

Effect of Low-Level Laser Therapy on Pain Following Activation of Orthodontic Final Archwires: A Randomized Controlled Clinical Trial

Angela Domínguez, DDS, and Sergio A. Velásquez, DDS

Abstract

Objective: The purpose of this study was to evaluate the efficacy of GaAlAs laser light to reduce pain induced by post-adjustment orthodontic final archwire, compared with a placebo control group, and also to evaluate if there are differences in pain gradient when conventional brackets or self-ligating brackets are used for orthodontic treatment. **Background data:** Previous reports indicate that laser therapy is a safe and efficient alternative to alleviate pain caused in the initial stages of treatment, but there are no studies about its efficacy during the last stages of orthodontic treatment. **Methods:** The initial sample was 60 orthodontic patients from a private practice, treated by straight wire technique, 30 of them with mini brackets Equilibrium® (Dentaurum, Ispringen, Germany) and 30 with self-ligation In-Ovation C® (GAC/Dentsply, Tokyo, Japan) slot 0.022 inch brackets. The archwires used in the final stage of orthodontic treatment were stainless steel 0.019 × 0.025 inch, slot 0.022 inch in both groups. In a design of divided mouth, the dental arches were randomly assigned to receive one dental arch irradiation with 830 nm 100mW therapeutic laser (Photon Lase II), for 22 sec (2.2 J, 80 J/cm²) along the vestibular surface and 22 sec (2.2 J, 80 J/cm²) along the palatal surface of the root in the randomly selected arch. The opposite dental arch received placebo treatment, with the laser light off. Pain was evaluated using a visual analog scale (VAS) after 2, 6, and 24 h, and 2, 3, and 7 days of application. **Results:** The time course of pain showed the same tendency in both groups, reaching a peak 24 h after the archwire activation. The application of laser therapy reduced pain for any period of time up to 7 days ($p < 0.00001$) and for any kind of bracket. **Conclusions:** Low intensity laser application reduces pain induced by archwires used during the final stage of orthodontic treatment, without any interference regarding the kind of bracket, as reported by patients.

Introduction

PAIN IS DEFINED as an unpleasant sensation physically located in any part of the body, caused by excitation of sensitive nervous fibers with varying degrees of severity. Pain is difficult to evaluate, as it has subjective components, but it is usually reported by the patients and considered in scientific literature as a relevant factor in determining the patient's decision to continue or not continue orthodontic treatment.^{1–6} O'Connor et al. reported in 2000⁷ that pain during treatment is the fourth most frequent reason for fear and apprehension in patients initiating any orthodontic treatment. Pain is a subjective response that depends upon many factors including age, gender, individual threshold, level of tolerance, emotional status, stress, cultural differences, and previous pain experiences.^{8–11}

For a long time, orthodontists have been studying many alternatives to treat pain induced by orthodontic treatment,¹²

including the use of ibuprofen, naproxen,^{13–15} chewing gum,¹⁶ topical anti-inflammatory medications,¹⁷ acetaminophen,¹⁸ transcutaneous electric stimulation,¹⁹ valdecoxib,²⁰ acupuncture,²¹ acetyl salicylic acid, rofecoxib,²² and, more recently, by application of laser therapy. A systematic review by Xiaoting et al.²³ evaluated the results of different approaches to pain control in orthodontics.

Previous reports indicate that laser therapy is a safe and efficient alternative, not only to increase the rate of orthodontic movement in humans,^{24–28} but also to alleviate pain caused by the application of separators^{29,30} in the initial stages of treatment^{31,32} and during canine retraction.^{26–28} but there are no studies about its efficacy during the last stages of orthodontic treatment. Therefore, the purpose of this clinical study, randomized and controlled, was to evaluate the efficacy of GaAlAs laser light to reduce pain induced by post-adjustment orthodontic final archwire, compared with a placebo control group, and also to evaluate if there are

differences in pain gradient when conventional brackets or self-ligating brackets are used for orthodontic treatment.

Methods

The study was designed as a clinical intervention: mouth-divided, randomly assigned, and with a placebo control group. Sixty patients from private practice were included in the study. The size of the sample was defined following a previous study published by us.²⁵

Thirty patients were treated by straight-wire technique with Equilibrium[®] brackets (Dentaurum, Ispringen, Germany) and 30 with In-Ovation C[®] (GAC/Dentsply, Tokyo, Japan) self-ligating brackets.

The inclusion criteria were:

- Age 20–30 years when the treatment was initiated
- Crowding up to 5 mm (measured by Little's irregularity index)
- Treatment without premolar extraction
- Periodontal and systemic healthy patients
- Willing to participate in the study as documented by signature of an informed consent
- Same socioeconomical group

The exclusion criteria were:

- Use of any medication (including analgesics) during this stage of the orthodontic treatment
- Pregnancy

All the brackets were bonded with Transbond XT[®] resin (Unitek, Monrovia, CA).

Ethical considerations

According to the research risk categories established by the Colombian Ministry of Health Resolution 008430 from 1993, the present study was classified as having a risk higher than minimum, and it was approved by the Institutional Ethics Committee Universidad del Valle, Cali, Colombia under Act 09–011.

Irradiation protocol

The 60 patients were randomly assigned to each bracket group and regarding which dental arch was to be irradiated. The randomization procedure was performed using a computer program (www.random.org).

During the visit scheduled to place the final archwires, either the upper or the lower dental arch was irradiated with the equipment Photon Lase II[®] (GaAlAs laser) (DMC Equipamentos, Sao Carlos, Brazil) at a wavelength of 830 nm, 100 mW, for 22 sec (80 J/cm², 2.2 J) along the vestibular surface and 22 sec (80 J/cm², 2.2 J) along the palatal surface of the root in the randomly selected arch. The spot size of the laser beam was 600 μ m, scanned 1 mm from the mucosa in the randomly selected arch. The opposite dental arch was placebo treated for the same period of time, with the laser off. All the applications and orthodontic treatments were performed by the same operator, strictly following the scheduled randomization.

Visual analog scale

All the patients were asked to mark in a 100 mm pain scale, the estimated pain felt, after 2 h (T1), 6 h (T2), 24 h (T3), 2 days (T4), 3 days (T5), and 7 days (T6), separately for each

dental arch (one of them was actively irradiated), marking every correspondent scale without spacing time between each other. The distance from zero to the mark was measured in millimeters using a digital caliper Bake SND-10 by one operator blind to the group assignment of the patients. All measurements were taken by a blinded analyst.

Statistical analysis

The results obtained in millimeters in the visual analog scale (VAS) were initially analyzed to evaluate normality of distribution. As the distribution was normal and the variances were homogeneous, the multiple comparison of averages was made by the Bonferroni test, at a significance level $p=0.01$. Using the software SPSS version 2010 for Windows.

Results

The final sample was of 30 patients for the group of Equilibrium[®] brackets and 29 for the group of In-Ovation C[®] brackets, because 1 patient in this group did not register complete results on the VAS.

The age in the In-Ovation C[®] group was 24.3 ± 3.2 years and in the Equilibrium[®] group it was 24.3 ± 3.1 years. The gender distribution was 18 women and 11 men in the In-Ovation C[®] group and 22 women and 8 men in the Equilibrium[®] group. These differences are not significant, as is expected when the randomization process is correctly implemented.

The results expressed as average \pm standard deviation for pain in mm, per group and time (2, 6, and 24 h and 2, 3, and 7 days, converted to hours to have a constant x-axis scale) are presented in Table 1.

The maximum pain occurred 24 h after activation, 3.26 ± 0.36 mm in the dental arch receiving laser irradiation; 6.96 ± 0.31 mm in the non-irradiated dental arch for the In-Ovation C[®] bracket group and 3.24 ± 0.35 mm in the dental arch receiving laser irradiation; and 6.91 ± 0.37 mm in the non-irradiated dental arch for the Equilibrium[®] bracket group.

Statistical analysis result is summarized in Tables 2 and 3. The difference of average pain between bracket groups is not significant ($p > 0.05$) whereas the average difference between

TABLE 1. MEAN PAIN SCORES IN MM AND STANDARD DEVIATIONS OF THE EXPERIMENTAL AND PLACEBO CONTROLLED GROUPS

		In Ovation C [®]		Equilibrium [®]	
		Laser	PCG	Laser	PCG
2 h	Mean	1.25	3.62	1.3	3.64
	\pm SD	0.227	0.358	0.2	0.332
6 h	Mean	2.38	5.31	2.34	5.3
	\pm SD	0.286	0.326	0.254	0.339
24 h	Mean	3.26	6.96	3.24	6.91
	\pm SD	0.368	0.315	0.356	0.379
2 days	Mean	2.74	6.28	2.74	6.27
	\pm SD	0.176	0.286	0.161	0.293
3 days	Mean	1.98	4.85	2	4.85
	\pm SD	0.487	0.431	0.5	0.42
7 days	Mean	0.62	2.1	0.95	2.23
	\pm SD	0.523	0.55	0.411	0.436

PCG, placebo controlled groups.

TABLE 2. BONFERRONI TEST COMPARISONS BETWEEN LASER AND PLACEBO CONTROLLED GROUPS

In-Ovation C [®] Brackets-laser vs. PCG	2 h	<0.00001
	6 h	<0.00001
	24 h	<0.00001
	2 days	<0.00001
	3 days	<0.00001
	7 days	<0.00001
Equilibrium [®] Brackets-laser vs. PCG	2 h	<0.00001
	6 h	<0.00001
	24 h	<0.00001
	2 h	<0.00001
	3 days	<0.00001
	7 days	<0.00001

PCG, placebo controlled groups.

active and placebo control groups with laser treatment is significant ($p < 0.00001$).

Discussion

The VAS is a reliable method to show differences in pain reported by patients, not only during orthodontic treatments but in many other research scenarios.^{33–35}

Studies on orthodontic pain tend to evaluate pain for varying periods of time, but the standard period of evaluation is extended to 7 days,^{9,14,36,37} and for the present study was considered relevant after short intervals as well as after a few days.

The peak of pain after placement of final archwires appears after 24 h, which is usually expected when brackets of stainless steel 0.019×0.025 inch with slot 0.022 inch are used.^{8,9,11,20} The time-related changes in pain observed in this study are similar to those reported in studies about the effect of analgesics, chewing gum, and soft and hard viscoelastic wafers on post-activation orthodontic pain.^{12,14,20,38}

The significant reduction of pain by laser irradiation obtained in the present study confirms the results of pain studies induced by separators,^{29,30} activation of initial archwires,³² and canine retraction.^{27,28}

A study that Rochkind et al.³⁹ made in rats that were exposed to a HeNe laser beam on the recovery of the injured peripheral and central nervous system, as well as healing of cutaneous wounds and burns, suggests a systemic effect

from laser applications; however, these effects depend on the frequency and the duration in time. In this study the effect of only one dose was evaluated, and a statistically significant difference was found between the irradiated arch and the non-irradiated arch, showing the laser analgesic effect, and no systemic effect that could influence the opposite arch.

In this study, an additional intention was to compare pain and its reduction by laser when the treatment was made using conventional brackets versus self-ligating brackets, considering that Miles et al.⁴⁰ had compared Damon 2[®] twin brackets versus conventional brackets, and they did not find a difference in pain either. Scott et al.⁴¹ also compared discomfort in 62 patients treated with conventional brackets (Synthesis) versus Damon 3[®] self-ligation brackets, and did not find significant difference in pain between these kinds of brackets. A similar result was obtained by Fleming et al.,⁴² comparing pain reported by patients treated with SmartClip[®] and Victory[®] (3M Unitek) brackets, and by Fleming and Johal in 2010,⁴³ in 160 patients, 83 treated with self-ligating brackets and 77 with conventional brackets, followed for 7 days. Hence, it appears from the present and other studies that the characteristics of brackets had no significant effect on subjective pain reported by the patients during the first week of active orthodontic treatment. The only results that are different to the above-mentioned reports are those of Pringle et al.,⁴⁴ who found fewer tendencies to pain in patients treated with Damon 3[®] brackets than in those treated with twin brackets.

So far, we are unaware of other studies that correlate pain with post-activation of the final orthodontic archwire. It is possible to integrate these results into previous reports in which low-intensity laser was applied for pain control in other stages of treatment. Then we might suggest that laser therapy is effective in reducing pain during all stages of orthodontic treatment.

Conclusions

The application of low-level laser therapy reduces pain induced during the final stage of orthodontic treatment when stainless steel archwires 0.019×0.025 inch are used, independently of the kind of bracket (either In-Ovation C[®] or Equilibrium[®]), on a 7-day follow-up schedule.

Acknowledgments

We thank Dr. Luis Rogelio Hernandez, Master of Science from the University of Southampton for his statistical analysis and the translation of this article.

Author Disclosure Statement

No competing financial interests exist.

References

1. Oliver, R.G., and Knapman, Y.M. (1985). Attitudes to orthodontic treatment. *Br. J. Orthod.* 12, 179–188.
2. Kluemper, G.T., Hiser, D.G., Rayens, M.K., and Jay, M.J. (2002). Efficacy of a wax containing benzocaine in the relief of oral mucosal pain caused by orthodontic appliances. *Am. J. Orthod. Dentofacial Orthop.* 122, 359–365.
3. Asham, A.A., and Southard, K.A. (2004). Orthodontic pain. *Am. J. Orthod. Dentofacial Orthop.* 125, 18a.

TABLE 3. BONFERRONI TEST COMPARISON BETWEEN BRACKETS GROUPS

Brackets In-Ovation C [®] vs. Equilibrium [®] -laser group	2 h	0.4
	6 h	0.61
	24 h	0.83
	48 h	0.85
	72 h	0.85
	168 h	0.85
In-Ovation C [®] vs. Equilibrium [®] -PCG	2 h	0.854
	6 h	0.874
	24 h	0.6
	48 h	0.873
	72 h	0.944
	168 h	0.32

PCG, placebo controlled group.

4. Keim, R.G. (2004). Managing orthodontic pain. *J. Clin. Orthod.* 38, 641–642.
5. Krishnan, V. (2007). Orthodontic pain: from causes to management — a review. *Eur. J. Orthod.* 29, 170–179.
6. Brown, D.F., and Moerenhout, R.G. (1991). The pain experience and psychological adjustments to orthodontic treatment of preadolescents, adolescents and adults. *Am. J. Orthod. Dentofacial Orthop.* 100, 349–356.
7. O'Connor, P.J. (2000). Patients' perceptions before, during, and after orthodontic treatment. *J. Clin. Orthod.* 34, 591–592.
8. Ngan, P., Kess, B., and Wilson, S. (1989). Perception of discomfort by patients undergoing orthodontic treatment. *Am. J. Orthod. Dentofacial Orthop.* 96, 47–53.
9. Scheurer, P.A., Firestone, A.R., and Bürgin, W.B. (1996). Perception of pain as a result of orthodontic treatment with fixed appliances. *Eur. J. Orthod.* 18, 349–357.
10. Firestone, A.R., Scheurer, P.A., and Bürgin, W.B. (1999). Patient's anticipation of pain and pain-related side effects, and their perception of pain as a result of orthodontic treatment with fixed appliances. *Eur. J. Orthod.* 21, 387–396.
11. Bergius, M., Kiliardis, S., and Berggren, U. (2000). Pain in orthodontics: a review and discussion of the literature. *J. Orofac Orthop.* 61, 125–137.
12. Polat, O., and Karaman, A.I. (2005). Pain control during fixed orthodontic appliance therapy. *Angle Orthod.* 75, 214–219.
13. Ngan, P., Wilson, S., Shanfeld, J., and Amini, H. (1994). The effect of ibuprofen on the level of discomfort in patients undergoing orthodontic treatment. *Am. J. Orthod. Dentofacial Orthop.* 106, 88–95.
14. Polat, O., Kararam, A.I., and Durmus, E. (2005). Effects of preoperative ibuprofen and naproxen sodium on orthodontic pain. *Angle Orthod.* 75, 791–796.
15. Steen Law, S.L., Southard K.A., Law, A.S., Logan, H.L., and Jakobsen, J.R. (2000). An evaluation of preoperative ibuprofen for treatment of pain associated with orthodontic separator placement. *Am. J. Orthod. Dentofacial Orthop.* 118, 629–633.
16. Mohri, Y., Fumoto, M., Sato-Suzuki, I., Umino, M., and Arita, H. (2005). Prolonged rhythmic gum chewing suppresses nociceptive response via serotonergic descending inhibitory pathway in humans. *Pain* 118, 35–42.
17. Pagaenelli, C. (1993). Pharmacological support during orthodontic therapy with a topical anti-inflammatory. *Minerva Stomatol.* 42, 271–274.
18. Roche, J.J., Cisneros, G.J., and Aes, G. (1997). The effect of acetaminophen on tooth movement in rabbits. *Angle Orthod.* 67, 231–236.
19. Roth, P.M., and Thrash, W.J. (1986). Effect of transcutaneous electrical nerve stimulation for controlling pain associated with orthodontic tooth movement. *Am. J. Orthod. Dentofacial Orthop.* 90, 132–138.
20. Young, A.N., Taylor, R.W., Taylor, S.E., Linnebur, S.E., and Buschang, P.H. (2006). Evaluation of preemptive valdecoxib therapy on initial archwire placement discomfort in adults. *Angle Orthod.* 76, 251–259.
21. Vachiramam, A., and Wang, W.C. (2005). Acupuncture and acupressure techniques for reducing orthodontic post-adjustment pain. *J. Contemp. Dent. Pract.* 6, 163–167.
22. Sari, E., Ölmez, H., and Gürton, A.V. (2004). Comparison of some effects of acetylsalicylic acid and rofecoxib during orthodontic tooth movement. *Am. J. Orthod. Dentofacial Orthop.* 125, 310–315.
23. Xiaoting, L., Yin, T., and Yangxi, C. (2010). Interventions for pain during fixed orthodontic appliance therapy. A systematic review. *Angle Orthod.* 80, 925–932.
24. Cruz, D.R., Kohara, E.K., Ribeiro, M.S., and Wetter, N.U. (2004). Effects of low-intensity laser therapy on the orthodontic movement velocity of human teeth: a preliminary study. *Lasers Surg. Med.* 35, 117–120.
25. Domínguez, A., and Velásquez, S. (2010). Acceleration effect of orthodontic movement by application of low-intensity laser. *Journal of Oral Laser Applications* 2, 99–105.
26. Sousa, M.V., Scanavini, M.A., Sannomiya, E.K., Velasco, L.G., and Angelieri, F. (2011). Influence of low-level laser on the speed of orthodontic movement. *Photomed. Laser Surg.* 29, 191–196.
27. Youssef, M., Ashkar, S., Hamade, E., Gutknecht, N., Lampert, F., and Mir, M. (2008). The effect of low-level laser therapy during orthodontic movement: a preliminary study. *Lasers Med. Sci.* 23, 27–33.
28. Doshi-Mehta, G., and Bhad-Patil, W.A. (2012). Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: a clinical investigation. *Am. J. Orthod. Dentofacial Orthop.* 141, 289–297.
29. Lim, H.M., Lew, K.K., and Tay, D.K. (1995). A clinical investigation of the efficacy of low level laser therapy in reducing orthodontic postadjustment pain. *Am. J. Orthod. Dentofacial Orthop.* 108, 614–622.
30. Fujiyama, K., Deguchi, T., Murakami, T., Fujii, A., Kushima, K., and Takano-Yamamoto, T. (2008). Clinical effect of CO(2) laser in reducing pain in orthodontics. *Angle Orthod.* 78, 299–303.
31. Turhani, D., Scheriau, M., Kapral, D., Benesch, T., Jonke, E., and Bantleon, H.P. (2006). Pain relief by single low-level laser irradiation in orthodontic patients undergoing fixed appliance therapy. *Am. J. Orthod. Dentofacial Orthop.* 130, 371–377.
32. Tortamano, A., Lenzi, D.C., Haddad, A.C., Bottino, M.C., Domínguez, G.C., and Vigorito, J.W. (2009). Low-level laser therapy for pain caused by placement of the first orthodontic archwire: a randomized clinical trial. *Am. J. Orthod. Dentofacial Orthop.* 136, 662–667.
33. Price, D.D., McGrat, P.A., Rafii, A., and Buckingham, B. (1983). The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. *Pain* 17, 45–56.
34. Wassell, R.W., Moufti, M.A., Meehan, J.G., Steen, I.N., and Steele, J.G. (2008). A method for clinically defining “improvers” in chronic pain studies. *J. Orofac. Pain* 22, 30–40.
35. Jones, M., and Chan, C. (1992). The pain and discomfort experienced during orthodontic treatment: a randomized controlled clinical trial of two initial aligning archwire. *Am. J. Orthod. Dentofacial Orthop.* 102, 373–381.
36. Otasevic, M., Naini, F.B., Gill, D.S., and Lee R.T. (2006). Prospective randomized clinical trial comparing the effects of a masticatory bite wafer and avoidance of hard food on pain associated with initial orthodontic tooth movement. *Am. J. Orthod. Dentofacial Orthop.* 130, 6.e9–15.
37. Murdock, S., Phillips, C., Khondker, Z., and Hershey, H.G. (2010). Treatment of pain after initial archwire placement: a noninferiority randomized clinical trial comparing over-the-counter analgesics and bite-wafer use. *Am. J. Orthod. Dentofacial Orthop.* 137, 316–323.
38. Farzanegan, F., Zebarjad, S.M., Alidades, S., and Ahrari, F. (2012). Pain reduction after initial archwire placement in orthodontic patients: a randomized clinical trial. *Am. J. Orthod. Dentofacial Orthop.* 141, 169–173.

39. Rochkind S., Rousso M., Nissan M., Villarreal M., Barr-Nea L., and Rees, D.G. (1989). Systemic effects of low-power laser irradiation on the peripheral and central nervous system, cutaneous wounds, and burns. *Lasers Surg. Med.* 9, 174–182.
40. Miles, P.G., Weyant, R.J., and Rustveld, L. (2006). A clinical trial of Damon 2 vs conventional twin brackets during initial alignment. *Angle Orthod.* 76, 480–485.
41. Scott, P., M. Sherriff, M., DiBiase, A.T., and Cobourne, M.T. (2008). Perception of discomfort during initial orthodontic tooth alignment using a self-ligating or conventional bracket system: a randomized clinical trial. *Eur. J. Orthod.* 30, 227–232.
42. Fleming, P.S., DiBiase, A.T., Sarri, G., and Lee, R.T. (2009). Pain experience during initial alignment with a self-ligating and a conventional fixed orthodontic appliance system. A randomized controlled clinical trial. *Angle Orthod.* 79, 46–50.
43. Fleming, P.S., and Johal, A. (2010). Self-ligating brackets in orthodontics. A systematic review. *Angle Orthod.* 80, 575–584.
44. Pringle, A.M., Petrie, A. Cunningham, S.J., and McKnight, H. (2009). Prospective randomized clinical trial to compare pain levels associated with 2 orthodontic fixed bracket systems. *Am. J. Orthod. Dentofacial Orthop.* 136, 160–167.

Address correspondence to:
Angela Domínguez
Department of Orthodontics
Faculty of Dentistry
Universidad del Valle
Calle 4B No 36-00
Cali
Colombia

E-mail: angela.dominguezc@gmail.com