(3): 191-196. https://doi.org/10.1089/pho.2009.2652
27. Furquim RD, Pascotto RC, Rino Neto J, Cardoso JR, Ramos AL. Low-level laser therapy effects on pain perception related to the use of orthodontic elastomeric separators. Dental Press J Orthod 2015; 20(3): 37-42. https://doi.org/10.1590/2176-9451.20.3.037-042.oar
28. Lim HM, Lew KK, Tay DK. A clinical investigation of the efficacy of low level laser therapy in reducing orthodontic postadjustment pain. Am J Orthod Dentofacial Orthop. 1995; 108(6): 614-622. https://doi.org/10.1016/s0889-5406(95)70007-2
29. Bicakci AA, Kocoglu-Altan B, Toker H, Mutaf I, Sumer Z. Efficiency of low-level laser therapy in reducing pain induced by orthodontic forces. Photomed Laser Surg 2012; 30(8): 460-465. https://doi.org/10.1089/pho.2012.3245
30. Artés-Ribas M, Arnabat-Dominguez J, Puigdollers A. Analgesic effect of a low-level laser therapy (830 nm) in early orthodontic treatment. Lasers Med Sci 2013; 28(1): 335-341. https://doi.org/10.1007/s10103-012-1135-y
31. Bello-Silva MS, de Freitas PM, Aranha AC, Lage-Marques JL, Simões A, de Paula Eduardo C. Low- and high-intensity lasers in the treatment of herpes simplex virus 1 infection. Photomed Laser Surg 2010; 28(1): 135-139. https://doi.org/10.1089/pho.2008.2458
32. Madan MS, Liu ZJ, Gu GM, King GJ. Effects of human relaxin on orthodontic tooth movement and periodontal ligaments in rats. Am J Orthod Dentofacial Orthop 2007; 131(1): 8.e1-10. https://doi.org/10.1016/j.ajodo.2006.06.014
33. Shi Q, Yang S, Jia F, Xu J. Does low level laser therapy relieve the pain caused by the placement of the orthodontic separators?--A meta-analysis. Head Face Med 2015; 11: 28. https://doi.org/10.1186/s13005-015-0085-6
34. Kau CH, Kantarci A, Shaughnessy T, Vachiramon A, Santiwong P, de la Fuente A, et al. Photobiomodulation accelerates orthodontic alignment in the early phase of treatment. Prog Orthod 2013; 14: 30. https://doi.org/10.1186/2196-1042-14-30

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