Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 6
Open Access

Impact of Low-Level Laser Therapy on Pain perception During Orthodontic Maxillary Incisor Intrusion with Connecticut's Intrusion Arch: A Randomized Clinical Trial

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Cite this paper as: Youssri Mahmoud Saleh (2024) Impact of Low-Level Laser Therapy on Pain perception During Orthodontic Maxillary Incisor Intrusion with Connecticut's Intrusion Arch: A Randomized Clinical Trial. *Frontiersin Health Informatics, 13* (6), 831-836

Abstract

Aim*: To assess the impact of low-level laser therapy on pain perception during intrusion of the maxillary incisors using Connecticut's intrusion arch in excessive overbite cases.*

Methods*: parallel groups randomized clinical trial with a 1:1 allocation ratio. Patients aged 12 to 19 years had an overbite greater than 40%, indicating the need for maxillary incisor intrusion using Connecticut's intrusion arch. Patients were recruited from the Department of Orthodontics outpatient clinics at the Faculty of Dental Medicine at AL-Azhar University in Cairo, Egypt. Eighteen patients were randomly assigned to two groups: one (test) group received low-level laser therapy after maxillary intrusion using Connecticut's intrusion arch. In contrast, the other group (control group) received no laser therapy. Post-operative pain levels were measured using a 10 cm visual analog scale immediately after the first intrusive arch placement and again after three and seven days. Continuous data were presented as means and standard deviations. The differences between the two groups were analyzed using an independent Welch t-test, while intragroup comparisons were evaluated using a one-way repeated measures ANOVA test.*

Results*: Low-level laser therapy had a statistically non-significant lower pain levels than the control group in all time points ($p > 0.05$). However, the pain levels were significantly reduced over time in each group ($p < 0.05$). Multiple pairwise paired t-tests revealed significant differences in all comparisons between different time points ($p < 0.05$).*

Conclusion*: Based on the current results, low-level laser therapy using the specified parameters and protocol has a minimal impact on the pain experienced during the intrusion of maxillary incisors with Connecticut`s intrusion arch.*

Keywords*: low-level laser therapy, maxillary incisor intrusion, Connecticut's intrusion arch, pain, excessive overbite.*

Introduction

A deep bite is a common malocclusion in which the mandibular incisors are excessively overlapped vertically by the maxillary incisors. Several treatment options are available to correct a deep bite, including flaring the anterior teeth, uprighting the posterior teeth, and either intrusion of the incisors or extrusion of the molars or a combination of these methods. However, extruding the posterior teeth is often more challenging and unstable in non-growing patients. In cases with elongated incisors and a gummy smile, intrusion of the incisors is a more effective treatment approach [1].

Various appliances and methods are available to address deep bite orthodontics. Extraoral appliances, such as J-hook headgear, are effective for controlling anchorage; however, they require the patient's cooperation to achieve the desired results. One advantage of this device is that it is easy for the patient and the dental team to use. However, a disadvantage is that it can lead to dental arch expansion [2]

In addition, there are intrusive arches, including Ricketts' utility arch, K-SIR loop, vertical loop, segmental

intrusion arches (like Burstone's intrusion arch and Connecticut's intrusion arch), and three-piece intrusion arches. These intraoral arches utilize posterior teeth as anchorage to intrude anterior teeth [1, 3, 4]. An exaggerated curve of Spee is a contributing factor to deep overbite in many malocclusions. One of the primary goals of orthodontic treatment is to level the curve of Spee. Generally, archwires with an accentuated and reversed curve of Spee are used to treat deep overbite in edgewise mechanics. This approach typically results in incisor intrusion and flaring [5].

Extended treatment times are one of the main reasons patients decline orthodontic treatment, as they can lead to negative consequences such as an increased risk of cavities and root resorption [6]. To address this issue, new methods have been developed to shorten orthodontic procedures, which helps reduce these side effects and encourages patients to complete their treatment. Various approaches, including local injections of biological substances and surgical, mechanical, and physical techniques, have been implemented to enhance the movement of teeth during orthodontic care [7, 8].

In orthodontic treatment, root resorption is an undesirable side effect. Research suggests that there may be a correlation between the type of tooth movement and the extent of root resorption. Specifically, intrusive movement is associated with a higher risk of root resorption due to the compression of the periodontal ligament and the root apex [2, 9]. When orthodontic forces are focused on the root, especially in the apical third, they can cause biological changes in the cementum and periodontal ligament, ultimately leading to root resorption. This condition is most commonly observed in the upper incisors during orthodontic treatment [5].

Low-level laser therapy (LLLT) is an effective physical treatment that promotes alveolar bone remodeling by increasing the number of osteoblasts and osteoclasts, facilitating rapid orthodontic tooth movement. However, there is limited information regarding the effects of LLLT on postoperative pain during orthodontic intrusion, especially concerning maxillary incisors. Overall, evidence confidence is very low regarding LLLT and its impact on pain levels, as demonstrated by a recent systematic review and meta-analysis [8], which recommended conducting more randomized clinical trials in this area. Therefore, this study aims to assess the effect of using LLLT during maxillary incisor intrusion on postoperative pain.

Materials and Methods

Study design and setting

The study was designed as a single-center, parallel-arms, randomized clinical trial with a 1:1 allocation ratio. It was conducted in the Department of Orthodontics outpatient clinics at the Faculty of Dental Medicine (Boys) at AL-Azhar University in Cairo, Egypt. The study protocol had been approved by the faculty's research ethics committee, approval # (796/2193). Before patients enrollment in this study, all patient and \ or guardian’s have clearly informed about the nature and objectives of study and all had freely signed an informed consent.

Sample size

Based on a previous study [10] and using the G power statistical power Analysis program (version 3.1.9.4) for sample size determination, A total sample size (n=18; subdivided to 9 in each group) will be sufficient to detect a large effect size (d) = 1.51, with an actual power (1-β error) of 0.8 (80%) and a significance level (α error) 0.05 (5%) for a two-sided hypothesis test.

Eligibility criteria

Participants were recruited from the outpatient clinic of the Department of Orthodontics, Faculty of Dental Medicine (Boys), AL-Azhar University, Cairo, Egypt. They were selected according to the following Inclusion criteria:

- Participants with an age range of 12 to 19 years.
- Overbite > 40% indicated for maxillary intrusion.
- No previous orthodontic treatment.
- Good oral hygiene, low caries index, and all permanent teeth erupted.

Participants who had retained or ankylosed deciduous teeth, missing maxillary teeth in the anterior region, a risk of root resorption, or any systemic conditions, as well as those with a history of chronic NSAID use that could affect orthodontic tooth movement, were excluded from the study. Participants who missed multiple

appointments or frequently broke their appliances were also discontinued from the trial.

Randomization and group allocation
After enrollment, participants were randomly assigned into two groups to receive LLLT with maxillary incisors intrusion (laser group) or maxillary incisors intrusion without LLLT (control group). The allocation sequence was generated by simple randomization using a computer-generated random number sequence. Allocation sequence concealment was carried out using sequentially numbered opaque sealed envelopes with the intervention or control written on a folded piece of paper. Blinding of the intervention wasn't possible due to its nature [11].

Interventions
A thorough clinical examination and full orthodontic records had been obtained for each patient before starting orthodontic treatment. All patients had received orthodontic treatment with Roth's pre-adjusted straight-wire metal brackets with 0.022x0.028-inch slot. Brackets were bonded in place using Greengloo light-cured adhesive. A transpalatal arch was fabricated and cemented on the maxillary 1st molar to augment anchorage, at the same time to ensure equal response to intrusive force on both sides of the arch. The molar bands had triple tubes to allow for installment of at least two arch wires. Leveling and alignment were done according to standard protocol [12] with an archwire sequence 0.012-, 0.014-, 0.016-, and 0.018-inch Nickel titanium followed by 0.017 x 0.025-inch stainless steel 3-piece sectional arch wires, which were used as stabilizing arch [13–15].
The maxillary incisors were intruded in both groups using Connecticut Intrusive Arches (CIA) fabricated from Nickel-Titanium alloy. The wire size used was 0.017 x 0.025, its anterior dimension was 34 mm, and the bypass was distal to the lateral incisors. The posterior dimensions were available in two lengths, short (15mm) and long (22mm), to accommodate extraction and non-extraction cases. The primary mechanism of CIA force delivery is a V-bend calibrated to deliver approximately 40–60g of force [16]. The selected CIA was inserted into the upper first molar auxiliary tube with the "V" bend located anterior to the molar tube. The anterior segment of a passive intrusive arch had located in a high position in the mucolabial fold, and to activate it, the anterior segment was pulled down incisally and tied to the distal wings of the maxillary lateral incisor brackets using a stainless-steel ligature. The force gauge was used to measure the applied intrusive force. The total intrusive force used was 60 gm [12, 15].
For the laser group, a gallium aluminum arsenide (Ga-Al-As) semiconductor diode laser (SMARTTM PRO, LASOTRONIX, Poland) was used for the LLLT. The laser used had the following perimeters: a wavelength of 635 nm, a power output of 220 mW, an energy density of 6.5 J/cm², and an exposure time of 15 seconds per point. It functioned in continuous mode and delivered the laser beam through an 8-mm diameter fiber optic tip [17]. According to standard safety rules, the operator and the patients wore protective eyeglasses appropriate for the wavelength used. The same operator performed all clinical procedures and laser irradiation.
The laser beam was applied to the roots of all four maxillary incisors. Each root was divided into two halves—cervical and apical—by an imaginary horizontal line. The tip of the laser device was positioned at the center of each half, perpendicular to the root and in direct contact with a previously dried area of the mucosa. This application was made from both the buccal and palatal sides, resulting in four application points for each tooth, with a total exposure time of one minute per tooth [18]. The laser application started immediately after the first intrusive wire and then at days 3,7,14 days and then every 15 days until achievement of the study objectives. The control group had the same interventional procedures but without laser application.

Post-operative pain assessment
Postoperative pain intensity measured by a 10 cm visual analog scale (VAS). The 10 cm VAS ranged from 0 (no pain) to 10 (the most severe pain). Patients were asked to record their pain in the pain assessment chart after the first application of laser and then at three and seven days for both groups.

Statistical methods
The level of statistical significance was set at 5%. Statistical analysis was done using R and R Studio software [19, 20]. Continuous data were summarized into mean and standard deviation. The normality of data distribution

was explored using the Shapiro-Wilk test. The independent Welch t-test was used for the intergroup comparison at different time points and one-way repeated measures ANOVA was used for the intragroup comparison between different time points in each group. In case of a significant one-way repeated measures ANOVA, multiple pairwise paired t-tests with Bonferroni adjustment will be used to check for significant comparisons.

Results

A total of 18 patients were enrolled in the study and randomized to receive LLLT with the intrusion of maxillary incisors teeth or no LLLT. All the 18 patients completed the follow-up visits. Patients ranged from 12 to 19 years, with a mean age of 17.31±0.57 and 16.93±1.23 in the laser and control groups, respectively. The CONSORT flow diagram shows the flow of the patients through the trial (Figure 1).

Table 1 shows the mean postoperative pain intensity for both groups at different time points. The laser group had non-significantly lower pain levels than the control group. However, pain was significantly reduced over time in both groups, as shown in Table 2. Multiple pairwise paired t-tests revealed that comparisons between different time points in intragroup comparisons were all statistically significant.

Table 1: Intergroup comparison showing mean pain intensity for each group.

Timepoint/Group	Laser group		Control group		T value	P value
	Mean	SD	Mean	SD		
Immediate after	4.30	0.67	4.79	1.04	-1.181	0.258 NS
72 hours	3.07	0.60	3.53	0.71	-1.499	0.154 NS
Seven days	1.79	0.54	1.99	0.38	-0.905	0.381 NS

SD: standard deviation, NS: non-significant.

Table 2: Intragroup comparison showing pain reduction through time in each group

Timepoint/Group	Laser group		Control group		F value		P value	
	Mean	SD	Mean	SD	Laser	Control	Laser	Control
Immediate after	4.30	0.67	4.79	1.04	53.86	27.85	0.0078*	0.0061*
72 hours	3.07	0.60	3.53	0.71				
Seven days	1.79	0.54	1.99	0.38				

*SD: standard deviation, *: significant.*

Discussion

It is evident that nearly all patients undergoing fixed orthodontic treatment experience some degree of discomfort. This discomfort may result from the separation of teeth for posterior orthodontic banding or following the insertion of archwires, which can discourage patients from adhering to their treatment plans or even lead them to discontinue treatment at the outset. Furthermore, the perception of pain varies significantly among individuals. As a result, pain is a highly subjective experience, posing challenges for quantification in scientific research [21, 22]. Usually, pain during orthodontic treatment is noticeable, mainly in the first three days, reaching its maximum level in 24 hours, and decreasing after the third day of activation [21].

LLLT has been studied as a potential method to accelerate tooth movement and reduce pain during orthodontic treatment. This is due to its analgesic properties, which help reduce inflammation and lower the levels of pro-inflammatory mediators, such as prostaglandins and cytokines, that contribute to pain perception [17, 23]. LLLT may also influence pain perception by affecting the conduction of nerve impulses in pain pathways. Additionally, LLLT could promote the release of endorphins, the body's natural pain relievers [24, 25]. However, the quality of evidence regarding the effect of LLLT on pain during orthodontic tooth movement is deficient, with controversial results, as demonstrated by a recent systematic review [8]. Therefore, this study aimed to assess the effect of LLLT during maxillary incisor intrusion on pain levels in deep overbite correction. The primary finding of this study indicates that pain levels were reduced in the LLLT group compared to the control group; however, this difference did not achieve statistical significance. This result is consistent with a

prior study [17] that evaluated the effects of LLLT on pain during the leveling and alignment of lower anterior teeth, which similarly reported no statistically significant difference in pain perception between the laser treatment and the non-laser group. Furthermore, an additional study [26] investigating the influence of LLLT on pain perception during maxillary canine retraction also found no statistically significant differences between the LLLT and control groups.

Some studies, however, disagree with our findings and indicate that LLLT positively affects pain relief during orthodontic treatment. One study [25] reported a significant reduction in pain scores among patients who received LLLT during the leveling and alignment of mandibular anterior crowding, particularly on days 3 and 7 following the initial archwire placement. Other studies [23, 27] found that participants who underwent LLLT required fewer orthodontic appliance adjustment appointments during the alignment stage and experienced significantly reduced pain and discomfort compared to those who did not receive LLLT. Our study findings revealed that pain levels decreased considerably over time, starting from the immediate post-operative stage and fading away after seven days. This agrees with previous studies on the effect of LLLT on pain during orthodontic treatment [21, 28].

Multiple factors contribute to the inconsistent findings regarding the effects of LLLT on pain. These include variations in laser parameters and the subjective nature of pain perception. Different studies have employed varying wavelengths, energy densities, exposure times, and application frequencies, complicating the comparison of results. Additionally, pain is a subjective experience influenced by individual characteristics, making it difficult to quantify and compare across different studies. A recent systematic review [8] highlighted the c

ontroversial results among the different studies assessing pain levels with LLLT during orthodontic treatment and concluded that there is very low-certainty evidence to suggest that applying LLLT affects the patient's perception of pain and discomfort during orthodontic treatment. However, the studies assessing LLLT and maxillary incisors using CIA were lacking, as identified by two systematic reviews [8, 24] and most of the identified studies focused on intrusion using mini-screws or mini-implants with varying laser parameters.

Conclusions

Based on the current results, it can be concluded that LLLT, using the specified parameters and protocol, has minimal impact on the pain experienced during the intrusion of maxillary incisors with the CIA. Given the lack of studies in this area, more research is needed to determine the true efficacy of LLLT for pain management in orthodontic treatment and to identify optimal parameters for specific applications.

References

[1] *Goel P, Tandon R, Agrawal KK. A comparative study of different intrusion methods and their effect on maxillary incisors. J Oral Biol Craniofac Res 2014; 4: 186.*

[2] Deguchi T, Murakami T, Kuroda S, et al. Comparison of the intrusion effects on the maxillary incisors between implant anchorage and J-hook headgear. Am J Orthod Dentofacial Orthop 2008; 133: 654–660.

[3] Dahiya A, Singh G. Incisor Intrusion with a Miniscrew-Anchored Segmental Utility Arch. Journal of clinical orthodontics 2016; 50: 375–6.

[4] Gupta H, Gupta A, Verma S, et al. Comparing the Effect of Miniscrew-Supported and Conventional Maxillary Incisor Intrusion on the Inclination of Maxillary Incisors and Molars - A Systematic Review and Meta-Analysis. Contemp Clin Dent 2022; 13: 307–314.

[5] Chiqueto K, Martins DR, Janson G. Effects of accentuated and reversed curve of Spee on apical root resorption. Am J Orthod Dentofacial Orthop 2008; 133: 261–268.

[6] Wazwaz F, Seehra J, Carpenter GH, et al. Duration of tooth alignment with fixed appliances: A systematic review and meta-analysis. Am J Orthod Dentofacial Orthop 2022; 161: 20–36.

[7] Fleming PS, Fedorowicz Z, Johal A, et al. Surgical adjunctive procedures for accelerating orthodontic treatment. Cochrane Database Syst Rev; 2015. Epub ahead of print 30 June 2015. DOI: 10.1002/14651858.CD010572.PUB2.

[8] El-Angbawi A, McIntyre G, Fleming PS, et al. Non-surgical adjunctive interventions for accelerating tooth movement in patients undergoing orthodontic treatment. Cochrane Database Syst Rev; 6. Epub ahead of print 20 June 2023. DOI: 10.1002/14651858.CD010887.PUB3.

[9] Puttaravuttiporn P, Wongsuwanlert M, Charoemratrote C, et al. Volumetric evaluation of root resorption on the upper incisors using cone beam computed tomography after 1 year of orthodontic treatment in adult patients with marginal bone loss. Angle Orthod 2018; 88: 710–718.
[10] Goel P, Tandon R, Agrawal KK. A comparative study of different intrusion methods and their effect on maxillary incisors. J Oral Biol Craniofac Res 2014; 4: 186–191.
[11] Viera AJ, Bangdiwala SI. Eliminating bias in randomized controlled trials: importance of allocation concealment and masking. Fam Med 2007; 39: 132–7.
[12] Schwertner A, De Almeida RR, De Almeida-Pedrin RR, et al. A prospective clinical trial of the effects produced by the Connecticut intrusion arch on the maxillary dental arch. Angle Orthod 2020; 90: 500–506.
[13] Gupta N, Tripathi T, Rai P, et al. A comparative evaluation of bite opening by temporary anchorage devices and Connecticut intrusion arch: An in vivo study. International Journal of Orthodontic Rehabilitation 2017; 8: 129.
[14] ÖLMEZ GÜRLEN S, ARAS I. Comparison of the Treatment Effects of Two Intrusive Mechanics: Connecticut Intrusion Arch and Mini-Implant. Turkiye Klinikleri Journal of Dental Sciences 2016; 22: 195–201.
[15] El Beali A, Hafez A, Badr H. Evaluation of the connecticut intrusion arch in leveling deep curve of Spee. Egyptian Orthodontic Journal 2011; 39: 49–62.
[16] Nanda R, Marzban R, Kuhlberg A. The Connecticut Intrusion Arch. Journal of clinical orthodontics 1998; 32: 708–15.
[17] elshehawy tharwat, El Awady A, Hussein F. Effect of Low-Level Laser Therapy on Pain Experienced During Leveling and Alignment of Lower Anterior Teeth: A Randomized Controlled Clinical Study. Al-Azhar Journal of Dental Science 2020; 23: 201–207.
[18] AlSayed Hasan MMA, Sultan K, Hamadah O. Low-level laser therapy effectiveness in accelerating orthodontic tooth movement: A randomized controlled clinical trial. Angle Orthod 2017; 87: 499–504.
[19] R Core Team. R: A Language and Environment for Statistical Computing, https://www.R-project.org/ (2023).
[20] Posit team. RStudio: Integrated Development Environment for R, http://www.posit.co/ (2023).
[21] Deana NF, Zaror C, Sandoval P, et al. Effectiveness of Low-Level Laser Therapy in Reducing Orthodontic Pain: A Systematic Review and Meta-Analysis. Pain Res Manag; 2017. Epub ahead of print 2017. DOI: 10.1155/2017/8560652.
[22] Uribe F, Padala S, Allareddy V, et al. Patients', parents', and orthodontists' perceptions of the need for and costs of additional procedures to reduce treatment time. Am J Orthod Dentofacial Orthop; 145. Epub ahead of print 2014. DOI: 10.1016/J.AJODO.2013.12.015.
[23] Al-Jundi A, Sakka S, Riba H, et al. Efficiency of Er:YAG utilization in accelerating deep bite orthodontic treatment. Laser Ther 2018; 27: 193.
[24] Inchingolo F, Inchingolo AM, Latini G, et al. Low-Level Light Therapy in Orthodontic Treatment: A Systematic Review. Applied Sciences; 13. Epub ahead of print 1 September 2023. DOI: 10.3390/app131810393.
[25] Ghaffar YKA, El Sharaby FA, Negm IM. Effect of low-level laser therapy on the time needed for leveling and alignment of mandibular anterior crowding: A randomized controlled clinical trial. Angle Orthodontist 2022; 92: 478–486.
[26] Farhadian N, Miresmaeili A, Borjali M, et al. The effect of intra-oral LED device and low-level laser therapy on orthodontic tooth movement in young adults: A randomized controlled trial. Int Orthod 2021; 19: 612–621.
[27] Alam MK. Laser-Assisted Orthodontic Tooth Movement in Saudi Population: A Prospective Clinical Intervention of Low-Level Laser Therapy in the 1st Week of Pain Perception in Four Treatment Modalities. Pain Res Manag; 2019. Epub ahead of print 2019. DOI: 10.1155/2019/6271835.
[28] Lazăr A-P, Dakó T, Bud A, et al. The Effects of Periodontal Laser Therapy on Pain in Adult Patients with Orthodontic Treatment: A Randomized Clinical Trial. Applied Sciences 2022; 12: 3601.