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Research Article

Photobiostimulatory Effect of a Single Dose of Low-Level Laser on Orthodontic Tooth Movement and Pain

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Objective. To assess the effect of low-level laser applied at 3 weeks intervals on orthodontic tooth movement (OTM) and pain using conventional brackets (CB). *Materials and Methods*. Twenty patients with Angle's class II div 1 (10 males and 10 females; aged 20.25 ± 3.88 years) needing bilateral extractions of maxillary first bicuspids were recruited. Conventional brackets MBT of 0.022 in slot (McLaughlin Bennett Trevisi) prescription braces (Ortho Organizers, Carlsbad, Calif) were bonded. After alignment and levelling phase, cuspid retraction began with nitinol closed coil spring on 19 × 25 stainless steel archwire, wielding 150 gram force. 7.5 J/cm^2 energy was applied on 10 points (5 buccal and 5 palatal) on the canine roots on the investigational side using gallium-aluminum-arsenic diode laser (940 nm wavelength, iLase™ Biolase, Irvine, USA) in a continuous mode. Target tissues were irradiated once in three weeks for 9 weeks at a stretch (T0, T1, and T2). Patients were given a feedback form based on the numeric rating scale (NRS) to record the pain intensity for a week. Silicon impressions preceded the coil activation at each visit (T0, T1, T2, and T3), and the casts obtained were scanned with the Planmeca CAD/CAM™ (Helsinki, Finland) scanner. *Results*. The regimen effectively accelerated (1.55 ± 0.25 mm) tooth movement with a significant reduction in distress on the investigational side as compared to the placebo side (94 ± 0.25 mm) ($p < 0.05$). *Conclusions*. This study reveals that the thrice-weekly LLLT application can accelerate OTM and reduce the associated pain.

1. Introduction

Fixed orthodontic treatment is a lengthy and time-consuming process and on average takes 12–36 months [1] and is associated with adverse outcomes, particularly pain and difficulty to carry out oral hygiene practices. Prolong treatment and difficulty is to maintain proper oral hygiene on mobile, and tender dentition is not only detrimental to the teeth and surrounding periodontal tissues but also influence patient compliance and productivity of the healthcare professionals [2]; therefore, orthodontic contemporaries are toiling on efficient and fast force delivery mechanics and approaches [3].

Interventions such as a local injection of pharmacological agents, use of magnets or direct current, and invasive surgical approaches (corticotomy) trim the total treatment time by stimulating bone remodelling but at the expense of either increased patient's suffering or systemic side effects [4].

Low-level laser therapy (LLLT) is being used to alleviate musculoskeletal pain for decades. However, its use in dentistry is gaining popularity as a noninvasive and safe modality. Moreover, its anti-inflammatory effects and potential to induce peripheral neural blockage makes it a suitable candidate for postactivation pain and healing of tissues [5].

LLLT, when applied at correct intensity and duration, has been proven to amp up tissue healing by increasing cell proliferation (fibroblasts, osteoclasts, and osteoblasts), angiogenesis, and collagen synthesis [6]. At the molecular level, red or infrared light donates free electrons to the electron transport chain in mitochondria to curb the oxidative stress and generate more ATP [7]. This cascade of reactions, in turn, triggers growth signalling pathways and upregulates various transcription factors [8], with an overall increase production of growth factors [5].

A handful of researchers document the effect of LLLT on OTM, but the diversity of results pertains to different laser specifications, dosages, points of application, and intervals of application results [9–12], therefore requiring further insight into precise and specific emissions of radiation to get optimal results.

This research was aimed at providing a single dose of LLLT application to expedite tooth movement and lessen the discomfort associated with it.

2. Materials and Methods

This was the placebo-controlled clinical study, and the research was conducted in the Department of Orthodontics at Baqai Medical University, Pakistan. Twenty-two patients, age ranging from 12 to 30 years (10 males and 10 females), with healthy medical and dental status (no missing or impacted teeth except third molars) and no history of orthodontic treatment were recruited in the trial.

The inclusion criteria were patients with 1/4 or half cusp, molar class II division 1 warranting extraction of upper bicuspids on both sides. Patients who require lower premolar extraction were excluded from the study because simultaneous lower canine retraction interferes with the retraction of upper canines. Patients with TMJ problems or taking medicines that modify bone turnover or interferes with tooth retraction, e.g., NSAIDs, bisphosphonates, and corticosteroids, were disqualified.

Regular diagnostic orthodontic records were collected and thoroughly examined after the approval from the ethical board of Baqai Medical University. The whole procedure was verbally explained, and assent form was signed from the patients and legal guardians of minors.

Split-mouth design was chosen by flipping a coin to circumvent individual bias, randomly assigning one side as an experimental and the other placebo group.

After all the necessary procedures, banding and bonding were carried out. MBT (McLaughlin Bennett Trevisi) of 0.22 inch slot prescription braces (Ortho Organizers, Carlsbad, Calif) were bonded. The first stage of levelling and alignment was commenced with 0.014 inch heat-activated nitinol (NiTi) wire and after that by 0.016 inch NiTi, 0.017×0.025 in NiTi, 0.019×0.025 inch NiTi, and 0.019×0.025 SS as the final working wire. The first bicuspid was then extracted at day 21, and individual canine retraction began with 6 mm close coil NiTi spring, stretched to 150 gm force, measured with the orthodontic dynamometer (Forestadent, Germany) and secured with a ligature tie between the power arm of canine and first molar band.

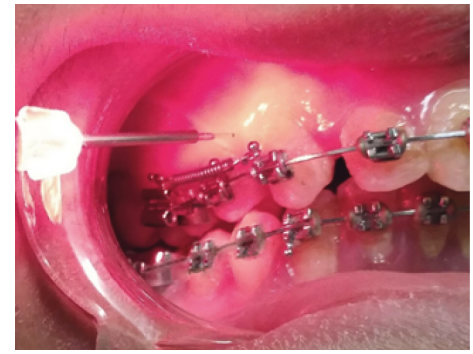

Figure 1: Laser application.

LLLT irradiation was applied soon after the placement of spring on the experimental side and was held at the placebo side without turning it on (Figure 1). The springs were activated at a three-week interval. Silicon impressions were taken before the first activation (T0) and repeated at every appointment before activation for nine consecutive weeks, i.e., T1, T2, and T3. Dental casts were scanned with the Planmeca CAD/CAM lab scanner for further analysis.

2.1. Laser Specification. Ga-Al-As diode laser (Ilase, USA) operated at 940 nm wavelength in a continuous, uninterrupted beam of light was used. Irradiations were delivered through the 0.04 cm^2 diameter optical fibre tip in light contact with the oral mucosa.

The target area was irradiated on ten sites, five points buccally and five palatally, for 3 secs each. The areas were as follows:

(i) Mesial and distal to the cervical area of the canine

(ii) Mesial and distal to the apical area of the canine

(iii) One point in the middle of the root

The power output set at 100 mW for 3 sec at each point made the cumulative of 7.5 J/cm^2 energy density. A separate room with loud music was reserved for the procedure. All the personnel wore protective shades near irradiated laser (patient, assistant, and dentist). To avoid the carryover effect, a plastic shield of the same wavelength as that of the laser was used.

2.2. Measurements

2.2.1. Rate of Canine Movement. To assess the effectiveness of regimen, the comparison of right and left sides was made, i.e., experimental and placebo at T0, T1, T2, and T3. A system suggested by Gebauer was used, and x and y marks were drawn on 3D imageries of study cast [13]. Y-axis was

Table 1: Median values and standard deviation of canine movements in experimental and placebo groups with confidence interval and p values.

	Experimental side (mean (SD))	95% CI		Placebo side (mean (SD))	95% CI		P value
		Lower bound	Upper bound		Lower bound	Upper bound	
T0-T1	1.79 (0.25)	1.63	1.95	1.12 (0.21)	0.98	1.25	<0.001*
T1-T2	1.59 (0.29)	1.40	1.78	0.91 (0.19)	0.79	1.03	<0.001*
T2-T3	1.29 (0.25)	1.12	1.45	0.80 (0.24)	0.64	0.95	<0.001*

*Significant at $p < 0.05$ (Mann–Whitney U test).

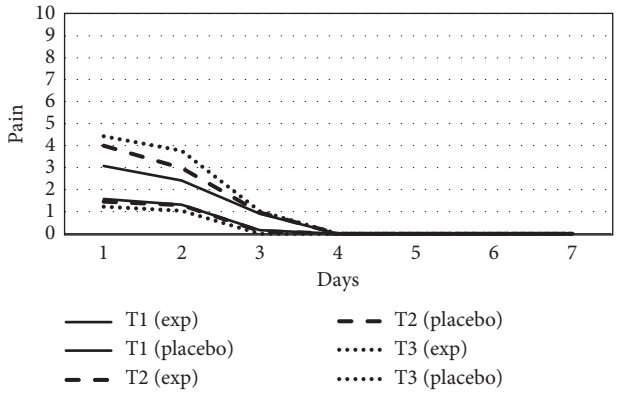

Figure 2: Comparison of pain among experimental side and placebo side in group A at T1, T2, and T3.

drawn a parallel to raphe line, and medial end of the prominent rugae marked the plane for the x-axis. The distance covered by canine was given by measuring the distance from x coordinate to the most distal point on canine on both the sides, and the two reading were later compared for the effectiveness.

2.3. Postactivation Pain. The analgesic effect of the LLLT evaluated by a feedback form was designed based on 11 points (from 0 to 10) numeric rating scale (NRS) where zero indicates no discomfort and 10 excruciating, terrible pain.

The form was given to the patient at each appointment and collected at the subsequent show-up. They were instructed to record the pain four hours after the activation and thereupon every 24-hour interval for the next 7 days. Patients were told not to take any analgesics if needed and advised to jot it down.

2.4. Statistical Analysis. Data were put in and interpreted on the SPSS 20.0 version. The Mann–Whitney U test was performed to compare the canine movement and Kruskal–Wallis test for pain comparison.

3. Results

3.1. Rate of Canine Retraction. 22 patients were recruited in the study, and two of them later were disqualified due to spring dislodgement and use of analgesics.

The Mann–Whitney U test shows a statistically significant acceleration in canine movement on the experimental side in comparison to the placebo group (Table 1). In 9 weeks, canine achieved 4.67 mm movement on the experimental side and 2.87 mm on the placebo side. Moreover, the average cuspid displacement in the experimental and placebo groups was 1.55 ± 0.25 mm and 0.94 ± 0.25 mm, respectively. The overall rate of displacement in the experimental group exceeded 1.66 times than the placebo group.

Pain. Most patients experienced the highest level of discomfort on the day the spring got activated. Females reported heightened pain sensitivity as compared to males. A significant reduction in pain in the lased group for initial 2 days was found. No difference was noted in the remaining days of the week.

Highest pain scores were recorded in the placebo side at T3 (Figure 2). There was a significant reduction in pain on the experimental side at all stages of treatment (T1, T2, and T3) as the level of pain was significantly higher on placebo sides.

4. Discussion

This research was undertaken to appraise the effectiveness of a single dose of laser on OTM and twinge using conventional brackets, applied at 3 weeks' interval.

Pain and rate of movement are subjective quantities and are greatly influenced by age, gender, hormones, pain threshold, and anatomic variations [14]. Therefore, the split-mouth design was considered to circumvent chances of error. However, it holds an inherent disadvantage of the carryover effect. For that, a plastic shield of the same wavelength as that of the laser was placed in the midline.

To maximize the effectiveness of placebo design, the whole protocol was carried out in a separate room, and loud music was played on to mingle it with the beeping sound of the laser. None of the patients complained about the heating, burning sensation, or any form of discomfort.

A bunch of researchers has employed single-blind trials with split-mouth design, but none of them brought the carryover effect and blinding into consideration [9, 10, 15–18].

Ga-Al-As semiconductor diode with 940 nm wavelength was used due to its deeper depth of penetration, about its low absorption coefficient in haemoglobin and water and its subsequent ability to stimulate osteoblastic activity on the target tissue [19]. Several previous authors also used Ga-Al-As with the wavelength ranging from 650 nm to 860 nm. Energy output, however, varied in all the studies and led to speckled results [2, 9–11, 15–18, 20].

In this study, energy dose was kept 7.5 J/cm^2 at each point as low doses impart biostimulatory effects [4, 21].

Research studies catering laser photobiostimulation on OTM reveals that patients had to make some additional visits along with the regular ones for the regimen, making it difficult for them to stick to it [9–12, 22]. In our research, LLLT was applied once in three weeks, and a profound acceleration was observed because LLLT works best to stimulate bone remodelling if applied within 48 hours after force application [23]. This is in agreement with few previous research studies which found a single dose of LLLT to be efficient in accelerating OTM and reducing associated pain [24–26].

Since bone remodelling is directly related to cytokine production, LLLT stimulates bone remodelling by accelerating the production of IL-β, and receptor activator which is crucial for osteoclastic activity on day 2 or 3 after laser application [27].

The overall rate of canine movement was 1.65 times greater in the present study. However, Youssef and Sousa concurred with twice the rate and Doshi-Mehta, and Bhad Patil found it to be 1.3 times faster than the control group [10–12]. Others found no significant acceleration [20, 28]. Qamruddin et al. reported 2.02 times acceleration in canine movement; however, more acceleration attributes to the use of frictionless self-ligating brackets in the study [24].

In previous research studies, the measurements were made from canine cusp tip or distal surface of canine to mesiobuccal cusp of the first molar with a digital calliper, held directly on the dental cast [11, 12, 15]. Curved palatal anatomy, rotated molars, and difficulty in holding the calliper directly over the cast pose difficulty in recording the precise measurements, therefore, in this research, we took medial part of most prominent rugae as a stable reference landmark [29] and scanned the respective models through the CAD/CAM scanner [20] to assure the accuracy in measurements.

To assess the pain levels in patients undergoing LLLT therapy, a questionnaire (feedback form) was formulated using NRS in contrast to others who employed a visual analogue scale (VAS). NRS is more accurate and easily understood by patients of any age and educational background [30].

In the present study, the pain rating was very low in the lased as well as the placebo group. Highest pain scores were reported on day 1 of coil activation, which agrees with the previous studies [31–33]. Experimental and placebo groups showed a significant difference in the level of pain. This is well supported by some studies which documented the pain-alleviating effect of LLLT [34–37] experienced during canine retraction [11, 12]. Almallah et al. also revealed a 12% decrease in discomfort after a single dose of low-level helium-neon laser in the experimental group [34]. Few more studies evinced the analgesic effects laser. However, the effects were on pain linked with the insertion of initial archwire [31–33]. Some authors find a nonsignificant difference in pain associated with canine retraction between the control and lased groups [9, 20].

5. Conclusion

Application of LLLT at regular orthodontic visits (3 weeks intervals) accelerates OTM and decreases the pain significantly. Hence, the above regimen can be implemented in fixed orthodontic treatment to avoid the risk of patient and operator burnout.

Data Availability

The data used to support the findings of this study are presented within the results section as tables and are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Irfan Qamruddin and Mohammad Khursheed Alam are the first authors. Verda Mahroof carried out clinical application. Mubassar Fida supervised the study. Mohd Fadhli Khamis and Adam Husein were involved in statistical input and final formatting.

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