Tooth Movement After Infrared Laser Phototherapy: Clinical Study in Rodents

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Abstract

Objectives: The aim of this research was to investigate the influence of low-power laser on tooth movement in rats. **Background:** Tooth movement is closely related to the process of bone remodeling. The biologic result, with the application of a force to the tooth, is bone absorption on the pressure side and neoformation on the traction side of the alveolar bone. The laser photobiomodulation is capable of providing an increase in cellular metabolism, blood flow, and lymphatic drainage. **Methods:** Thirty young-adult male Wistar rats weighing between 250 and 300 g were divided into two groups, control and experimental, containing 15 animals each. The animals received orthodontic devices calibrated to release a force of 40 g/F, with the purpose of moving the first upper molar mesially. Low-intensity laser, wavelength 790 nm, was used in the experimental group; the dose was 4.5 J/cm² per point, mesial and distal, on the palatal side, 11 J/cm² on the buccal side, and this procedure was repeated every 48 h, totaling nine applications. The active movement was clinically evaluated after 7, 13, and 19 days. **Results and conclusion:** The results showed no statistically significant difference, $p=0.079$ (T0–T7), $p=0.597$ (T7–T13), and $p=0.550$ (T13–T19) between the laser and control groups on the amount of tooth movement in the different times evaluated. It may be concluded that laser phototherapy, with the parameters in the present study, did not significantly increase the amount of tooth displacement during induced orthodontic movement in rodents.

Introduction

TEETH MOVE PHYSIOLOGICALLY and constantly during the life span to maintain the harmony of the stomatologic system. Orthodontists considering these aspects developed a system of artificial forces to treat malocclusion and to restore the occlusion to its normal esthetics and functionality.¹

Orthodontic treatment is based on the principle that if a prolonged force is applied to a tooth, the tooth will move itself as the alveolar bone is remodeling.²

The search for rapid and safe orthodontic movement has led to several studies involving drugs or alternative or complementary therapeutic approaches or both.^{3,4} Several studies using substances such as precursors of nitric oxide, prostacyclin, thromboxane A₂, and tezocentan showed that tooth movement increases with their use.^{5–7} Conversely, in-

terleukin-1, TN α ; metalloproteinase, and γ -interferon may inhibit this movement.^{8–10}

Previous reports found elsewhere on the literature have shown that the use of infrared (IR) laser light increases orthodontic movement. This effect has been attributed to the proliferation of periodontal cells, improved local circulation, as well as an increase of the activity of both osteoblasts and osteoclasts.^{11–14} The use of laser phototherapy (LPT) on bone has been well studied.^{15–17} Previous results found elsewhere on the literature are conflicting in regard to the amount of movement achieved because of the huge variation of the parameters used.^{13,17,18}

Several aspects are important for the outcome of treatments involving the use of light sources. Most of the proposed protocols used different parameters, and this resulted in conflicting results. The choice of appropriate parameters is

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essential for the results of the treatment. These parameters include wavelength, power density, energy, and time and frequency of application.¹⁹

Laser phototherapy (LPT) may be used alone or with other techniques to stimulate tissues. It is known that the effects of LPT may not be the cause of healing.^{20–22} Some wavelengths possess therapeutic effects, and these are related to the use of adequate protocols. Laser light may affect cell metabolism in many ways and also may affect the secretion of β -endorphins, bradykinin, serotonin, and others.²³ In orthodontics, LPT has been used as analgesic and a stimulant of bone repair.^{21,24}

We aimed to study the effect of the use of IR LPT on orthodontic movement in rodents.

Methods

After approval by the Animal Experimentation Ethics Committee of the School of Dentistry of the Federal University of Bahia, we obtained 30 healthy *Rattus norvegicus* young adult-male Wistar rats with an average age of 3 months and weighing between 250 and 300 g. The animals were obtained from the Animal House of the School of Veterinary Medicine of the Federal University of Bahia and were kept at the Animal Experimentation Laboratory of the School of Dentistry of the Federal University of Bahia. The animals were kept in individual plastic cages lined with wood chips and maintained at 22°C in a day/night light cycle. The animals were fed a standard laboratory diet and had water available *ad libitum*. After a regular quarantine period, the animals were randomly distributed into two major groups with 15 animals in each. Group I acted as untreated control. The animals were subdivided into three subgroups according to the timing of the animal death (7, 13, and 19 days).

Orthodontic movement was carried out by using the apparatus devised by King et al.²⁵ The apparatus was installed on the upper arch of each animal. The force was applied by using a 0.010-inch wire (Morelli, Sorocaba, SP, Brazil) fixed to both extremities of one NiTi coil (Reflex Closed Coil Springs, light, 150 g, 3 mm; TP Orthodontics, La Porte, IN). The apparatus was installed under general anesthesia. To fix the wire anteriorly, a hole was drilled with a round bur (KG Sorensen, São Paulo, SP, Brazil) between the two central incisors. The teeth were then conditioned with 37% phosphoric acid (Alpha Acid; DFL, Rio de Janeiro, RJ, Brazil) solution. A force of 40 g/F was adjusted to the system with a dynamometer (25–250 dial type, HALDA, Halmstad, Sweden). The wire was marked on the lingual face and fixed with composite resin (Fill Magic Ortodôntico com Flúor; Vigodent, Rio de Janeiro, RJ, Brazil). Lower incisors were reduced in size to avoid damage to the apparatus during feeding. The first upper molar tooth was removed to eliminate mechanical interference (chewing) that could interfere with the desired mesial movement of the left upper first molar tooth. The apparatus used may be seen in Fig. 1.

LPT was carried out by using a diode laser (Laser Unit; Kondortech, São Carlos, SP, Brazil; λ 790 nm, 40 mW ϕ $\sim$ 2 mm, SAEF of 20 J/cm² per session).^{21,22} The treatment was carried out every other day during the experimental time, and the session dose (SAEF) was divided into three parts: 4.5 J/cm² applied both mesially and distally, and 11 J/

FIG. 1. System used for the experiment.

cm² on the buccal side, the last applied extraorally because of the anatomic impossibility of delivering the dose precisely intraorally. On this application point, the dose was increased in 20% to compensate for losses due to transcutaneous application of the light.¹⁹ Animal death occurred after overdose of general anesthetics at days 7, 13, and 19 after installation of the apparatus. The animal weight did not change significantly during the experimental time in both groups.

The forces of the coil at the different times were calculated to verify whether they remained constant during the experiment. For this, Hooke's law was used, and this indicates that the deforming force is proportional to the elastic generation caused by the force.

Measurement of the distance between the most prominent point of the mesial surface of the first molar to the perforation on the resin bulk was performed in each animal immediately and at days 7, 13, and 19. This procedure was used to assess the dislocation of the tooth and was carried out with a precision digital caliper (Beerendonk Caliper 78532; Aesculap, Tuttlingen, Germany).

Statistical analysis used the Kolmogorov-Smirnov test. Intergroup testing was carried out with Student's *t* test. Significance level was set at 5%.

Results

The data were normally distributed (Student's *t* test). Table 1 shows the central tendency of measurements and dispersion of the data (in millimeters) of the distance between the reference points on the upper central incisor to the

TABLE 1. CENTRAL TENDENCY AND DISPERSION OF MOVEMENT DURING THE EXPERIMENT

Time (days)	Group	Mean	Standard deviation
0	Control	14.711	0.683
	Laser	14.119	1.115
7	Control	13.765	0.763
	Laser	13.307	1.131
13	Control	13.331	0.857
	Laser	12.831	1.168
19	Control	12.958	0.832
	Laser	12.386	1.320

mesial surface of the upper first molar tooth on both groups during the experimental time. Table 2 shows the variation of the distance between these two points in relation to the time. The force of the coil at each time may be seen in Fig. 2. Although the force was slightly higher in the irradiated group than in the Controls, this was not significant at T7 ($p=0.079$); T13 ($p=0.455$), and T19 ($p=0.914$).

Discussion

Rodents (*Rattus norvegicus*) have been widely used in different experimental models of orthodontic movement because of their accelerated metabolism.^{2,5,7,8,10,13,26–28} For the orthodontic movement to be efficient, some variables are essential, including the magnitude and duration of the force and the morphology and alveolar bone density.¹ In our study, the initial force (40 g/F) was applied continuously to induce more tooth movement. Similar forces have been used previously.²⁷

It is known that LPT stimulates cells of the periodontal ligament, increases numbers of osteoclasts, and improves the local blood supply. These factors may be indicative that this modality of treatment may accelerate tooth movement during orthodontic treatment.²⁹

The choice of the timing of the experiments was because most studies using the animal model of tooth movement use periods of observation ranging from 10 to 15 days.^{2,9,30–32} We used the treatment at 48-h intervals, and with this time, we could assess the effect of the light during different phases of the movement.

In the present study, we measured the distance between the mesial point of the first molar and a reference point on the incisors and did not measure directly the space between the first and second molars. The main point that influenced our decision was that, when we mesially move a tooth, the adjacent tooth may also move because the presence of the transseptum periodontal fibers³³ interferes with the measurement of the distance between the first and second molars.

Some previous reports on tooth movement used contralateral control^{3,12,18} and did not consider the systemic effect of LPT,²⁵ perhaps making comparison with our results tricky. We opted for not using contralateral controls as did previous reports in the literature.^{13,17} The protocol used on our study was also based on previous studies.^{3,11,13,18}

Another aspect to consider was the site of application of the LPT. We opted for both intra- and extraoral application because of anatomic constraints. This may also further complicate comparisons with studies that used only intraoral applications.^{12,18}

TABLE 2. AMOUNT OF TOOTH DISPLACEMENT DURING THE EXPERIMENT

Time interval	Control (mm) $\pm$ SD	Laser (mm) $\pm$ SD	p ^a
T0–T7	0.946 $\pm$ 0.224	0.812 $\pm$ 0.169	0.079
T7–T13	0.434 $\pm$ 0.189	0.476 $\pm$ 0.231	0.597
T13–T19	0.373 $\pm$ 0.295	0.445 $\pm$ 0.353	0.550
T0–T13	1.379 $\pm$ 0.294	1.288 $\pm$ 0.362	0.455
T0–T19	1.753 $\pm$ 0.331	1.733 $\pm$ 0.601	0.914

^aStudent's *t* test.

SD, standard deviation.

FIG. 2. Mean and 95% confidence interval of the force (g/F) of the coil at the different experimental groups and times.

It is known that prolonged force application on one tooth will result in its displacement,^{1,2,27,34–38} as seen in the present study. We found a significant reduction in the displacement between the beginning and the end of the treatment in both control and irradiated subjects ($p < 0.001$ and $p = 0.001$), as seen in Table 1.

Our findings are indicative that the use of LPT did not significantly interfere with tooth displacement during orthodontic movement, as seen in Table 2, as mentioned previously.¹⁸ It also must be considered that this late report was based on human data and a different protocol. Conversely, different experimental setups have shown increased tooth displacement associated with the use of LPT.^{12,13} Our best result in this regard was found between T0 and T7 when LPT-treated subjects showed a smaller displacement than did the control.

The force used in the study seems not to have had a significant influence on the results, as no significant difference was found between the groups during the experimental time. We were not able to find any previous reports on the assessment of the degradation of the force during induced orthodontic movement in animals.

The fact that our results suggest that LPT does not significantly affect tooth displacement during orthodontic movement also considers previous reports that LPT possesses an analgesic effect.^{24,39} It may be possible that post-activation pain may be ameliorated by using LPT, without compromising movement. Another aspect that may also be considered is that LPT has been shown effective in bone repair after maxillary expansion, postactivation pain, and the healing of traumatic soft-tissue lesions caused by the orthodontic apparatus.⁴⁰

A study from our group showed that LPT is capable of causing histologic changes related to the movement of teeth during orthodontic movement. Habib,¹⁵ similar to us, used nonirradiated subjects as controls because of the systemic effect of the LPT, different from other studies that did not consider this aspect or did not use it. The parameters used in the present study were based on work described previously in the literature. Habib showed a significant increase in the number of osteoblasts from days 7 to 13 after activation in LPT-treated animals. It was suggested that newly formed

bone after LPT shows better quality than does nonirradiated bone and may lead to a quickening of the movement and alveolar bone remodeling. The results of Habib's study showed that LPT was able to increase the number of osteoblasts on the tension side. This aspect may lead to an improved capacity of the alveolar bone to remodel. An increased amount of collagen matrix was reported on the pressure side in irradiated subjects at both 13 and 19 days, when compared with nonirradiated animals. The same was also seen on the tension side. It is known that LPT has the capacity to stimulate both the secretion and proliferation of fibroblasts and consequent increased collagen matrix deposition. The fibroblasts of the periodontal ligament are actively involved in alveolar bone remodeling during orthodontic movement.⁴¹

The literature reports some previous works in which is suggested that laser treatment does interfere with tooth movement in rats, as this model features easy handling and standardization.^{3,12,17,29,30,36,42} Although we were not able to find a significant difference between irradiated and nonirradiated groups, we found that tooth displacement was becoming more similar during the experimental time (T0-T19; $p=0.914$). It is possible that the rapid metabolism in the animal model may also have influenced the outcome of the study. It is possible that earlier observation times may result in different findings. It is also possible that the amount of energy was too high, as other studies using less energy reported acceleration of the movement.¹³

It may be concluded that LPT, using the parameters adopted in the present study, did not significantly increase the amount of teeth displacement during induced orthodontic movement in rodents

Author Disclosure Statement

No competing financial interests exist.

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