

The effect of low level laser therapy on orthodontic tooth movement

ADRIANA MONEA*, M. MONEA, D. POP, G. BEREȘESCU

Faculty of Dental Medicine, University of Medicine and Pharmacy Tirgu-Mures, Romania

The aim of the study was to investigate if the low level laser therapy (LLLT) associated to mechanical forces stimulates the rate of orthodontic tooth movement. The study was conducted on 10 young adult subjects who required retraction of maxillary canines into first premolar extraction sites using tension elastic chain with fixed appliance. LLLT at an intensity of 20 mW/cm² was applied for 10 days buccally to the canine on the test side and using a pseudo application on the placebo site. Dental impressions, casts and profile cephalographs were taken at the beginning of the trial and 10 days post LLLT treatment. Data of the biometrical progress on both sites (study and control) were statistically compared. All subjects showed significant acceleration of the retraction of canines on the side treated with LLLT when compared to the control ($p < 0.05$). Our findings suggest that LLLT does accelerate human teeth movement and could therefore shorten the whole treatment duration.

(Received November 27, 2014; accepted January 21, 2015)

Keywords: Low Level Laser Therapy, Orthodontics

1. Introduction

Low Level Laser Therapy (LLLT) is the application of light (usually a low power laser or LED in the range of 1mW-500 mW) to pathology in order to reduce inflammation, promote tissue regeneration and relieve pain. The light is typically of narrow spectrum width in the red or near infrared spectrum (600 -1,000) nm with a power density irradiance between 1mW/cm² and 5 mW/cm². Unlike other medical laser procedures LLLT is not provoking an ablative or thermal mechanism but rather a photochemical effect comparable to photosynthesis in plants whereby the light is absorbed and exerts a chemical change [1].

Photobiomodulation by light in the red to near infrared range (630-1,000) nm using low level laser or light emitting diode (LED) arrays has been shown to accelerate wound healing. Positive outcomes of photobiomodulation have been published on pathologies as diverse as osteoarthritis [2, 3, 4], tendinopathies [5, 6], wounds [7, 8], back pain [9], neck pain [10], muscle fatigue [11, 12], peripheral nerve injuries [13], and strokes [14].

Low Level Laser Treatment (LLLT) is more often used nowadays in Dental Medicine as an adjuvant in the treatment of different conditions. It is mainly used for bone regeneration, a process which includes proliferation and differentiation of the osteoblasts, matrix formation and calcification, being influenced by biomechanical, biochemical, cellular, hormonal, and pathological factors. LLLT affects various tissue responses such as blood flow, inflammation, cellular proliferation and cellular differentiation, thus being supportive in healing processes. In 2001, Pinheiro *et al.* [15] reported that bone irradiated with infrared wavelengths shows increased osteoblastic

proliferation, collagen deposition and bone neoformation when compared to the non irradiated bone, the effect of the laser therapy being more effective if the treatment was carried out in the early stages of bone healing and remodeling, when there was high cellular proliferation.

On the other hand, orthodontic treatment is the result of orthodontic forces promoting resorption, healing, and remodeling of alveolar bone tissue. Acceleration of teeth movement is desirable, because the treatment duration is frequently of several years, but this might lead to collateral side effects such as bone necrosis or root resorption. Thus, LLLT could be a method to stimulate bone remodeling and prevent orthodontic treatment side effects.

Aim

The aim of the study was to investigate if LLLT associated to mechanical forces stimulates the rate of orthodontic tooth movement.

2. Material and methods

The study was conducted on 10 young female adult subjects aged 15 to 18 years, nonsmokers, who had their left and right first maxillary premolars extracted for orthodontic purposes. Fixed orthodontic appliance was installed to close the space created and to restore an ideal occlusion and facial esthetic. The orthodontic appliance was constructed with Roth brackets from right to left second maxillary premolars, with slot .022 (Avex™ Suite, Opal Orthodontics by ULTRADENT), bonded with Opal® Seal Adhesive Kit (Opal Orthodontics by ULTRADENT). A palatine bar bonded on the first molars, cemented with Glass Ionomer Cement (Ketac-Cem®, ESPE Dental-Medizin GmbH & Co., Germany) 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 rectangular wires (0.16 x 0.22). The teeth were tied to wires using elastic ligatures. The rectangular wire guided the canine retraction, which was done using an elastic chain (Opalastic Chain, Opal Orthodontics by ULTRADENT) positioned from the canine to the first molar band.

Laser irradiation was done with OsseoPulse® AR300 device (BIOLUX, Canada) at an intensity of 20 mW/cm² applied for 10 days buccally to the canine on the test side and using a pseudo application on the placebo side.

Dental impressions, casts and profile cephalographs were taken at the beginning of the trial and 10 days post LLLT treatment. Data of the biometrical progress on both sites (study and control) were statistically compared.

The degree of canine movement was considered as the distance between the distal slot of the canine bracket and the mesial slot of the second premolar bracket, measured in loco with a digital electronic ruler and on the study models taken before, during and after LLLT treatment.

The patients and their legal responsible were informed about the risks and benefits of the procedure and they consented to participate in this study. Ethical approval was obtained from the Ethical Committee of the University of Medicine and Pharmacy Tîrgu-Mures, Romania.

3. Results

The canines were moved bodily throughout the orthodontic treatment, with a slight tipping ($< 10^\circ$) in both groups. All patients showed significant acceleration of the retraction of canines on the side treated with LLLT when compared to the control side ($p < 0.05$). The figures below show clinical aspects before extractions, at the beginning of LLLT and 10 days post LLLT. It can be observed that canine retraction is always higher in the lased side compared to control side. Depending on the initial diagnosis and lack of space, in some cases we did succeed total space closure at 10 days post LLLT.



Fig. 1. Upper arch – initial aspect.



Fig. 2. Upper arch aspect at the end of LLLT (10 sessions).



Fig. 3. Complete closure of extraction space at 10 days post LLLT.



Fig. 4. Upper arch – initial aspect.



Fig. 5. Upper arch aspect at the end of LLLT (10 sessions).



Fig. 6. Upper arch aspect at 10 days post LLLT.

Table 1 shows canine retraction values after 10 days of LLLT and at 10 days post LLLT for each group. The mean value of canine retraction in lased group was significant higher than in the control group for both time intervals.

Table 1. Retraction obtained after 10 days of LLLT treatment and at 10 days post LLLT treatment

Group	Canine retraction at the end of LLLT (mm)	Canine retraction after 10 days post LLLT (mm)
Lased side	1.38 ± 0.27*	3.39 ± 0.20**
Control side	0.82 ± 0.24*	1.73 ± 0.18**

*Significant difference ($p < 0.05$)

**Extremely significant difference ($p < 0.001$)

4. Discussions

Our results showed that LLLT treatment can accelerate tooth movement during orthodontic treatment, shortening the whole treatment duration, without dental or periodontal side effects.

In our study we measured canine retraction of (1.38 ± 0.27) mm in lased side compared to (0.82 ± 0.24) mm in control side at 10 days of LLLT ($p < 0.05$). At 10 days post LLLT we found an extremely significant difference ($p < 0.001$) between canine retraction values in lased side (3.39 ± 0.20) mm versus control side (1.73 ± 0.18) mm. These results correlate with other reports on the effect of LLLT during orthodontic treatment in animals [16, 17]. These authors showed (20-40) % better results in the LLLT treated group compared to controls, our findings being similar to these reports.

Photobiomodulation by light in the red to near infrared range (630-1,000) nm using low level laser or light emitting diode (LED) arrays has been shown to accelerate wound healing. Several studies have demonstrated that the LLLT can biomodulate and accelerate the repair process stimulating cell proliferation and vascularisation in the injured tissues [18, 19, 20]. Recent evidence indicates that the therapeutic effects of the red to near infrared light results in part from intracellular signaling mechanism triggered by the interaction of the NIR light with the mitochondrial photoreceptor cytochrome c oxidase. Low energy photon irradiation by light in the far to near infrared spectral range (630-1,000) nm using light emitting diode arrays or low energy lasers has been proved to modulate several biological processes in animal models and cell cultures [21, 22]. At cellular level, photo-irradiation at low frequencies can generate significant biological effects including cellular proliferation, collagen synthesis and release of the growth factors from the cells [23]. Moreover, photobiomodulation has been applied clinically in the treatment of soft tissue injuries and to accelerate wound healing for more than 30 years [24].

Investigations into low energy stimulation of tissue by lasers have shown to increase cellular activity during wound healing including increase collagen production and angiogenesis [23, 25]. The data suggested that the monochromatic near infrared laser biostimulation produces its primary effect during the cell proliferation phase. Lasers, however have some properties that make their use in clinical settings problematic including the limitation in the wavelength and the beam width. NASA however developed light emitting diode LED as an alternative to the lasers. These diodes can be configured to produce multiple wave lengths, can be arranged in different arrays in order to cover large wounds that have to be treated and they produce no heat. Furthermore the LED therapy has been deemed a non-significant risk by the FDA and the FDA approval for the use of LEDs in human for light therapy has been obtained. The optimal wavelength used in the treatment of wound healing ranges from 630 nm to 1,000 nm [23, 24, 26, 27, 28]. The depth of LED light penetration in the human tissue has been measured spectroscopically and it has been demonstrated that most of the photons at wavelengths between 630nm and 800 nm travel approximately 23 cm through the skin surface and muscle [26, 27].

The clinical importance of our findings is that LLLT associated to orthodontic treatment leads to accelerated

orthodontic movements with a healthy response from periodontal tissues, shortening whole treatment duration and lowering treatment costs.

Limitations of the study are that we included only young adult females, non-smokers, in order to minimize confounding variables. Further research should include smokers, as unfortunately smoking is a common habit in Romanian young population, that can interfere with blood circulation and bone remodeling. Also, further studies are required to optimize LLLT parameters.

5. Conclusions

Our findings suggest that LLLT does accelerate human teeth movement and could therefore shorten the whole treatment duration.

The irradiation parameters and protocol used in this study were successful in decreasing treatment time.

LLLT continued to have effects on tooth movement and bone remodeling even after ending of treatment sessions.

LLLT is a simple to perform therapy and uses equipments that can be utilized for several different treatments in the clinical practice, such as orthodontics.

Further studies are required to optimize the treatment parameters.

Acknowledgement

This paper was published under the frame of European Social Found, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/136893.

References

- [1] J. S. Huangh, X. B. Zhu, *Clin Oral Implants Res* **20**(8) 772 (2009).
- [2] L. E. Bertolucci, T. Grey, *TMJ degenerative joints. Cranio.* **13**, 26 (1995).
- [3] F. Özdemir, M. Birtane, S. Kokino. *Clinical rheumatology* **20**(3), 181 (2001).
- [4] J Stelian, I Gil, B Habot, M Rosenthal, I Abramovici, N Kutok, A Khahil. *J Am Geriatr Soc.* **40**, 23 (1992).
- [5] J. M. Bjordal, R. A. B. Lopes-Martins, V. V. Iversen. *British journal of sports medicine* **40**(1), 76 (2006).
- [6] Stergioulas, Apostolos, et al. *The American journal of sports medicine* **36**(5), 881 (2008).
- [7] Ozcelik, Onur, et al. *Journal of clinical periodontology* **35**(3), 250 (2008).
- [8] Schubert, Mark M., et al. *Supportive Care in Cancer* **15**(10), 1145 (2007).
- [9] Basford, Jeffrey R., Charles G. Sheffield, William S. Harmsen. *Archives of physical medicine and rehabilitation* **80**(6), 647 (1999).
- [10] Chow, Roberta T., et al. *The Lancet* **374**(9705), 1897 (2009).
- [11] Junior, Ernesto Cesar Pinto Leal, et al. *European journal of applied physiology* **108**(6), 1083 (2010).
- [12] Junior, Ernesto Cesar Pinto Leal, et al. *Lasers in medical science* **24**(3), 425 (2009).
- [13] Rochkind, Shimon, et al. *Photomedicine and laser surgery* **25**(3), 137 (2007).
- [14] J. A. Zivin, G. W. Albers, N. Bornstein, T. Chippendale, B. Dahlof, T. Devlin, M. Fisher, W. Hacke, W. Holt, S. Ilic, S. Kasner, R Lew, M. Nash, J. Perez, M Rymer, P Schellinger, D Schneider, S Schwab, R Veltkamp, M Walker, J. Streeter Effectiveness and safety of transcranial laser therapy for acute ischemic stroke. *Stroke* **40**, 1359 (2009)
- [15] A.L.B. Pinheiro M.G. Oliveira, P.P.M. Martins et al *Biomodulatory effects of LLLT on bone regeneration Laser Ther* **13**:73-9, (2001)
- [16] Saito, Shiro, and Noriyoshi Shimizu. *American journal of orthodontics and dentofacial orthopedics* **111**(5), 525 (1997).
- [17] Kawasaki, Koichiro, Noriyoshi Shimizu. *Lasers in surgery and medicine* **26**(3), 282, (2000).
- [18] A Benedicenti, M Verrando, F Cherleone, O Brunnetti, *Paradontol Stomatolog* **23**(2), 167 (1984).
- [19] Dörtbudak, Orhun, Robert Haas, Georg Mailath-Pokorny, *Clinical oral implants research* **11**(6), 540 (2000).
- [20] I. Garavello-Freitas,, et al. *Journal of Photochemistry and Photobiology B: Biology* **70**(2), 81 (2003).
- [21] Karu, Tiina I., Ludmila V. Pyatibrat, Galina S. Kalendo, *Lasers in surgery and medicine* **29**(3), 274 (2001).
- [22] T Karu, *Low level laser therapy Biomedical Photonics Handbook CRC press LLC chapter* 48, (2003)
- [23] AP Sommer, ALB Pinheiro, AR Mester, RP Franke HT. Whelan, *J Clinc Laser Med Surg* **19**, 29 (2001)
- [24] TI Karu, *Photobiology of low level laser therapy, Harwood, Academic London* (1989)
- [25] Posten, William, et al. *Dermatologic surgery* **31**(3), 334 (2005).
- [26] B Beauvoit, Sm Evans, TW Jenkins, EE Miller *Anla Biochem* **226**, 167 (1995)
- [27] B Beauvoit, T Kitai, B. Chance, *Biophys. J.* **67**, 2501 (1994).

*Corresponding author: adriana.monea@gmail.com