Effects of low-level laser irradiation on the rate of orthodontic tooth movement and associated pain with self-ligating brackets

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Introduction: The aim of this study was to evaluate the effect of low-level laser irradiation applied at 3-week intervals on orthodontic tooth movement and pain associated with orthodontic tooth movement using self-ligating brackets. **Methods:** Twenty-two patients (11 male, 11 female; mean age, 19.8 ± 3.1 years) with Angle Class II Division 1 malocclusion were recruited for this split-mouth clinical trial; they required extraction of maxillary first premolars bilaterally. After leveling and alignment with self-ligating brackets (SmartClip SL3; 3M Unitek, St Paul, Minn), a 150-g force was applied to retract the canines bilaterally using 6-mm nickel-titanium closed-coil springs on 0.019 x 0.025-in stainless steel archwires. A gallium-aluminum-arsenic diode laser (iLas; Biolase, Irvine, Calif) with a wavelength of 940 nm in a continuous mode (energy density, 7.5 J/cm^2/point; diameter of optical fiber tip, 0.04 cm^2) was applied at 5 points buccally and palatally around the canine roots on the experimental side; the other side was designated as the placebo. Laser irradiation was applied at baseline and then repeated after 3 weeks for 2 more consecutive follow-up visits. Questionnaires based on the numeric rating scale were given to the patients to record their pain intensity for 1 week. Impressions were made at each visit before the application of irradiation at baseline and the 3 visits. Models were scanned with a CAD/CAM scanner (Planmeca, Helsinki, Finland). **Results:** Canine retraction was significantly greater (1.60 ± 0.38 mm) on the experimental side compared with the placebo side (0.79 ± 0.35 mm) (P <0.05). Pain was significantly less on the experimental side only on the first day after application of LLLI and at the second visit (1.4 ± 0.82 and 1.4 ± 0.64) compared with the placebo sides (2.2 ± 0.41 and 2.4 ± 1.53). **Conclusions:** Low-level laser irradiation applied at 3-week intervals can accelerate orthodontic tooth movement and reduce the pain associated with it. (Am J Orthod Dentofacial Orthop 2017;152:622-30)

Orthodontic treatment with fixed appliances is a lengthy and painful process. Numerous techniques to reduce the treatment duration and the level of discomfort have evolved over the time. A few of them shorten the treatment duration by accelerating the velocity of orthodontic tooth movement (OTM) by increasing bone remodeling, whereas other methods are intended to make the mechanical force delivery system more efficient.[1-4]

Low-level laser irradiation (LLLI) has been reported to enhance the velocity of tooth movement by accelerating bone remodeling.[4-7] It induces a photochemical reaction (biostimulation) at the cellular level in which the light energy is absorbed by the cellular photoreceptors and converted into adenosine triphosphate by mitochondria. This subsequently increases the cellular activities such as DNA, RNA, and protein synthesis. Some electromagnetic energy increases the local tissue temperature causing

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vasodilation, eventually inducing cellular proliferation, differentiation, and tissue healing.[8-10]

Additionally, LLLI has also been shown to have analgesic effects in various clinical and therapeutic applications.[11-13] It is believed that LLLI minimizes pain perception by inhibiting the release of arachidonic acid, which decreases the levels of prostaglandin E2.[14-16] Also, it induces the release of an endogenous opioid neuropeptide (beta-endorphin) that produces potent analgesic effects.[17] Moreover, LLLI stabilizes the membrane potential and henceforth inhibits activation and transmission of the pain signal.[10]

Since pain and longer duration of orthodontic treatment are among the worst aspects of fixed appliance therapy, LLLI could be an ideal modality to address both concerns. Various authors have investigated the biostimulating and analgesic effects of LLLI in relation to OTM in animals and humans. In-vivo animal studies have shown that low-energy laser irradiation can induce the proliferation and activation of both osteoblasts and osteoclasts through the expression of RANK and RANKL, accelerating the remodeling of bone and eventually increasing the velocity of OTM.[18-20] However, recently, some authors have observed no acceleration in OTM after application of LLLI.[21,22]

Several clinical trials involving the use of LLLI in human subjects have shown different outcomes. Some authors have reported positive effects on the speed of OTM, whereas others did not support any enhancement in velocity.[5,23-26] A few studies that evaluated the effects of LLLI on OTM and associated pain simultaneously also showed divergent results.[27,28] The role of LLLI in decreasing the perceived pain levels for the first few days after separator placement and initial archwire insertion has been reported by a number of studies; however, consistent reports of the effectiveness of LLLI on relieving the pain related to OTM are still not available.[7,29-33]

So far, the application of LLLI to investigate the acceleration of tooth movement was either on a daily basis or with a short interval between the visits, which became unmanageable for the patients because of forgetfulness or time constraints (Table I).[34] Therefore, the purpose of this study was to evaluate the effects of LLLI applied at 3-week intervals on the velocity of OTM and the pain associated with it using self-ligating brackets. It was hypothesized that the application of LLLI at 3-week intervals would expedite OTM and reduce the pain effectively.

MATERIAL AND METHODS

This single-blind, randomized clinical trial was conducted at the Orthodontic Department in Baqai Medical University, Pakistan. The study was approved by the ethics committee of Baqai Medical University, Pakistan. Twenty-two healthy orthodontic patients of Pakistani ethnic background (11 male, 11 female) with ages between 12 and 25 years (19.8 ± 3.1 years) were selected for the study.

The sample size was determined using power analysis, based on the tooth movement objective. Having 80% power, an alpha that indicates the significance level was set at 0.05, with a standard deviation of 0.99 mm and considering a 1-mm mean difference as clinically meaningful.[27] The minimum sample size calculated with this method was 19. Including expected dropouts, 22 patients were recruited for the study (Fig 1).

Selection criteria were Angle Class II Division 1 malocclusion requiring extraction of first premolars bilaterally in the maxillary arch only. Patients with moderate-to-severe crowding who required extractions of premolars for alignment were not included in the sample. Patients on long-term medication, or with parafunctional habits, temporomandibular joint dysfunction, craniofacial malformation, multiple missing teeth, and impacted teeth except for third molars, or periodontally compromised patients were excluded from the study. The informed consents of the patients were taken, after explaining the procedure verbally. Legal guardians signed the consent form if the age of the patient was below 18 years.

The orthodontic treatment was initiated with a banding procedure followed by bonding passive self-ligating MBT brackets having a 0.022-in slot (SmartCli SL3; 3M Unitek, St Paul, Minn). After alignment and leveling with 0.014-in nickel-titanium wires, and following the sequence of wires (0.016-in, 0.017 × 0.025-in, and 0.019 x 0.025-in), which took approximately 6 months (each archwire was placed for 6 weeks), a final working wire of 0.019 × 0.025-in stainless steel was placed. Twenty-one days after the working wire placement, extractions were performed, and a silicone impression was made (before the experiment) a week after the extractions. Canine retractions were started bilaterally using 6-mm nickel-titanium closed-coil springs, placed from the first molar band hook to the power arm of the canine brackets secured through the ligature wire. The incisors were consolidated using 0.010-in steel ligature wires so that spaces did not appear between them during canine retraction. A constant retraction force of 150 g was exerted for canine retraction measured with an orthodontic dynamometer (Forestadent, Pforzheim, Germany).

The maxillary arch was divided into experimental and placebo groups randomly by flipping a coin. LLLI was applied on the experimental side immediately after the retraction force. LLLI was applied on a total of 10 points, 5 on the buccal side and 5 on the palatal side (T0). The points to be irradiated on the buccal sides were mesial and distal to the apical area of the canine, and mesial