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Low level laser therapy efficacy on orthodontic induced pain management: A review

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ABSTRACT

Introduction: Pain control in patients undergoing orthodontic treatment is one of the major challenges of such treatments. The use of new technologies such as Laser offers promising results in this field. The goal of this study is to survey the works on effect of low-power laser on pain relief during orthodontic treatments.

Materials and Methods: The key terms including "orthodontics, reduction, pain, low level, power, laser and laser therapy" alone as well as combinations. Those key terms were used to search the databases including "Google Scholar, Science Direct, and PubMed". The review of collected sources was done which led to selection of 557 papers. The validation was done through CONSORT guidelines.

Results: After review of selected papers, 34 studies including 32 human studies and 2 animal studies were selected.

Conclusion: The positive findings of reviewed studies on use of laser therapy suggest that low power laser could be effective on pain relief. Conducting further studies on this subject will be beneficial.

Keywords: Orthodontics; Pain; Review; Low-power; Laser.

Introduction

About 91 percent of patients undergoing orthodontic treatments report periods of pain and 39 percent of such patients feel pain during each activation [1]. Until now, numerous methods of orthodontic pain control such as prescription of paracetamol, ibuprofen and tenoxicm (i.e. pharmacological methods) and low-level laser therapy, calling the patients on phone, chewing gum or gel of naproxen or benzocaine, benzocaine muco-adhesive patches, vibration systems, bite wafer, cognitive behavior therapy and music (i.e. non-pharmacological methods) have been introduced [2,3]. Because of effects of sedatives on quality and quantity of orthodontic movement of teeth, other method is preferred [4]. Low-power laser therapy (LLLT) is proved to reduce the synthesis of meditators of inflation in nervous tissues, contribute to quicker maturity and restoration of axonal growth and increase the myelination of damaged nerves [5,6]. For the past 20 years, soft laser therapy has been used for pain relief of teeth during orthodontic treatment [7]. Low-power laser therapy (LLLT) could reduce TNFalevel in the case of acute inflammation which leads to lower acute inflammation and pain [8]. LLLT could influence inflammatory processes in a dose-dependent manner. This means that higher dose of laser is correlated with higher effect of laser on pain relief [9]. LLLT is used to reduce the pain of different parts of the body [10-12]. Temporomandibular joints (TJM) ia an example of using LLLT in order to pain control [13]. It is suggested that LLLT could increase blood perfusion [14] and decrease inflammation [15]. The exact mechanism of pain relief through LLLT is not clear but some studies suggest the reduced activity of nervous fibers after LLLT [16]. LLLT reduces edema and hyperalgesia in the cases of acute and chronic inflammation [17]. Regarding maxillofacial region, LLLT was used to relieve the pain of stomatitis caused by hand-foot-and mouth disease [18]. LLLT is also used for cases of paresthesia, trigeminal neuralgia, and periodontitis [19]. Orthodontic treatment causes neurosensory changes in patients and repetitive and transient pain of orthodontic treatment causes peripheral and central sensitization of the nerves [20]. Cessation of blood perfusion during orthodontic tooth movement adds to the size of hyalinised areas [21] and development of hyalinised areas is usually accompanied by pain [22].

Orthodontic pain is suggested to start 12 hours after application of force and it becomes maximum after 1 day. However, the pain reduces in the next 3 to 7 days and it minimizes after a month [23]. The orthodontic tooth movement is accompanied by remodeling which is an inflammatory process. Specifically, pain might occur after activation of orthodontic appliances [24]. The mechanisms of biostimulation or photobiostimulation through reduction of meditators of inflammation, change of nervous impulse transmission, and release of endorphins are used to explain the effect of LLLT on pain relief [25,26]. The increase of Na-K-ATPase and degranulation of mast cells are other suggested mechanisms of pain relief through LLLT [27]. LLLT exerts anti-inflammatory effect on PDL cells and it influence such cells through CAMP/NF-KB regulation [28].

Understanding of pain has a critical role in patients' cooperation and successful orthodontic treatment [29]. Pain is a complication of orthodontic treatment with significant effect on the life of orthodontic patients, especially during early phases of their treatments [30, 31]. The studies on pain often use visual analogue scale which is composed of 100 mm or 10 cm scaling. Based on extent of feeling pain, the patient selects a VAS scale from 0 (lack of pain) to 10 (maximum pain) [32]. The goal of present review is discussion of latest studies about the effect of low-power laser therapy on pain relief during orthodontic treatments.

Materials and Methods

Data bases were included: Science Direct, PubMed, and Google Scholar. key terms were included: laser, laser therapy, low-level, orthodontics, reduction, pain and power as well as combinations of them. Without paying attention to publication source, the collected studies were reviewed to find the intended studies. The time limitation set for the search signified that the studies published between 2012 and 2018 were intended. After initial search, 557 papers on Google Scholar, 61 papers on PubMed and 156 papers on Science Direct were found. The review of the found sources of study led to no new study.

The inclusion criteria of present study were:

- Animal intervention or clinical studies consisting of an intervention group and a control group.

- Sufficient description of animals.

- Inclusion of at least 5 animals or human subjects in each group.

- Proper and complete description of specific factors of the used lasers.

- Complete description of times and duration of radiation.

- Complete and precise description of measurement of pain.

- Sufficient statistical analysis.

- English language.

- Ethical code of the study.

Lack of each of above-mentioned items causes the exclusion of a study from the collection of studies. The CONSORT guidelines were used to validate the remaining studies.

Results

After review of found papers, 34 studies (i.e. 32 human studies and 2 animal studies) were selected for the next step. The search led to only two animal studies. Deguchi et al [33] used CO_2 laser to examine its effect on neurochemical markers of pain in rats [33]. Hosseyni [34] used GaAiAs laser to determine the effect of LLLT on pain during palatal expansion of rats. In the latter study, weights of rats were used as pain measurement scale [34]. The other studies used human samples to examine pain. The summary of reviewed studies is included in table 1. As described below, different low-power laser devises have been used for relief of orthodontic pain.

Qamruddin et al 2018 (35)	*Effects of single-dose, low-level laser therapy on pain associated with the initial stage of fixed orthodontic treatment: A randomized clinical trial*	*42 patients One side of the mouth was experimental while the other side served as placebo (LLLT simulation)*	*GaAlAs diode*	*λ: 940 nm, power: 100 mW, diameter of the optical fiber tip:0.04 cm^2, energy density: 7.5 J/cm^2*	*NiTiarchwire sequence(0.012, 0.014, 0.016, 0.018-inchin) in the maxillary archin order to alignment*	*A questionnaire of numerical rating scale (NRS)*	*A single dose of LLLT considerably lessened postoperative pain of super-elastic NiTi wires placement for initial alignment and leveling*
Farias et al 2018 (30)	*Low-level laser therapy for controlling pain in orthodontic patients during the use of elastic separators: randomized clinical trial*	*40 patients split to 2 groups: G1—exposed hemi-arch (received LLLT) and G2 non-irradiated hemi-arch (LLLT simulation)*	*Not mentioned*	*wavelength of 808 nm, output of 100 mW, dosage of 2 J/cm^2, and a duration of 15s per point*	*Orthodontic tabs(separators) were placed in the upper first molar*	*VAS scale*	*A significant reduction in pain in laser-treated hemi-arch compared to non-exposed hemi-arch at all time-intervals was observed*
Guram et al 2018 (36)	*Evaluation of Low-Level Laser Therapy on Orthodontic Tooth Movement: A Randomized Control Study*	*20 patients with bimaxillary protrusion, each quadrant divided as study (LLLT) and control (no laser therapy) group*	*GaAlAs diode Semiconductor*	*λ: 810 nm, energy density: 5 J/cm^2 power output: 0.2 W frequency: 2Hz T: 80 s continuous mode*	*canine retraction with closing loops with a force of 150 g*	*Wong-Baker Faces Rating Scale*	*LLLT can increase rate of tooth movement and reduce orthodontic pain experience*

Martins et al 2018 (37)	w-level laser therapy (830 nm) on orthodontic pain: blinded randomized clinical trial	62 patients	GaAlAs diode	λ: 830 nm and the tip's area: 0.03cm2 power: 100 mW, E: 95 J/cm2, T:30s	Separator placement on the mesial and distal interproximal spaces of the first lower permanent molars with 1week interval between 2 sides	VAS	The laser irradiation to reduce the pain was only effective when irradiated-immediately after separation
Lo Giudice et al 2018 (38)	Is Low-level Laser Therapy an effective method to alleviate pain induced by active orthodontic alignment arch-wire? A randomized clinical trial.	90 patients, in 3 groups: 1. tested group (LLLT) 2. placebo group (simulated LLLT) 3. control group	Diode laser(Wiser; Doctor Smile–Lambda Spa, Brendola, VI),	λ: 980 nm beam spot size: 1 cm2 output power: 1W total energy density of 150 J/cm^2	0.014-inch thermal Ni-Tiarchwire for alignment	numeric rating scale (NRS)	LLLT is effective in reducing the pain after the engagement of initial alignment archwire.
Matarese et al 2018 (39)	Evaluation of Low-Level Laser Therapy with Diode Laser for the Enhancement of the Orthodontic Tooth Movement : a Split-Mouth Study	14 patients, (24 mandibular canines) one side of arch as diode Laser group, the other side not irradiated as control Group	Diode laser (Wiser Laser Doctor Smile, Lambda)	λ: 810nm power: 1 W ontinuous wave of 66.7 J/cm^2 continuous wave mode	Premolar extraction and canine retraction by using NiTi spring	patients were asked about the pain experience by choosing one of5 degrees of no pain (0), mild pain (1), moderate pain (2), severe pain (3), intolerable pain (4)	diode laser therapy can effectively reduce pain level during orthodontic treatment
Nahin et al 2018 (40)	The Efficacy of Low-level Laser Therapy on Pain caused by Placement of the First Orthodontic Archwire: A Clinical Study	10 patients with anterior crowding were divided to experimental group (LLLT) and control group (no laser therapy)	GaAlAs diode	λ: 830 nm Each area was exposed to LLLT for 16 seconds or 0.5 J per cm^2 . Each tooth received a dose of 2.5 J per cm^2 on each side	Placement 0f 0.016″ superelastic nickel–titanium (NiTi) wire as first archwire	VAS	Low-level laser therapy was an effective and noninvasive method for reducing the duration and intensity of pain after receiving their first archwires

WU et al 2018 (41)	Effect of low-level laser therapy on tooth-related pain and somatosensory function evoked by orthodontic treatment	40 individuals were randomly divided into a laser group (LG) or a placebo group (PG)	GaAlAs diode	ʎ: 810nm power: 400 mW, energy density: 2 J/cm^2, continuous mode	Initial Alignment with 0.014 Niti wire	Numerical rating scale (NRS), cold detection thresholds, warmth detection thresholds,pressure pain thresholds ,cold pain thresholds and heat pain thresholds	The application of LLLT might reduce thesensitivity of the tooth and gingiva associated with orthodontic treatment and pain
Qamruddin et al 2017 (42)	Effects of low-level laser irradiation on the rate of orthodontic tooth movement and associated pain with self-ligating brackets	22 patients with Class II Division 1 malocclusion	GaAlAs diode	ʎ: 940 nm energy density: 7.5J/cm2 diameter of optical fiber tip: 0.04cm^2	placement of closed-coil springs to retract canines to premolar extraction sites	Numerical rating scale	LLLT applicationcan accelerate tooth movement and reduce the pain
Deguchi et al 2017 (33)	CO2 low- level laser therapy has an early but not delayed pain effect during experimental tooth movement	65 adult Sprague Dawley rats, in 13 groups	CO2 laser	T: 30S (repetition output of 0.01 seconds on time and 0.09 seconds off, 1.0 W)	Separators inserted between the maxillary first and second molars	Immunohistochemistry assessment for GFAP, CD-11b and C-fos in the Rats brain stem was performed	LLLT may reduce early neurochemical pain markers but have no effect on delayed neurochemical pain markers after separator placement
Kochar et al 2017 (43)	Effect of Low-level Laser Therapy on Orthodontic Tooth Movement	20 patients dental Class I bimaxillary protrusion one side in each patient received LLLT and other side did not receive any LLLT	AIGaAs diode Semiconductor	ʎ: 810 nm power: 100 mW irradiation area: 0.4 cm^2 power: 100 mW, dose: 5.0 J/cm2, T: 10 s, continuous wave mode	Extraction of all first premolars and placement of nickel–titanium (Ni-Ti) closed-coil spring	VAS	LLLT was effective in pain reduction

Moaffak et al 2017 (44)	*Original Research Effects of Low-Level Laser Therapy in Orthodontic Patients on Immediate Inflammatory Response After Mini-Implants Insertion: A Preliminary Report*	*10 volunteer With indication of use of bilateral mini-implants, on the right side, LLLT was applied, left side was control group*	*Diode laser (Twin Laser MMOptics, Sao Carlos, Brazil)*	*ʎ: 660 nm, power: 40 mW, Laser beam area: 0.04 cm2, T: 60 sec Energy density: 4 J/cm^2*	*Insertion of two mini-implants (1.3 mm diameter, 7 mm length) bilaterally on maxilla and without any load*	*peri-implant crevicular fluid (PGF) was obtained to identify levels of interleukin (IL)-6 and IL-8 around mini-implants and around upper first premolars*	*LLLT modulates the initial inflammation after the insertion of orthodontic mini-implant, keeping IL-8 levels lower than non-irradiated area, but increasing IL-6 levels.*
Yanaguizawa et al 2016 (45)	*Original Research Effects of Low-Level Laser Therapy in Orthodontic Patients on Immediate Inflammatory Response After Mini-Implants Insertion: A Preliminary Report*	*10 volunteer With indication of use of bilateral mini-implants, on the right side, LLLT was applied, left side was control group*	*Diode laser (Twin Laser MMOptics, Sao Carlos, Brazil)*	*ʎ: 660 nm, power: 40 mW, Laser beam area: 0.04 cm^2, T: 60 sec Energy density: 4 J/cm2*	*Insertion of two mini-implants (1.3 mm diameter, 7 mm length) bilaterally on maxilla and without any load*	*peri-implant crevicular fluid (PGF) was obtained to identify levels of interleukin (IL)-6 and IL-8 around mini-implants and around upper first premolars*	*LLLT modulates the initial inflammation after the insertion of orthodontic mini-implant, keeping IL-8 levels lower than non-irradiated area, but increasing IL-6 levels.*
Bayani et al 2016 (46)	*A randomized clinical trial comparing the efficacy of bite wafer and low level laser therapy in reducing pain following initial arch wire placement*	*100, in 5 groups: 1: placebo medication 2: ibuprofen 3: bite wafer 4: low level red laser LLRL 5: low level infrared laser; LLIL*	*indium-gallium-aluminum-phosphide InGaAlP diode and GaAlAs diode*	*InGaAlP: ʎ: 660 nm, energy density: 14.3 J/cm^2, power: 200 mW, T: 30S GaAlAs: ʎ: 810 nm, energy density: 3.6 J/cm^2, power: 200 mW, T: 30S*	*Initial alignment with 0.014 Nitiarchwire*	*VAS: 10 cm in length (0=no pain, 10=worst pain)*	*A single irradiation from a low level infrared laser proved to be the best strategy for orthodontic pain control. Alternatively, chewing on a bite wafer could be recommended. These methods should be considered as suitable alternatives for ibuprofen in orthodontic patients.*

Almallah et al 2016 (47)	Evaluation of Low Level Laser Therapy on Pain Perception Following Orthodontic Elastomeric Separation: A Randomized Controlled Trial	36 in 2 groups: 1: single irradiation 2: double irradiation	Gallium Aluminum Arsenide (GaAlAs) diode Semiconductor	ʎ : 830 nm, energy density: 4J/cm^2, power: 100 mW, laser spot diameter 7mm, T: 28S	Elastomeric separator placement for first molars	Visual Analog Scale (VAS)	LLLT showed a significant reduction in the pain following orthodontic separator placement. Double irradiation did not shown any additional benefit.
Deshpande et al 2016 (48)	Low-level laser therapy for alleviation of pain from fi xed orthodontic appliance therapy: A randomized controlled trial	30, in 3 groups: 1. LLLT Group 2. Placebo group (simulated LLLT) 3. Control group	Gallium arsenide (GaAs) laser	ʎ; 904 nm Each area was irradiated with impulse power of 10W frequency: 60 Hz for 2 min using a 5 mm nozzle (emits a 12 mm zone of irradiation), method of irradiation: contact	Placement of fixed orthodontic appliance along with intialarchwire placed in one arch	Ppain questionnaire	LLLT reduced theintensityand duration of the pain inpatients
Farias et al 2016 (49)	Evaluation of the use of low-level laser therapy in pain control in orthodontic :patients A randomized split-mouth clinical trial	patients 30 divided in 2 :groups one quadrant was considered as experiment group and other the control group	AIGaAs diode	ʎ: 810nm E: 2 j/cm^2 Power: 100mw	elastic separators placement for the first molars at different times	VAS	LLLT may be useful for the control of pain in the early stages of orthodontic treatment
Qamruddin et al 2016 (50)	Effect of a single dose of low-level laser therapy on spontaneous and chewing pain caused by elastomeric separators	88 patients each arch was divided into experimental and control groups	GaAlAs diode	ʎ: 940 nm, power: 200 Mw, T: 20s, continuous wave mode	Placement of elastomeric separators both sides of all first molars	A questionnaire of numerical rating scale (NRS)	A single dose of LLLT can be effective foralleviate associated pain with the placement of separators

Sobouti et al 2015 (51)	Effect of single-dose low-level helium-neon laser irradiation on orthodontic pain: a split-mouth single-blind placebo-controlled randomized clinical trial	30 patients requiring upper first premolar extraction. LLLT was done for the One quadrant of maxilla and the other side servedas the placebo side	helium-neon laser	ʎ: 632.8 nm, power: 10mw, energy density: 6 j/cm^2	extraction of upper premolars and placement of power chain	VAS	Single-dose LLLT might reduce orthodontic pain
Furquim et al 2015 (52)	Low-level laser therapy effects on pain perception related to the use of orthodontic elastomeric separators	100 patients divided in 4 groups: 1, LLLT on left side and placebo on right side (blind) 2, LLLT on left side and control on right side (aware) 3, control on right side and placebo on left side (blind) 4, control on both sides(aware) - 21 dropped out	AsGaAl laser	ʎ: 808nm E: 80 j/cm2 6J of energy per tooth	Elastomeric separators placement in first maxillary molars	VAS	a single-dose of LLLT did not cause significant reduction in orthodontic pain
Hosseyni et al 2015 (34)	Effect of Low Level Laser Therapy on Pain Reduction After Midpalatal Expansion in Rats	60 male Sprague six -week rats, in 3 groups: 2 experimental: expansion with and without laser therapy and 1control group	GaAlAs diode	ʎ: 810 nm output power: 100 mW E: 4 J/cm^2	Placement of orthodontic appliances for maxillary expansion	Assessment of pain reduction after midpalatal expansion in rats by monitoring the body weight of animals during the treatment period	Pain control after midpalatal expansion in the irradiated group was more efficient

Abtahi et al 2013 (53)	Effect of low-level laser therapy on dental pain induced by separator force in orthodontic treatment	29 patients, In maxilla or mandibul one side considered as LLLT side and the other side was considered as control side	Gallium arsenide (GaAs) laser Superpulsed	ʎ: 940nm power output:200mw E=6j T: 30sec	Placement of elastic orthodontic separators for the upper and lower first molars	VAS	Pain differencebetween both groups was not statistically significant except the second day after LLLT
Domı´nguez et al 2013 (54)	Effect of Low-Level Laser Therapy on Pain Following Activation of Orthodontic Final Archwires: A Randomized Controlled Clinical Trial	60 patients divided in 2 groups: 1. treated by With Equilibrium Òbrackets 2. with In-Ovation CÒ self-ligating brackets. (opposite arch was placebo treated with the laser off)	GaAlAs	ʎ: 830 nm, Power: 100 Mw, (T: 22s E: 80 J/cm2) along the vestibular and palatal surface of the root The spot size of the laser beam :600μm, scanned	Activation of orthodontic final archwires	VAS	LLLT reduces pain during the final stage of orthodontic treatment
Domı´nguez et al 2013 (55)	Effects of low-level laser therapy on orthodontics: rate of tooth movement, pain, and release of RANKL and OPG in GCF	10 systemically healthy subjects (half of their upper arcade as control and half as laser-treated)	diode laser (Periowave)	ʎ:670 nm, power: 200 mW, power density: 6.37 W/cm^2, continuous wave	First premolar retraction withnitinol coil spring with a constant force of 150	VAS	Results showed some improvement with complementary use of LLLT to the orthodontic treatment as a slight reduction of pain
Eslamian et al 2013 (56)	The effect of 810-nm low-level laser therapy on pain caused by orthodontic elastomeric separators	37 patients One quadrant was randomly used as a placebo group	GaAlAs	ʎ:810nm E:2 j/cm^2 power:100mw T:20sec 10 dose	Placement of 4 elastomeric separators for the first molars (distal and mesial), either on maxillary or mandibular	VAS	The LLLT significantly reduced patients pain in the first 3 days after orthodontic separator placement.
Kim et al 2013 (57)	Effect of frequent laser irradiation on orthodontic pain A single-blind randomized clinical trial	88 patients divided in 3 groups: 1. laser group 2. light-emitting diode (LED) 3. control group	AlGaInP diode Semiconductor	ʎ: 635nm E: 10mj Power: 6mw field diameter: 5.6 mm	placement of elastomeric separators for right and left maxillary first molars	VAS	LLLT may reduce orthodontic pain during the first day after separation.

Marini et al 2013 (58)	The effect of diode superpulsed low-level laser therapy on experimental orthodontic pain caused by elastomeric separators: a randomized controlled clinical trial	120 patients divided to upper and lower jaw groups/ in subgroups of: laser, placebo and control	GaAs diode Superpulsed	ʎ: 910 nm, power: 160 mW, beam diameter: 8 mm, applied for 340s	Placement of elastomeric separators for right first molar and premolars	VAS	LLLT was effective in reducing thed-uration and intensity of pain
Nobrega et al 2013 (59)	Low-Level Laser Therapy for Treatment of Pain Associated with Orthodontic Elastomeric Separator Placement: A Placebo-Controlled Randomized Double-Blind Clinical Trial	60 patients divided to two groups: the control group and the intervention group	GaAlAsdiod	ʎ: 830 nm laser spot diameter was 2 mm irradiation time was 25 sec per each 1 J/cm^2	Placement of elastomeric separators for alower first molar	VAS forspontaneous and in occlusion pain assessment	LLLT efficiently controlled elastomeric separators placement pain
Artés-Ribas et al 2012 (60)	Analgesic effect of a low-level laser therapy (830 nm) in early orthodontic treatment	20 volunteers	GaAlAs diode	ʎ : 830 nm, energy density: 5J/cm2, power: 100 mW, beam diameter: 7 mm, T: 20S	Elastic separator placement in the mesial and distal of maxillary premolars	VAS	LLLT is effective for pain control after orthodontic separator placement.
Bicakci et al 2012 (61)	Efficiency of Low-Level Laser Therapy in Reducing Pain Induced by Orthodontic Forces	19 patients	GaAlAs diode	ʎ: 820 nm, energy density: 7.96J/cm2, power: 50 mW, T: 5s, focal spot: 0.0314 cm^2, power density: 1.59 W/cm^2, energy dose: 0.25 J, area irradiated: 0.125cm^2	Band placement for maxillary first molars (one as control, one as lase-irradiate)	VAS and GCF collection from the gingival sulcus of first molars to evaluate PGE2 levels, before band placement, 1 h and 24 h after LLLT	The significant reductions in pain and PGE2 levels indicated that LLLT was efficient in reducing orthodontic pain.

Doshimehta et al 2012 (62)	*Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: A clinical investigation*	*20 patients(10 with extraction of maxillary first premolars and 10 With extraction of mandibular first premolars) Divided to two groups: 1. Control group of 30 quadrants 2. laser-treated 30 quadrants*	*GaAlAsdiod Semiconductor*	*ʎ:800 nm, power: 0.7 mW, T: 30s, a continuous wave mode*	*Extraction of the maxillary or mandibular first premolars (or both) and placement of nickel-titanium coil spring*	*Visual pain scale*	*LLLT is a good way to reduce pain and treatment duration*

Table 1.

GaAlAs Diode Laser

In different studies, laser in wavelength range of 800 to 940 nm were used. The laser is most commonly used in studies on pain relief. Qamruddin et al [35] put laser tip in contact with tissue and laser was radiated on 5 spots of buccal region and 5 spots of palatal region. The radiation time for each spot was 3 seconds and laser was radiated on a row of teeth from central tooth to first molar teeth. The spontaneous pain and pain during chewing were measured on NRS scale every 12 hours for 7 days [35]. Guram et al [36] used laser of infrared wavelength range (80 seconds radiation per week for 21 days) in close contact with tissues. In their study, 3 spots of buccal region and 3 spots of palatal region were radiated. Then, pain was measured 1 day after radiation through Wong-Baker Faces Rating Scale [36].

Martin et al [37] exposed mucosa to laser vertically. In their study, 8 periodontal spots including 2 spots of mesial region, 2 spots of distal region, 2 spots of buccal region and 2 spots of lingual region were laser-radiated. Laser radiation was done immediately before and after installing separator, and 24 and 48 hours later. Pain was measured on VAS scale in 7 time points (i.e. before placement of device, immediately after placement of device, after placement of separator, 24 hours after placement of separator and before laser radiation, 24 hours after placement of separator and laser radiation, 48 hours before laser radiation and 48 hours after placing separator and laser radiation) [37].

Nahin et al [40] used laser therapy immediately after placing the first orthodontic wire on 5 buccal spots and 5 lingual spots of each tooth. The time of laser radiation per each spot was 16 seconds. In each quadrant, 18.5 and 16 minutes of laser radiation for patients without and with tooth extraction were done respectively. During the first week, pain was measured daily on VAS scale [40]. WU et al [41] used laser radiation immediately after setup of 14 NiTi wire, and 2 hours, 24 hours, 4 days and 7 days later. Laser was radiated on 3 spots of buccal region and 3 spots of lingual region of canine tooth. Laser was radiated at a distance of 10mm from gingiva and perpendicular to longitudinal axis of tooth [41].

After application of retraction force on canine tooth, Qamruddin et al [42] sought immediate laser radiation by targeting 5 spots of buccal area and 5 spots of lingual area. The radiation was vertical and tangent with the surface. A patient had to visit once every 3 weeks (up to 3 visits). During first and second visit, laser therapy were done. The 11-scale NRS questionnaire was filled in after each laser radiation session, namely 4 hours after laser therapy and then every 24 hours for the future 7 days. At the time of visit, the patients were asked to report their highest pain in the past 24 hours [42].

Kochar et al [43] used infrared radiation laser. At the time of laser radiation, tip of the laser was in contact with the tissue without employing any pressure. The radiation was done on 5 spots of buccal region, 5 spots of palatal region immediately after activation of spring, on 3rd and 7th day and then every 21 days. Pain was measured on VAS scale in 6 hours after laser radiation and then daily from second to seventh day [43]. Moafak et al [44] used two different regimes of laser radiation for two test groups. Laser was radiated on a spot of mesial region and one spot of distal region. The laser was perpendicular to tooth and in direct contact with mucosa. The patients were asked to chew a piece of bread in 1 hour, 6 hours, 12 hours, 1 day, 2 day and 3 days after laser radiation and report pain on VAS scale [44]. In the case of their test group, Bayani et al [46] used an infrared laser to radiate 3 spots of buccal region and 3 spots of lingual region. The tip of the laser was in close contact with intended surface. Pain was measured on VAS scale in 2 hours and 6 hours after installation of wire and during daily sleep. The patients were also asked to report pain in 24 hours, 2 days, 3 days and 7 days after installation of wire [46].

Almallah et al [47] used laser radiation for a test group immediately after placement of separator. In the case of another group, a laser dose was radiated immediately after placing the separator. The second dose was radiated after 24 hours. In this case, 8 spots in each side including buccal, palatal mesial and distal regions of first molar, buccal and palatal mesial region of second premolar tooth and buccal and palatal distal regions of second molar tooth were placed under laser radiation. Pain was measured on VAS scale in 1 hour, 6 hours, 1 day, 2 days and 3 days after placing the separator [47].

Farias et al [49] used infrared laser radiation on 3 spots of buccal region. Pain was measured on VAS scale in 5 minutes, 24 hours and 120 hours after laser radiation. Qamruddin et al [50] used laser radiation of 3 spots of buccal region of tooth after separator had been placed. The laser was radiated perpendicular to the surface and in close contact with mucosa. Spontaneous pain was daily measured on NRS for 7 days. In addition, pain during chewing was measured every 24 hours for a week [50]. Furquim et al [52] radiated laser on 3 spots of buccal region which were 4mm away from each other. Radiation was done in contact with mucosa. Pain was measured on VAS scale in 6 hours, 12 hours, 1 day, 2 days and 3 days after intervention [52]. In their animal study, Hosseyni et al [34] used laser radiation of a spot of buccal region and 3 spots of palatal region in zero, 2nd, 4th, 6th, 8th, 10th, 12th, and 14th day after palatal expansion. As pain scale, the weights of rats were measured every day [34]. Deminquez et al [54] applied radiation on a spot of buccal region and a spot of palatal region. Radiation was 1mm away from mucosa. In their study, pain was measured on VAS scale in 2, 6, 24 hours and 2, 3 and 7 days after radiation [54].

Eslamian and colleagues exposed the laser perpendicular to the longitudinal axis of the tooth, 5 doses at the buccal surface and 5 doses at the palatal, mesial and distal surface of teeth 5 and 6 and the distal of teeth 7, and after 24 hours, 10 other doses of laser radiation were repeated in the same way. VAS was measured as a measure of pain on day zero, before laser radiation, after 6, 24, and 30 hours, and 3, 4, 5 and 7 days [56]. In a study by Nobrega et al., Infrared lasers were radiated on a point at the buccal surface and three points at the palatal surface. The pain was measured by VAS in jaw relaxation and occlusion mode at 2, 6, and 24 hours, 3 and 5 days after insertion of the separator [59].

In the study by Artes-Ribas et al., the laser power was measured before each radiation by a Pow-105 power meter and the laser was exposed to tissue in 3 points at buccal surface and 3 points at palatal surface. The pain was measured by the VAS before the separator was placed and 5 minutes after the separator was inserted and the laser irradiation was performed at 6, 24, 48, and 72 hours later [60]. Bicakci and colleagues exposed the laser to four points around the teeth, including the mesiobuccal, distobuccal, mesiolingual and distolingual, and in contact with tissue. The pain was measured by VAS at 5 minutes, 1 hour, 24 hours after insertion of the band [61]. Doshimehta and colleagues exposed the infrared laser in direct contact with tissue at retraction spring activation day on the buccal and palatal canine tooth surfaces. The pain was measured by VPS on the first day (immediately after activation), on day 3 and day 30 [63].

2. Diode laser: GaAs

Was investigated with 904, 910, and 940 nm wavelengths in three studies. In study by Deshpande et al., laser radiation was applied to the buccal and palatal surfaces of canine tooth involved in arch wire. Pain questionnaires were filled in 1, 24, 48 and 72 hours after laser radiation [48]. Abtahi and colleagues exposed the infrared laser vertically and in contact with the gum tissue to a point on the buccal and a point on the palatal tooth. The pain was measured by VAS after insertion of the separator before and after each laser irradiation [53]. In a study by Marini et al., The laser was immediately exposed to a point at the buccal surface and a palatal point immediately after insertion of the separator. VAS measurement was performed after inserting the separator, 12, 24, 36, 48, 72 and 96 hours and 4 days later [58].

3. Diode laser: InGaAlP

Was used in two studies with wavelengths of 635 and 660nm. In a study by Kim et al., laser was exposed in close contact with tissue on mesiobuccal, dysto-buccal, mesiolingual, and dystolingualsurfaces of the 6th upper tooth immediately after insertion of the Separator, 12 hours and one week later. The pain was measured by VAS for 5 minutes, 1, 6, 12 hours, 1, 2, 3, 4, 5, 6, and 7 days after insertion of the Separator [57].

Bayani and colleagues used a red laser with a radiation on3 points of buccal surface and 3 points at the lingual surface in which laser tip wasnear the tissue. The pain was measured by VAS for 2 hours, 6 hours and bedtime on the wire insertion day, and then at 24 hours, 2 days, 3 days, and 7 days after insertion of the wire [46].

3. Co2 laser

Only in the animal study by Deguchi et al., the laser was introduced to the buccal and palatine surface of the Rat's tooth with low power after the Separator was placed. In this study, the laser wavelength used was not mentioned. The pain was measured by immunohistochemistry [33].

4. Helium-neon laser:

In thesobouti study, it was used with a wavelength of 632.8nm. The laser tip was perpendicular to the longitudinal axis of the tooth and in contact with soft tissue, and the teeth were exposed to both the buccal and palatal surfaces under laser irradiation. The pain was measured by VAS separately for left and right sides on day 1, 2, 4, and 7 after force application [51].

5. Diode Laser:

Four studies did not mention the type of medium used in the manufacture of diode lasers, and only referred to the use of diode lasers, which consisted of periowave commercial brand with wavelength of 670 nm and twinlaser brand with wavelength of 660 nm and wiser brand with wavelengths of 980nm and 810 Nanometer. In a study by Dominguez et al., the laser tip was inserted into periodontal pocket and shifted throughout the entire sulcusduring radiation, and the buccal, lingual and distal regions were irradiated on days 0, 1, 2, 3, 4 and 7. The pain was measured by VAS before inserting the appliance (day zero) and after the laser irradiation, on days 1, 2, 3, 4, 7, 30, and 45 [55]. Yanaguizawa and colleagues performed laser radiation directly to the Mini Screw immediately after inserting the Mini Screw and 24 and 48 hours later. They examined IL-6, IL-8 inflammatory mediators as indirect indications of pain by Elisa's test [45]. In the study by Matarese et al., Laser irradiation was performed at 3 points on the buccal and 3 pointon the lingual surface on days 0, 3, 7 and 14 after spring activation. The severity of pain after spring activation was asked from the patient [39].

In the Lo Giudice study, the entire mandibular arc was irradiated by moving the infrared laser beam along the arc. The pain was measured by NRS 2, 6, 24 hours, and 2 to 7 days after radiation [38].

Only one study mentioned the type of laser used [30]. In this study, the infrared laser was exposed to 3 buccal surfaces and the pain was measured by VAS for 5 minutes, 24, and 120 hours after insertion of the separator. Patient satisfaction from LLLT was verified by standardized Likert Scale.

Orthodontic intervention:

1. Aligning & leveling with NiTiarchwire

In 6 studies, different sizes of NiTi wires were used for alignment and leveling. In the Lo Giudice study, Empower's self-ligate brackets and 0.014-inch Thermal-activated wire were used [38]. In the Qamruddin study the complete sequence of NiTi wires until the completion of the Aligning & Leveling phase included 0.012, 0.014, 0.016 and 0.018 inch wires [35]. Three studies used 0.014-inch wire and one used NiTi 0.016-inch as first wire, and in one study, the size of the first wire was not mentioned [40,41,46,48].

2. Separator placement

In most studies (14 studies), elastomeric separators were inserted between the teeth and the pain was measured after placement. Separators are located between the teeth and usually in the mesial and distal sides of the 6th tooth onupper and lower jaws. Besides to the teeth, the Separator insertion time is different between different studies [30,33,37,44,47,49,52,53,56-60].

3. Retraction

In 7 studies, different teeth retractions including canine and first premolar, were performed using different mechanics such as NiTicoilspring, power chain and sectional closing loop [36,39,42,43,51,55,62].

4. Mini-implants

Only in one study, the effect of LLLT on immediate inflammatory response after mini-implant placement was investigated. In this study, two mini-implants with a diameter of 1.3 mm and a length of 7 mm were placed bilaterally in the upper jaw [45].

5. Maxillary expansion

Only in one animal study, the effect of low-power laser radiation on pain due to palate expansion was investigated [34]. No human studies have ever been performed on this orthodontic intervention.

6. Activating the final archwire

In a study, the effect of LLLT on the activation of final archwires was investigated. Of course, the activation mentioned in the title of this study is simply the insertion of the final arch wires in the Preadjusted brackets. This study did not mention the size and material of these final arch wires [54].

7. Band placement

In a study, the effect of LLLT on pain after band placement on the maxillary first molarswas persued. Bands were cemented by glass ionomer in situ [61]. In most studies, pain was measured by VAS (Visual Analog Scale) of 10cm or 100mm [30,37,40,43,44,46,47,49, 51-62]. Based on the severity of the pain that it felt, the patient chooses number zero (painless) up to 10 (maximum pain) on this criterion. A method similar to VAS is the Numerical Rating Scale (NRS) questionnaire, which was used in a number of studies [35,38,41,42,50]. In another study, pain was measured using the Wong-baker faces rating, which shows the degree of pain as emoticon images [36]. In an animal study, immunohistochemical methods were used to examine the chemical markers of pain [33]. In a human study, Interleukin 6 and 8 were examined around the mini- implants in the cervicular fluid [45]. An animal study determined the weight of the rats as a pain measure after palate expansion [34]. In all studies, except one study [44], LLLT reduced the pain of various orthodontic therapies in human and animal studies. See Table 1 for more information.

Discussion

In 2018, Shafeqee et al. conducted a review of the effects of LLLT on pain in orthodontic treatment. They mostly looked at biology and the effect of low-power laser on pain and did not pay attention to the parameters and types of laser. There were no tables in this article for a review of the studies. In our study, we focused on laser parameters and a table was designed to examine the details of each study [64]. In a study by Deana et al. in 2017, they reviewed RCT studies on the effect of LLLT on reducing orthodontic pain at 24 and 72 hours after applying orthodontic force. They introduced 20 RCT studies, and after meta-analysis of pain sources, they reported LLLT treatment in favor of pain relief at 24 and 72 hours after insertion of orthodontic archwires and separators. However, due to the low quality of the studies, they advised to interpret the results with caution. Our study, due to time limitations, only explores new studies. One of the reasons why meta-analysis is difficult to perform in these studies is firstly the poor quality of human studies, and secondly, different radiation protocols and different types of lasers [65].

In, Maheshvari et al. reviewed a recent approach to pain control in orthodontic treatment. The LLLT was studied in addition to the methods used, and only three LLLT studies were investigated [66]. He and his colleagues in 2013 conducted a review of the effect of LLLT on orthodontic pain management. They only introduced Rct, quasi-rct, andcct (controlled clinical trial) orthodontic studies. They eventually included 4 RCTs, including 1 split mouth study and 3 parallel-design studies. They concluded that LLLT was successful in reducing the incidence of pain, but due to its heterozygosity and bias risk problems, studies recommended higher quality RCT research [67]. Keane et al., In 2017, conducted a study to compare non-pharmacological interventions with pharmacological studies in reducing orthodontic pain. They concluded that no non-pharmacologic method was effective as pharmacological methods, but some methods, such as cold laser therapy, were promising, but pharmacological standards would remain gold standard until high-quality studies are conducted [68].

Farsaii et al., In 2017, reviewed the effect of LLLT on accelerating tooth movement, preventing orthodontic relapse and altering acute orthodontic pain. They found 13 studies in the field of pain control. 10 RCT and 3 CCT studies that had different orthodontic therapies, including separator placement. The most common method was VAS pain relief and NRS was used in three studies. They concluded that the quality of evidence regarding the effect of LLLT on accelerating tooth movement and acute pain control are very low and low, respectively [69]. Fleming et al. Reviewed the non-pharmacological accelerated movement of the teeth in 2016. They only introduced RCT studies.

They introduced 7 studies into their meta-analysis. They finally concluded that there was no reliable data on the non-pharmacological methods of pain management in orthodontics, and only a small number of low-quality evidence studies found that LLLT in the short term could reduce orthodontic pain [70]. In 2018, Fleming et al. Conducted a study on the effects of non-pharmacological subsidiary methods and their effect on patient collaboration. In the context of LLLT, they examined two studies and concluded that there was a low quality of evidence that the use of LLLT reduced the pain by the VAS criteria at 6, 24, and 3 days, and one week after the placement of the appliance [71]. Li and colleagues in 2014 conducted a review on the relationship between LLLT and orthodontic pain. They only included RCT studies. They entered 11 studies and finally concluded that there was a lack of evidence regarding the effect of LLLT on reducing orthodontic pain, but stated that LLLT is the most promising way to reduce orthodontic pain at present [72].

Ren et al in 2015 conducted a study on the effect of LLLT on orthodontic pain control. They only introduced Rct studies into their research. They entered 14 studies, and concluded that there was not enough evidence to confirm or reject the effect of low-power diode lasers in pain management. In spite of numerous methodological and heterozygosity problems, diode laser showed advantages in reducing the prevalence and early termination of orthodontic pain. Also, the diode laser was shown to be effective on reduction of pain severity [73]. Sonesson et al., In 2017, conducted a study to investigate the effect of LLLT on accelerated dental movement, relapse prevention, and management of acute orthodontic treatment pain. On the effect of LLLT, they obtained 13 studies (10 rct and 3 cct). From these studies, 11 studies did not find any significant differences and 2 did not find any differences. They concluded that the quality of current evidence about the effect of LLLT on reducing orthodontic pain was low [74].

Sandhu et al. In 2016 conducted a study to compare the effects of pharmacological and non-pharmacological methods of pain relief on maximal intensity of orthodontic pain. They took 24 rctstudies into their research. They finally concluded that laser and analgesics have been recognized as the most effective methods for reducing the maximum intensity of orthodontic pain. Among the lasers, the super pulse laser was more effective than continuous pulse due to the greater penetration depth in the tissue, although they used only three studies in the case of lasers [75]. Our study, similar to the studies mentioned above, found positive effects of LLLT in reducing pain based on the latest evidence. Diversity in interventions and even the manner in which an intervention is conducted does not allow certain conclusions as mentioned in the above studies. Most studies may be conducted due to convenience and less time spent on the Separator placement. In some studies with Split-mouth design, systemic LLLT effects may also be interfering and reduce the accuracy of the study.

Conclusion

Our findings Demonstrate effectiveness of LLLT on pain control in different studies. Although the current study performed as a narrative review and it's not possible to find definite result.

Suggestions

According to our findings, LLLT could be a useful way for management of orthodontics induced pains. In order to find and prove the definite way further studies are necessary. Studies including meta-analysis or praleel designed Randomized clinical trial.

Conflict of Interest

There is no conflict of interest to declare.

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