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# Effects of Low-Intensity Laser Therapy on the Orthodontic Movement Velocity of Human Teeth: A Preliminary Study

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**Background and Objectives:** Low-intensity laser therapy (LILT) has been studied in many fields of dentistry, but to our knowledge, this is the first time that its effects on orthodontic movement velocity in humans are investigated.
**Study Design/Patients and Methods:** Eleven patients were recruited for this 2-month study. One half of the upper arcade was considered control group (CG) and received mechanical activation of the canine teeth every 30 days. The opposite half received the same mechanical activation and was also irradiated with a diode laser emitting light at 780 nm, during 10 seconds at 20 mW, 5 J/cm$^2$, on 4 days of each month. Data of the biometrical progress of both groups were statistically compared.
**Results:** All patients showed significant higher acceleration of the retraction of canines on the side treated with LILT when compared to the control.
**Conclusions:** Our findings suggest that LILT does accelerate human teeth movement and could therefore considerably shorten the whole treatment duration. Lasers Surg. Med. 35:117–120, 2004. © 2004 Wiley-Liss, Inc.

**Key words:** diode laser; orthodontic tooth movement; bone remodeling; canine retraction

## INTRODUCTION

Orthodontic treatment has its importance based on esthetic and functional rehabilitation of the masticatory system. Because it is the result of orthodontic forces promoting the remodeling of alveolar bone tissue, the movement should be as slight as possible, in order to prevent collateral effects such as bone necrosis or root resorption. From the patients' point of view, accelerating the teeth movement is desirable, because the treatment duration, frequently months or even years, is considered very long.

Literature shows some methods to stimulate bone remodeling such as drug injections [1], electric stimulation [2], and ultrasound application [3]. These methods depend on injections, that could be associated to discomfort and pain, or a sophisticated apparatus that demands applications for a long term to achieve its therapeutic effects. Low-intensity laser therapy (LILT) is simple to perform and uses inexpensive equipments that can be utilized for several different treatments in the clinical practice of orthodontics such as in reduction of post adjustment pain [4] or in the treatment of traumatic ulcers promoted by the appliance in the oral mucosa [5]. Some reports have suggested that LILT is able to accelerate teeth movement in animals by increased midpalatal suture expansion in rats with formation of better quality bone [6] and augmented production of differentiated osteoclasts [7]. Given the problems in extrapolating results and parameters from animal research to human practice, trials in humans are essential. To the best of our knowledge, effects of biomodulation promoted by LILT to accelerate human teeth movement have never been reported.

The aim of this innovative study was to analyze the effects of 780-nm diode laser irradiation on human canines' retraction during an orthodontic movement with a healthy tissular response, by the measurement of the biometrical progress. A higher retraction velocity could decrease treatment time and therefore treatment costs.

## PATIENTS AND METHODS

### Human Subjects

Eleven Caucasian patients of both genders, with age ranging from 12 to 18 years, were attended at a private office. They all had a clinical indication for extracting both first maxillary (upper) premolars, because there was not enough space for a complete alignment or presence of biprotrusion. For each patient, this diagnosis was based on a standard orthodontic documentation with photographs, model cast, cephalometric, panorama, and superior premolar periapical radiographies. The following criteria were observed for selection of the patients: they should appear to have an adequate nutrition, with no signals of systemic illnesses and the patient should not be under medical treatment that could interfere in the orthodontic movement like ingestion of analgesics, anti-inflammatory medicine, or antibiotics.

The patients and each legal responsible were informed about the risks and benefits of the procedures performed and they consented to participate in this study. Ethical approval was obtained from the Research Ethical

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### Orthodontic Treatment

All 11 patients had their left and right first maxillary premolars extracted and a fixed orthodontic appliance installed to close the space created and to restore an ideal occlusion and facial esthetic. Only one half was irradiated and it was considered lased group (LG); the non-irradiated half was considered control group (CG). Left and right halves of the upper arcades were randomly divided into the described groups and the same materials and procedures, except laser irradiation, were applied to both groups.

The orthodontic appliance was constructed with Roth brackets from right to left canines, with slot $0.22 \times 0.28$ (Dental Morelli Ltda., Sorocaba, SP, Brazil), bonded with Light Bond (Reliance Orthodontic Products, Inc., Itasca, IL). A modified Nance arch on both second maxillary premolars and a palatine bar on the first molars, cemented with Precedent Fluoride Glass Ionomer Cement (Reliance Orthodontic Products, Inc.) gave the posterior anchorage at the moment of canine retraction. Before the movement procedure, the canines were leveled and aligned using round NiTi wires (0.12, 0.14, and 0.16), round steel wires (0.18 and 0.20), and rectangular wires ($0.17 \times 0.25$). The teeth were tied to the wire using 0.01 steel wires. The rectangular wire guided the canine retraction, which was done by a 12-mm Nickel-Titanium closed-loop coil spring (Abzil Lancer, SP, Brazil) with constant force $k = 12.5$ gf/mm, positioned from the canine to the first molar bracket [8]. The total force used was 150 gf as confirmed after each activation with the help of an orthodontic dynamometer (Dental Morelli Ltda., Sorocaba, SP, Brazil).

### Laser Irradiation

The equipment used in this study was a Gallium Aluminum Arsenide (GaAlAs) semiconductor diode laser (Twin Laser, MM Optics Ltda., São Carlos, SP, Brazil), emitting infrared radiation at 780 nm, operating in continuous wave mode with a cylindrical quartz tip of 4 $mm^2$ surface.

All irradiations were done by the same operator with an output power of 20 mW, dose of 5 $J/cm^2$, and exposure time of 10 seconds. The tip was held perpendicular and in contact to the mucosa during the laser procedure. A total of ten irradiations each time, five by the buccal side and five by the palatal side, were carried out, distributed, and ordered as follows, in order to cover the periodontal fibers and alveolar process around the canine teeth:

(a) Two irradiation doses on the cervical third (one medial and one distal);
(b) Two on the apical third (one medial and one distal);
(c) One on the medium third (on the center of the root).

### Data Collection

The extension of canine movement was considered as the decrease of the distance between the distal slot of the canine bracket and the medial slot of the first molar bracket, measured in loco with a digital electronic caliper (L.S. Starrett Co., Athol, MA). The sequence of steps carried out during each clinical attendance is shown in Table 1. The data were compared by a paired *t*-test. After the period of 2 months, the involved area from both groups received radiographic documentation to verify any occurrence of damage to the adjacent periodontal and dental tissues.

**TABLE 1. Sequence of Steps Carried Out in Each Attendance**

| | Lased group | | | Control group | |
|---|---|---|---|---|---|
| Days | Step 1 | Step 2 | Step 3 | Step 1 | Step 2 |
| 0 and 30 | DM | AA | Laser | DM | AA |
| 3 and 33 | DM | Laser | | DM | |
| 7 and 37 | DM | Laser | | DM | |
| 14 and 44 | DM | Laser | | DM | |
| 21 and 51 | DM | | | DM | |
| 60 | DM | | | DM | |

DM, distance measurement; AA, appliance activation.

## RESULTS

Teeth were moved bodily throughout the movement procedure, showing only a slight tipping (<11°) for both groups at the end of the experimental procedure.

Table 2 shows the canine retraction in each group after 60 days. The mean value of the LG/CG ratios obtained from the patients was $1.34 \pm 0.03$, with statistical significance at the $P < 0.001$ value. Therefore, the LG retracted 34% more than the CG.

Figure 1 displays the accumulated distance during the experimental period as obtained from Table 2. It can be observed that for the lased side, the means are always higher than on the control side. Figure 2 shows the mean retraction velocity as measured between two clinical attendances using the data from Figure 1. Observe that the irradiated half always shows higher values than the CG.

The radiographies taken after the period of this study did not show any evidence of damage to the roots, alveolar bone, or periodontal tissues.

## DISCUSSION

Biologically, the orthodontic movement can be defined as the results of bone and other periodontal tissues being remodelated when some mechanic force is applied. Bone remodelating is the sum of bone absorption by osteoclasts

**TABLE 2. Retraction Obtained After 60 Days of Treatment**

| Group | Canine retraction (mm) |
|---|---|
| Lased group | $4.39 \pm 0.27$ |
| Control group | $3.30 \pm 0.24$ |

Significant difference ($P < 0.001$).

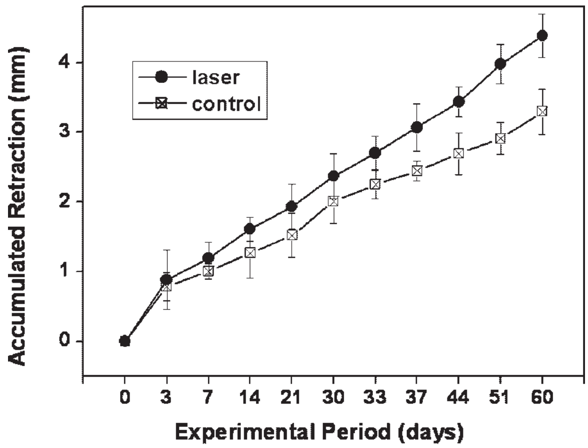


Fig. 1. Mean values ± SD of the accumulated retraction during the experimental period.

on pressure areas and bone deposition by osteoblasts on tension areas of the root. When bone absorption and deposition occur at different places of the same tooth, the result is its movement [9].

Some treatments can interfere in the bone absorption/deposition velocity [10]. Injections of prostaglandin [8,11] and osteocalcin [12] can increase the orthodontic movement, with no damage to the periodontal tissue. However, in clinical practice this is associated to pain and discomfort. In order to decrease the injection fear and avoid pain, some ways to increase bone tissue metabolism by non-invasive methods have been studied, as electric stimulation [2], ultrasound [13], or LILT [10].

It is well known that LILT can reduce discomfort and pain promoted by trauma or even by the forces applied on the teeth by a biostimulation effect in the irradiated area [4]. This stimulation could also increase bone repair, which can be considered a way to accelerate post-surgery, ortho-

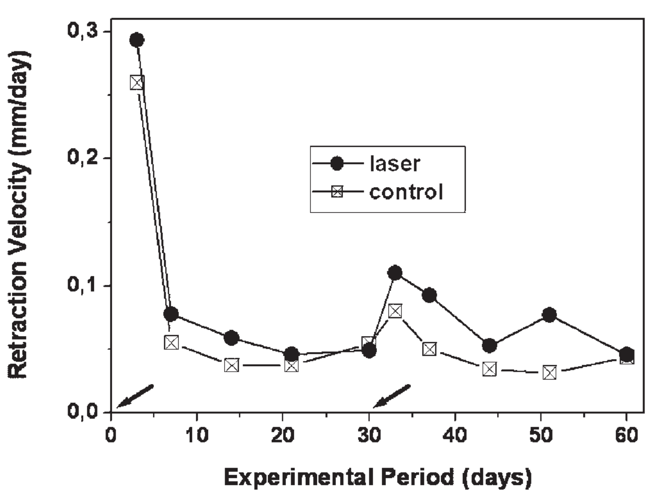


Fig. 2. Mean retraction velocity for each period as calculated from Figure 1. The arrows indicate the days at which the appliance was activated.

pedics or implant procedures. Trelles and Mayayo [14] suggest in their study, using a He-Ne laser with energy of 2.4 J applied every 2 days in broken tibia of rats, that the LILT does promote the conditions to have a faster osteosynthesis with an increase in newly formed bone quality, due to a biomodulation of the osteocytes activity and increase of blood circulation. Luger et al. [15] related that the bone mechanic properties of rats could be enhanced by LILT during the healing process. This enhancement can be the result of osteoblasts proliferation and differentiation [16], and intracellular changes in these cells [17].

Biostimulation effects on the bone repair are directly dependent on the dose applied [18]. Different parameters have proven to be effective for several different lasers, inducing changes within cell cultures and leading to an increased healing effect. Nevertheless, the optimal parameters have yet to be determined [19,20]. Luger et al. used doses of about 64 J/cm$^2$ during 14 days and although this dose could be excessive within the focused area, the authors believe that the scattering reduces the energy level of the laser beams to between 3% and 6% of its original intensity [15]. In this study, the dose of 5 J/cm$^2$ at each of the different points around the tooth is lower than the used by Luger et al. (64 J/cm$^2$), but the distribution of energy into ten points surrounding the canine teeth could be more adequate due to a more homogeneous distribution of the energy. Also, it is still unknown if LILT can act at distance from the irradiated area.

Infrared radiation has a low absorption coefficient in hemoglobin and water and consequently a high penetration depth in the irradiated tissue. It is well known that infrared radiation at 750 nm can penetrate more than visible radiation at 550 nm into soft tissues [21]. As the objective of this study was to stimulate bone cells, which are placed under the hypodermic layer, the infrared laser was selected for this study.

Some authors have analyzed the effects of LILT during orthodontic treatment in animals. Saito and Shimizu [6] studied the effects of LILT on the expansion of midpalatal sutures in rats, comparing the bone regeneration obtained with and without laser treatment. Their results showed that the therapeutic effects of laser are dependent on the total dosage, the frequency, and the duration of the treatment. Their laser irradiated group showed 20–40% better results when compared to the CG. In another study, Kawasaki and Shimizu [7] showed that the orthodontic movement of laser irradiated rats teeth was 30% quicker than the non-irradiated rats, due to acceleration of bone formation as a result from the cellular stimulation promoted by LILT.

Our findings are very similar to these reports. The ratio LG/CG obtained in this study was 1.34 (Fig. 1). This ratio could be the biostimulation factor promoted by LILT, but the literature is still scarce with respect to the effects of this treatment on orthodontic movement.

From Figure 2, we can observe that the retraction velocity measured on day 3 and 33 (always the first visit after appliance activation) are higher than on other days, specially for the LG. After some days, this difference decreases until at the end of each activation period (on day 30 and 60) when they are approximately the same. The spring coil used in this study has a constant force of $k = 12.5$ gf/mm. It means that after 1 mm of teeth movement, the force decreases 12.5 gf. Therefore the spring of the LG exerts a lower force at the end of each 30-day period. After this period, the calculated total force applied by the spring of the CG is 125 gf and for the LG is 119 gf. An activation after a period shorter than 30 days would not only maintain spring tension values closer to the initial value of 150 gf but probably also decrease the necessary treatment time even more. More investigations are necessary to show if such a procedure is safe and results in the desired effects.

It is important to ensure that damage to host tissues does not occur when a new therapeutic modality is proposed. In this study, radiographies showed no evidence of damage in the dental and periodontal tissue promoted by the LILT. Further studies are required to explain the mechanisms of laser biomodulation and clinical trails to optimize treatment parameters and discover other effects promoted by LILT.

## CONCLUSION

The results of this preliminary study suggest that LILT significantly accelerates orthodontic movement in humans with a healthy response from periodontal tissues. The irradiation parameters and protocol used in this study were successful in decreasing treatment time. As a consequence, future perspectives of this innovation are decreased treatment costs and less discomfort for the patient. Further studies are still required to explain the mechanisms of LILT and more clinical trails are necessary to optimize treatment parameters.

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