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ORIGINAL ARTICLE

Low-level laser therapy (830 nm) on orthodontic pain: blinded randomized clinical trial

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Abstract

The objective of this research was to compare the effect single low-level laser therapy (LLLT) irradiation on pain perception in patients having fixed appliance treatment in the clinic of orthodontics. Sixty-two patients were recruited to participate in this randomized, double-blinded, placebo-controlled study. The patients were assigned to four groups: group I—laser on the right side; group II—placebo on the right side; group III—laser on the left side; group IV—placebo on the left. The laser or placebo was applied before separation, 24 and 48 h after separation of their first permanent molars in the lower arch. Just after the separation, the average of the pain for the placebo group was 1.6, significantly greater than the average of 1.1 registered for the laser group ($p = 0.013$). After 24 h and before the new irradiation, the values registered among the different groups did not show any differences. In relation to the gender, only after the first irradiation in placebo group, the female had a level of pain (0.1) significantly higher ($p = 0.04$) compared to male, and after 48 h, the group where the laser was applied had a difference ($p = 0.04$) among the gender with a value of lower pain for men (0.6) than for women (1.6).

The laser irradiation to minimize the pain was only effective when applied immediately after treatment and separation. In general way, there were no differences between the genders, except after the first placebo group irradiation in which the female had a significantly higher level of pain compared to male and after 48 h. The pain cycle observed in this study had its peak in 24 h, both for laser's and placebo's group.

Keywords LLLT · Laser therapy · Facial pain · Orthodontic

Introduction

Approximately 95% of patients report pain 24 h after their orthodontic appointments [1, 2]. The pain felt by patients can be characterized as a short-time acute pain, which lasts up to 6–7 days and peaks around 24 h [1, 3–6]. Pain is important because it discourages people from seeking orthodontic treatment [7]. Pain can also cause patients to interrupt their treatments, even at the beginning of treatment [8, 9].

Different pharmacological and non-pharmacological methods have been proposed in order to enhance the control of orthodontic pain [6, 10–18]. Low-level laser therapy (LLLT) is one of the newer approaches proposed to control pain [19]. Lasers have been used in the medical and dental areas as an alternative to control pain [20–22]. They hold promise in controlling orthodontic pain because lasers do not have the side effect of the non-steroidal anti-inflammatory drugs. Lasers are thought to control pain by hyperpolarization of the nerve cell membrane, which increases the patient's pain threshold, coupled with the lowest cell depolarization, among other factors [23].

Even though lasers hold potential for the treatment of pain, they remain controversial. There are only a few papers pertaining to the subject and their results. While two

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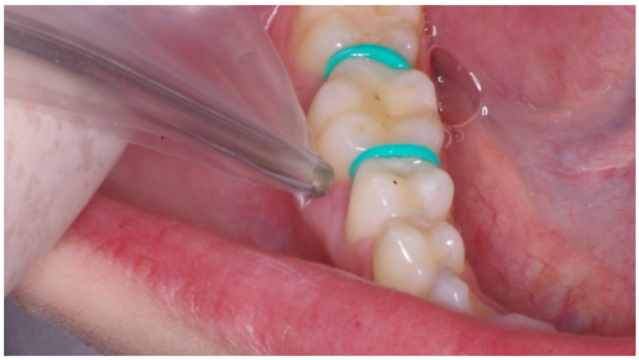

Fig. 1 Laser application in the molar region

papers describe lasers as ineffective tools for controlling pain [19, 24], most studies have reported reductions of pain [25–29]. Because there are several kinds of lasers with different dosages, wavelengths, and power, comparisons are difficult. The four studies that have used true placebos and a visual analog scale (VAS) [19, 28, 29] also remain controversial.

The aim of this paper was to evaluate the ability of a low-level laser in diminishing orthodontic pain, using a double-blind, split-mouth randomized clinical trial, using a VAS.

Materials and methods

This sample consisted of 62 patients (26 males and 36 females with an average age of 19.8 years) who were about to begin orthodontic treatment. All of them provided informed consent, which was approved by the University's IRB (protocol number 23/10 FOAr-UNESP).

In order to access pain, orthodontic separators were placed on the mesial and distal interproximal spaces of the first lower permanent molars. Since applying separator to both sides at the same time could confound patient's sensitivity and confound the results, the separators were placed 1 week apart (Fig. 1 and Table 1). One week was needed in order to ensure that no underling pain existed from one separation placement to the other.

In order to control for bias, patients were given one of four protocols, according to which treatment was given first and what side was treated first (Table 1). One group of patients had separators placed and the laser applied on their right lower first molars and 1 week later, separators were placed on their left side and placebo laser treatment was applied (protocol 1). In the second group, the placebo was applied first on the right side and the laser was applied on the left side 1 week later (protocol 2). In the third and fourth groups, the same respective procedures were performed as in the first two groups, but the left side was experimented first (protocols 3 and 4). The data from the four groups were merged and grouped as LASER or PLACEBO. The combination of initial and 1 week treatment time points was performed because there were no significant differences detected between sides over time (Table 2).

Both the laser and the placebo treatments were applied by the same device, which was custom made for this research (Therpapy XT—DMC Equipamentos, São Carlos, SP, Brazil). The operator, by turning on or off a switch on the device, could apply either laser or only a light, and the sound that came out on the device was always the same. The laser and the placebo lights were red (guide light) and only the operator knew whether the laser or the placebo light had been applied.

The laser used was a gallium-aluminum-arsenide diode, applied continuously, with a wavelength of 830 nm and the tip's area is 0.03 cm^2. The device was set to a power of 100 mW, producing 3 J of energy and a power density of 95 J/cm^2. The application on each group was realized in different times (laser and placebo), because of the possible systemic effect that the laser might have done on the placebo's group.

The laser was applied perpendicular to and in contact with the gingiva at eight locations on either side of the separators: two mesial and two distal interproximally on the buccal side and two mesial and two distal of the lingual side. Each application took 30 s, producing a total of 24 J of energy per molar. Applications were performed immediately before and after the separators were placed, as well as 24 and 48 h after the separators were placed (Fig. 2).

Pain was evaluated using a visual analog scale (VAS) at seven different time points once and 1 week later switching the side of treatment: 1 and 8—before the first application, 2 and 9—immediately after the application, 3 and 10—after the separators were placed, 4 and 11—24 h after separator placement, but before laser application, 5 and 12—24 h after separator and laser application, 6 and 13—48 h afterwards, before

Table 1 Distribution of application of laser or placebo for bias control

Protocol	First experimented side (treatment)	Second experimented side (treatment)
1	Right (laser)	Left (placebo)
2	Right (placebo)	Left (laser)
3	Left (laser)	Right (placebo)
4	Left (placebo)	Right (laser)

Table 2 VAS average scores and standard deviations for both groups and significance level

	Time period	Placebo	Laser	*p*
Initial	Before treatment	0.0* (0.0)	0.0* (0.0)	a
	After treatment	0.1* (0.2)	0.0* (0.1)	0.182
	After separators were placed	1.6 (1.5)	1.1 (1.3)	0.013
24 h	Before treatment	2.6 (2.2)	2.2 (2.2)	0.133
	After treatment	1.8 (2.0)	1.6 (1.8)	0.351
48 h	Before treatment	1.2 (1.6)	1.2 (1.8)	0.834
	After treatment	1.1 (1.4)	0.8 (1.4)	0.132

*Insignificant values

[a] *p* value could not be computed

laser application, and 7 and 14—48 h after separator and laser application (Table 2). The VAS ranged from 0 to 10, with zero representing "no pain at all" and 10 representing "the greatest pain they ever felt."

The data collected for laser and placebo sides were grouped and paired and the values were blinded to whom analyzed the data. The SPSS software v.16.0 (Chicago, IL, EUA) was used for statistical analysis. Since the data presented normality, a paired *t* test was used with significance (0.01) to compare the VAS values of the experimental sides to the placebo sides.

Results

Before and after the treatment was applied, the average VAS scores for both the laser and placebo groups were insignificant. After the separators were placed, the VAS scores were significantly ($p = 0.013$) higher in the placebo (1.6) group than in the laser (1.1) group (Table 3).

After 24 h, and before the new treatment, the VAS scores averaged 2.6 and 2.2 for the placebo and laser groups, respectively, with no statistically significant ($p = 0.133$) group differences. After the treatment, pain levels decreased to 1.8 in the placebo group and 1.6 in the laser group, again with no significant ($p = 0.351$) group differences (Table 2).

After 48 h and before the last treatment, VAS scores dropped to 1.2 in both groups ($p = 0.834$). After treatment, VAS scores had a further drop to 1.1 in the placebo group and to 0.8 in the laser group, with no significant ($p = 0.0132$) difference between them (Table 2).

Discussion

The laser was effective in diminishing pain, but only immediately after the separators were initially placed, suggesting a limited effect. The studies that have found that laser therapy decreases [25–31] or does not decrease [19, 24, 32] pain are difficult to directly compare with the present results. Among the four studies that used a VAS and true placebo controls, two detected significant laser effects on pain agreeing with our results [28, 29], while the remaining reported no treatment effect [19, 24, 32, 33]. The differences among the studies are probably due to the different power, energy, and wavelength settings used (Table 3) [19, 29]. One study evaluating different dosages reported no differences [19]. More research is required with different designs to determine the best protocol to use the laser.

Since our application was before the placement of separators, maybe there is a preemptive effect of infrared lasers on pain that has yet to be confirmed. The bioelectric effect of laser modifying the membrane potential due to changes in the sodium and potassium channels may explain this effect. Hyperpolarization of the membrane hinders depolarization and thus increases the patient's pain threshold, decreasing

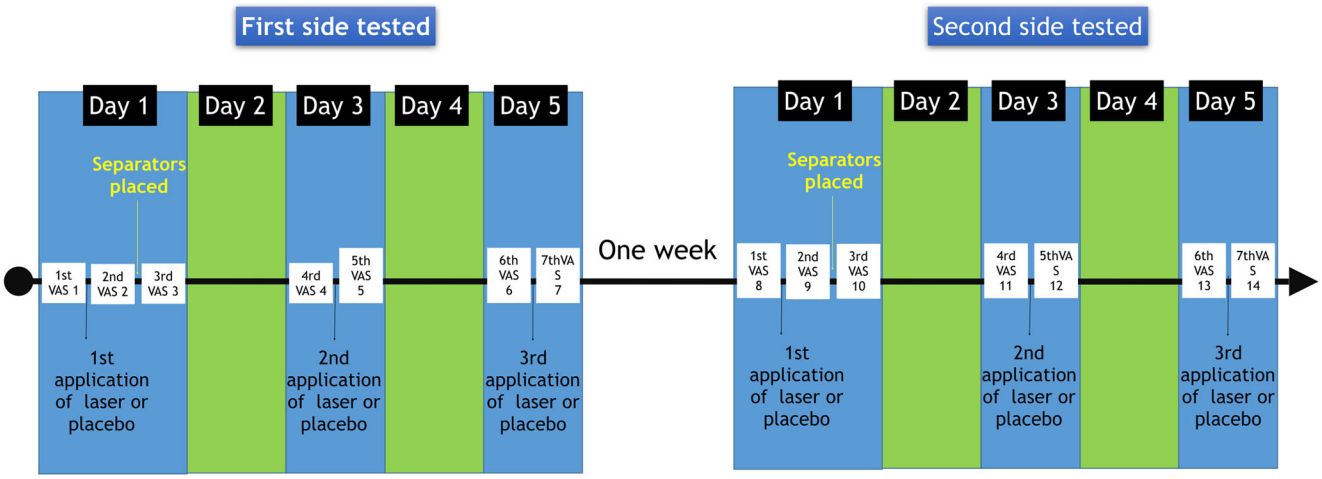

Fig. 2 Research design—laser application, insertion of retractors, and data collection

Table 3 Calculation were made for the analgesic effect only whenever the study has subsequent applications but not pain registration

Paper	Laser type	Wavelength (nm)	Energy per application (J)	Total energy per tooth per day (J)	Applications	Dosage	VAS	Split-mouth placebo	Result
Harazaki and Isshiki	He-Ne	632.8	0.18	0.36	Immediate	6 mW/30 s	No	No	Reduction of pain was found*
Harazaki et al.	He-Ne	632.8	0.18	0.36	Immediate	6 mW/30 s	No	No	Significant effect
Angelieri et al.	Al-Ga-As	780	0.2	2	Immediate and at 3rd day	20 mW/10 s	Yes	Yes	No effect
Turhani et al.	In-Ga-Al-P	670	2.25	2.25	Immediate	75 mW/30 s	Yes	No	Significant effect
Doshi-Mehta and Bhad-Patil	Al-Ga-As	810	0.021	0.042	Immediate, at 2nd and 3rd days	0.7 mW/30 s	Yes	Yes	Significant effect**
Youssef et al.	Al-Ga-As	809	1 or 2	8	Immediate, at 3, 7, and 14 days after each activation	100 mW/10 and 20 s	No	Yes	Significant effect
Fujiyama et al.	CO2	–	60	120	Immediate	2000 mW/30 s	Yes	Yes	Significant effect
Tortamano et al.	Al-Ga-As	830	0.48	4.8	Immediate	30 mW/16 s	Yes	Yes	Significant effect
Lim et al.	Al-Ga-As	830	0.45, 0.9, and 1.8	0.45, 0.9, and 1.8	Immediate through the 5th day	30 mW/15, 30, and 60 s	Yes	Yes	No effect

*Descriptive statistics only

**Considered up to the third day (dosage changed after that)

sensitivity [11]. No research has moved towards that direction, and maybe after the most effective dosages are found, a research evaluating regimen of application might be necessary.

The literature clearly shows a difference of laser parameters in the treatments for pain and orthodontic movement [10, 11, 13, 29, 33–35]. In the treatment of pain, both potency and higher doses have presented better results. On the other hand, when compared to the treatments of orthodontic movement, the parameters with better results are of potencies and lower doses with more frequency of applications. The bioelectric effect described above explains one of the main mechanisms of action of the laser in the control of pain [10, 11, 13, 35]. In orthodontic movement, the stimulations to cellular metabolism, angiogenesis, cell proliferation, and fibronectin are the events stimulated by the LLLT that explain the acceleration [29, 33, 34].

The cycle of pain observed in this study had its peak around 24 h, and the pain values decreased afterwards, in both groups. This cycle of pain is in agreement with the one reported by the literature [3–5, 10, 19], where after the second day, the pain slowly decreases and is minimal after the sixth day [5, 6, 11, 13]. Moreover, an interesting placebo effect was detected, since after the application of the laser or the placebo light, the VAS scores decreased.

In our methodology, we included the comparative groups placebo, and laser treatment. This methodology truly evaluates the effect of 830 nm on controlling pain. The results showed a significant initial effect of the decrease of the pain of the laser group in comparison placebo. This fact may stimulate orthodontists to at least apply laser before insertion of the spacers. After the initial time, what may explain the non-difference between the laser group and placebo is the patient's difficulty in reporting specifically where they feel the pain, since the sensation of pain can be radiated. In addition, each patient presents a different degree and tolerance for pain, making it difficult to homogenize the responses [24, 32, 34, 35]. However, we have been able to clinically present a pain control effect with the therapeutic laser in the preparation of the teeth to receive orthodontic treatment. The benefit of this treatment can help many patients as well as decrease the use of painkiller-based and anti-inflammatory drugs that are used in some cases.

Conclusions

According to the results found in this research, we can conclude the following:

– Laser application was effective in diminishing orthodontic pain immediately after separation of the first molars.

– The cycle of pain observed for both the placebo and experimental group was similar, with the peak to pain in 24 h.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Protocol 23/10 FOAr/UNESP

References

1. Ngan P, Kess B, Wilson S (1989) Perception of discomfort by patients undergoing orthodontic treatment. Am J Orthod Dentofac Orthop 96(1):47–53
2. Scheurer PA, Firestone AR, Burgin WB (1996) Perception of pain as a result of orthodontic treatment with fixed appliances. Eur J Orthod 18(4):349–357
3. Jones M, Chan C (1992) The pain and discomfort experienced during orthodontic treatment: a randomized controlled clinical trial of two initial aligning arch wires. Am J Orthod Dentofac Orthop 102(4):373–381
4. Bergius M, Berggren U, Kiliaridis S (2002) Experience of pain during an orthodontic procedure. Eur J Oral Sci 110(2):92–98
5. Erdinc AM, Dincer B (2004) Perception of pain during orthodontic treatment with fixed appliances. Eur J Orthod 26(1):79–85
6. Polat O, Karaman AI (2005) Pain control during fixed orthodontic appliance therapy. Angle Orthod 75(2):214–219. https://doi.org/10.1043/0003-3219(2005)075<0210:PCDFOA>2.0.CO;2
7. Oliver RG, Knapman YM (1985) Attitudes to orthodontic treatment. Br J Orthod 12(4):179–188
8. Haynes S (1974) Discontinuation of orthodontic treatment relative to patient age. J Dent 2(4):138–142
9. Brown DF, Moerenhout RG (1991) The pain experience and psychological adjustment to orthodontic treatment of preadolescents, adolescents, and adults. Am J Orthod Dentofac Orthop 100(4):349–356. https://doi.org/10.1016/0889-5406(91)70073-6
10. Yamasaki K, Shibata Y, Imai S, Tani Y, Shibasaki Y, Fukuhara T (1984) Clinical application of prostaglandin E1 (PGE1) upon orthodontic tooth movement. Am J Orthod 85(6):508–518
11. Roth PM, Thrash WJ (1986) Effect of transcutaneous electrical nerve stimulation for controlling pain associated with orthodontic tooth movement. Am J Orthod Dentofac Orthop 90(2):132–138
12. Kehoe MJ, Cohen SM, Zarrinnia K, Cowan A (1996) The effect of acetaminophen, ibuprofen, and misoprostol on prostaglandin E2 synthesis and the degree and rate of orthodontic tooth movement. Angle Orthod 66(5):339–349. https://doi.org/10.1043/0003-3219(1996)066<0339:TEOAIA>2.3.CO;2
13. Bergius M, Kiliaridis S, Berggren U (2000) Pain in orthodontics. A review and discussion of the literature. J Orofac Orthop 61(2):125–137
14. Steen Law SL, Southard KA, Law AS, Logan HL, Jakobsen JR (2000) An evaluation of preoperative ibuprofen for treatment of pain associated with orthodontic separator placement. Am J Orthod Dentofac Orthop 118(6):629–635. https://doi.org/10.1067/mod.2000.110638
15. Kluemper GT, Hiser DG, Rayens MK, Jay MJ (2002) Efficacy of a wax containing benzocaine in the relief of oral mucosal pain caused by orthodontic appliances. Am J Orthod Dentofac Orthop 122(4):359–365
16. Polat O, Karaman AI, Durmus E (2005) Effects of preoperative ibuprofen and naproxen sodium on orthodontic pain. Angle Orthod 75(5):791–796. https://doi.org/10.1043/0003-3219(2005)75[791:EOPIAN]2.0.CO;2
17. Young AN, Taylor RW, Taylor SE, Linnebur SA, Buschang PH (2006) Evaluation of preemptive valdecoxib therapy on initial archwire placement discomfort in adults. Angle Orthod 76(2):251–259. https://doi.org/10.1043/0003-3219(2006)076[0251:EOPVTO]2.0.CO;2
18. Bradley RL, Ellis PE, Thomas P, Bellis H, Ireland AJ, Sandy JR (2007) A randomized clinical trial comparing the efficacy of ibuprofen and paracetamol in the control of orthodontic pain. Am J Orthod Dentofac Orthop 132(4):511–517. https://doi.org/10.1016/j.ajodo.2006.12.009
19. Lim HM, Lew KK, Tay DK (1995) A clinical investigation of the efficacy of low level laser therapy in reducing orthodontic postadjustment pain. Am J Orthod Dentofac Orthop 108(6):614–622
20. Topolski F, Moro A, Correr GM, Schimim SC (2018) Optimal management of orthodontic pain. J Pain Res 11:589–598. https://doi.org/10.2147/JPR.S127945
21. Deana NF, Zaror C, Sandoval P, Alves N (2017) Effectiveness of low-level laser therapy in reducing orthodontic pain: a systematic review and meta-analysis. Pain Res Manag 2017:8560652. https://doi.org/10.1155/2017/8560652
22. Cetiner S, Kahraman SA, Yucetas S (2006) Evaluation of low-level laser therapy in the treatment of temporomandibular disorders. Photomed Laser Surg 24(5):637–641. https://doi.org/10.1089/pho.2006.24.637
23. Sun G, Tuner J (2004) Low-level laser therapy in dentistry. Dent Clin N Am 48 (4):1061–1076, viii. doi:https://doi.org/10.1016/j.cden.2004.05.004
24. Farsaii A, Al-Jewair T (2017) Insufficient evidence supports the use of low-level laser therapy to accelerate tooth movement, prevent orthodontic relapse, and modulate acute pain during orthodontic treatment. J Evid Based Dent Pract 17(3):262–264. https://doi.org/10.1016/j.jebdp.2017.06.008
25. Turhani D, Scheriau M, Kapral D, Benesch T, Jonke E, Bantleon HP (2006) Pain relief by single low-level laser irradiation in orthodontic patients undergoing fixed appliance therapy. Am J Orthod Dentofac Orthop 130(3):371–377. https://doi.org/10.1016/j.ajodo.2005.04.036
26. Fujiyama K, Deguchi T, Murakami T, Fujii A, Kushima K, Takano-Yamamoto T (2008) Clinical effect of CO(2) laser in reducing pain in orthodontics. Angle Orthod 78(2):299–303. https://doi.org/10.2319/033007-153.1
27. Youssef M, Ashkar S, Hamade E, Gutknecht N, Lampert F, Mir M (2008) The effect of low-level laser therapy during orthodontic movement: a preliminary study. Lasers Med Sci 23(1):27–33. https://doi.org/10.1007/s10103-007-0449-7
28. Tortamano A, Lenzi DC, Haddad AC, Bottino MC, Dominguez GC, Vigorito JW (2009) Low-level laser therapy for pain caused by placement of the first orthodontic archwire: a randomized clinical trial. Am J Orthod Dentofac Orthop 136(5):662–667. https://doi.org/10.1016/j.ajodo.2008.06.028
29. Doshi-Mehta G, Bhad-Patil WA (2012) Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: a clinical investigation. Am J Orthod Dentofac Orthop 141(3):289–297. https://doi.org/10.1016/j.ajodo.2011.09.009
30. Harazaki M, Isshiki Y (1997) Soft laser irradiation effects on pain reduction in orthodontic treatment. Bull Tokyo Dent Coll 38(4):291–295

31. Harazaki M, Takahashi H, Ito A, Isshiki Y (1998) Soft laser irradiation induced pain reduction in orthodontic treatment. Bull Tokyo Dent Coll 39(2):95–101
32. Ren C, McGrath C, Yang Y (2015) The effectiveness of low-level diode laser therapy on orthodontic pain management: a systematic review and meta-analysis. Lasers Med Sci 30(7):1881–1893. https://doi.org/10.1007/s10103-015-1743-4
33. Sonesson M, De Geer E, Subraian J, Petren S (2016) Efficacy of low-level laser therapy in accelerating tooth movement, preventing relapse and managing acute pain during orthodontic treatment in humans: a systematic review. BMC Oral Health 17(1):11. https://doi.org/10.1186/s12903-016-0242-8
34. Sousa MV, Pinzan A, Consolaro A, Henriques JF, de Freitas MR (2014) Systematic literature review: influence of low-level laser on orthodontic movement and pain control in humans. Photomed Laser Surg 32(11):592–599. https://doi.org/10.1089/pho.2014.3789
35. Li FJ, Zhang JY, Zeng XT, Guo Y (2015) Low-level laser therapy for orthodontic pain: a systematic review. Lasers Med Sci 30(6):1789–1803. https://doi.org/10.1007/s10103-014-1661-x