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Periodontal effects with self ligating appliances and laser biostimulation

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ABSTRACT

Background: Recently, various biostimulation's effects of low energy laser irradiation have been reported. The present study was designed to examine the effects of low-energy laser irradiation on alveolar bone remodelling during orthodontic tooth movement and finally on formation of new keratinized gingiva.

Materials and Methods: 22 patients and 27 teeth in vestibular mucosal without keratinized gingiva were selected. Every patient was treated with self ligating appliances. In every orthodontic session the patient was treated with Diode laser biostimulation. At the moment of debonding, 27 teeth involved in the research were evaluated in terms of quality and quantity of attached gingiva. BOP and CAL loss were investigated.

Results: Every tooth considered at the end of orthodontic treatment showed an attached gingiva around the crown: The average of keratinized gingiva at the end of the study was 3.10 mm and the mean increasing at each month was 0,49 mm.

Conclusions: The combination between self ligating appliances and laser's biostimulation could improve the differentiation of periodontal ligaments stem cells in fibroblasts, able to promote attached gingiva around the crown of the teeth erupted in oral vestibular mucosa.

Key Words: Biostimulation, low friction, periodontal tissue, stem cells

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INTRODUCTION

In orthodontic treatment, tooth movement is related to the response to applied orthodontic forces that cause remodelling of the periodontal tissues, especially alveolar bone. The typical 2- to 3-year treatment period is burdensome for patients, so it is very important to accelerate alveolar bone remodelling during treatment in order to abbreviate the required time.

Recently, various biostimulatory effects of low energy laser irradiation that involves wound healing and fibroblast proliferation, collagen synthesis, and nerve regeneration have been reported.[1-3] In particular, the acceleration of bone regeneration by laser treatment has been a focus of contemporary researches. Therefore, if laser irradiation can cause the acceleration of bone remodelling, it may also have great benefit in abbreviating the orthodontic treatment period.[1,2]

The present study was designed to examine the effects of low-energy laser irradiation on alveolar bone remodelling during orthodontic tooth movement and on formation of new keratinized gingiva.

Low level laser therapy

Low level laser therapy (LLLT) is also known as "soft laser therapy" and bio-stimulation. The use of LLLT in health care has been documented in the

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literature for more than 30 years and many research studies have demonstrated that LLLT is effective for some specific applications in dentistry. Recently, various effects of low-energy laser irradiation have been reported, including wound healing, fibroblast proliferation, collagen synthesis and nerve regeneration. In particular, the focus of recent studies has been the acceleration of bone regeneration by laser treatment.[1-3]

In orthodontics, low-energy laser irradiation can be useful for several different treatments, such as: Reduction of post-adjustment pain, treatment of traumatic ulcers in the oral mucosa induced by an orthodontic appliance, increasing keratinized gingiva.[4] It is also been demonstrated that LLLT stimulates the velocity of tooth movement and the osteoclastogenesisin the pressure site via stimulation of the activator receptor of nuclear factor kappa B (RANK)/RANK ligand (RANKL) system and by the expression of the macrophage colony-stimulating factor (M-CSF)/its receptor (c-Fms) expressions.[3]

Mechanism of action

The mechanisms of low level laser therapy are complex, but essentially rely upon the absorption of particular visible red and near-infrared wave-lengths in photoreceptors within sub-cellular components, particularly the electron transport (respiratory) chain within the membranes of mitochondria. The absorption of light by the respiratory chain components causes a short-term activation of the respiratory chain, and oxidation of the NADH pool. This stimulation of oxidative phosphorylation leads to changes in the redox status of both the mitochondria and the cytoplasm of the cell. The electron transport chain is able to provide increased levels of promotive force to the cell, through increased supply of ATP, as well as an increased in the electrical potential of the mitochondria membrane, alkalization of the cytoplasm, and activation of nucleic acid synthesis. Because ATP is the “energy currency” for a cell, LLLT has a potent action that results in stimulation of the normal functions of the cell.[1]

By increasing the respiratory metabolism of the cell, LLLT can also affect the electro-physiological properties of the cell. This has relevance in terms of mast cells, which are triggered to respond by ionic gradients.[1]

In addiction it has been demonstrated that laser irradiation stimulates cellular proliferation and differentiation of osteoblast lineage nodule-forming cells, especially in committed precursors, resulting in an increase in the number of differentiated osteoblastic cells as well as in bone formation.

LLLT has also been shown to cause vasodilatation, with increased local blood flow. This vasoactive effect is of relevance to the treatment of joint inflammation such as those may occur in the TMJ.

The effects of different types of light on mast cells are well recognized. There is direct evidence that 660, 820, and 940 nm light can trigger mast cell degranulation. These types of cell are distributed preferentially about the microvascular endothelium in skin, oral mucosa and dental pulp. Mast cells in these locations contain the pro-inflammatory cytokine TNFα (tumor necrosis factor) in their granules. Release of TNFα promotes leukocyte infiltration of tissues by enhancing expression of endothelial-leukocyte adhesion molecules.[2]

In addition, must cell proteases, such as chymase, facilitate entry of leukocytes into tissues.[2]

Because mast cells play a fundamental role in controlling leukocyte traffic, modulation of mast cell functions by LLLT can be of considerable importance in the treatment of sites of inflammation in the oral cavity.

A final aspect of the effect of LLLT on cells is related to the effects of laser light on the cytoskeleton. Several studies have suggested that LLLT can modulate cell behaviour by causing re-arrangements of the cytoskeleton. Myofibroblasts are responsible for the contraction force during wound healing. These cells are observed in normal tissue, granulation one, and some pathological conditions. Because LLLT is an effective stimulator of differentiation to myo-fibroblasts, the process of wound healing should be accelerated.[1,2]

LLLT has also been proven to reduce synthesis of inflammatory mediators in neural tissue, as well as more rapid maturation and regeneration, particularly axonal growth. It also reduces pain in patients suffering from post-herpetic neuralgia, from cervical dentinal hypersensitivity, and from periodontal pain during orthodontic tooth movement.

In conclusion low level laser therapy accelerates wound healing and reduces pain, by stimulating oxidative phosphorylation in mitochondria and modulating inflammatory responses. By influencing the biological function of a variety of cell types, it is able to exert a range of several beneficial effects upon inflammation and healing.

Low friction techniques (Low Forces)

The low friction philosophy is based on the principle of using just enough force to initiate tooth movement-the threshold force. The underlying principle behind the threshold force is that it must be low enough to prevent occluding the blood vessels in the periodontal ligament. This allows the cells and the necessary biochemical messengers to be transported to the site where bone resorption and apposition will occur, thus permitting tooth movement.[5-7]

A passive self-ligation mechanism has the lowest frictional resistance of any ligation system.

The forces generated by the archwire are transmitted directly to the teeth and the supporting structures without absorption or transformation by the ligature system. The forces generated by elastomeric ligatures can have unwanted effects on treatment progress.[5-7]

Compared with conventional edgewise appliances, the use of passive self-ligation results in a significant reduction in the:

1. Use of anchorage devices, because the frictional resistance generated by ligatures is not present. It was demonstrated that passive self-ligating appliances use less anchorage than conventional appliances. This supports the reduction in the use of anchorage devices experienced by users of passive self-ligation.
2. Use of intraoral expansion auxiliaries because the force of the archwire is not transformed or absorbed by the ligatures and the necessary expansion can be achieved by the force of the archwires.
3. Need for extractions to facilitate orthodontic mechanics because alignment is not hindered by ligature frictional resistance and can therefore largely be achieved with small diameter copper nickel titanium archwires. Tooth alignment therefore places minimal stress on the periodontium and the possibility of iatrogenic damage to the periodontium is reduced.[5-7]

In addition, a passive self-ligation system provides three key features:

1. Very low levels of static and dynamic friction.
2. Rigid ligation due to the positive closure of the slot by the gate or slide.
3. Control of tooth position because there is a slot of adequate width and depth.

This allows extended intervals between treatment visits, particularly in the early stages of treatment, a reduced number of visits during a course of treatment, and shortened treatment times.

The static friction developed by passive self-ligating brackets is almost negligible. As angulation[8] or inclination is applied to the bracket, binding occurs although the force generated by this binding is less for self-ligating brackets than for conventional ligation.

If alignment and space closure can be achieved more quickly with self-ligating brackets due to reduced friction, the treatment times might be shorter using self-ligating brackets.[5,6]

Combination between LLLT and low friction techniques during the orthodontic treatment of teeth erupted in oral mucosa (without keratinized gum) makes possible the formation of new keratinized gingiva.

MATERIALS AND METHODS

The sample of this clinical trial comprised a total of 22 patients and 27 teeth (10 upper cuspids, 8 lower cuspids, 3 upper first bicuspids, 2 upper second bicuspids, 3 lower first bicuspids and 1 lower second bicuspid) erupted in oral mucosa completely without keratinized gingiva. Vestibular infra-bone position of cuspids was detected in 4 of these patients [Figure 1]. It was made a surgical approach with a Diode Laser [Figure 2].[8-12] All the patients were treated with passive self-ligating orthodontic appliance system using termicarchwire 0-13 AM ORTH and these teeth were bio-stimulated with laser (LLLT). We used different brackets, in particular: Time (AM ORTH) in 70% of treated subjects (Time2 for 40% and Time3 for 30%), Smartclip (3M Unitek) in 15%, and Empower (AM ORTH) in 15%. A diode laser with a wavelength of 980 nm and continuous wave at 1 Watt output power was used in the study.

The average age of the sample was 13,5-years-old and the female patients were 13 instead the male ones were 11.

The laser used is a Diode laser 980 nm (Wiser-Doctor Smile). The beam was delivered by a plane wave optical fiber (Doctor SmileManipoloOndaPiana) and irradiation was administered by placing the end of the optical fiber tip direct where missing keratinized gingiva, on cement-enamel junction (CEJ) of

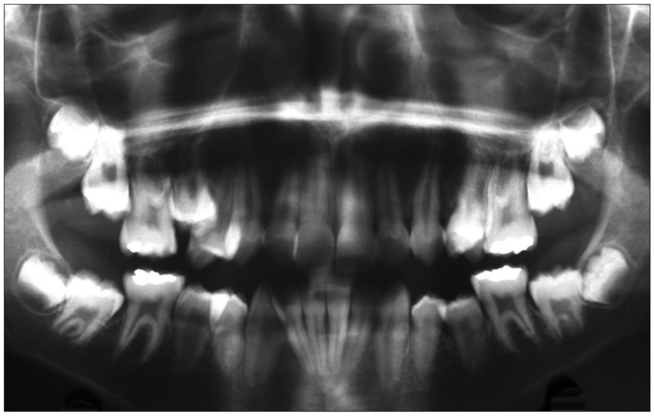

Figure 1: X ray: 25 impacted

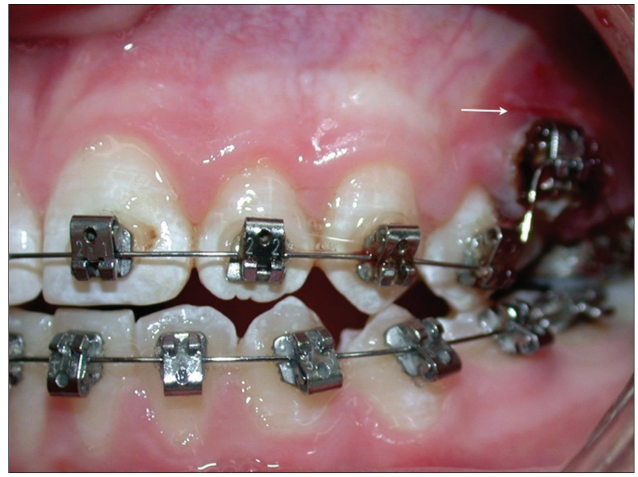

Figure 2: 25: Surgical approach with Diode Laser. No attached gingiva at Time 0. First bio-stimulation therapy at the end of the surgery. Self ligating orthodontic treatment. Time 2 Appliance (AM ORTH)

upper and lower cuspids and bicuspids undergoing orthodontic tooth movement (1,5 cm as minimum on defocalization, as prescribed by the Producer, Doctor SmileManipoloOndaPiana). Irradiation was performed for 50 seconds at each point × 3 times, every 2 minutes on relaxing time, (a total of 150 seconds) once a month on months 0-6 (a total of seven times). We utilized 1 watt, continuous wave, as indicated by the producer (Doctor Smile-ManipoloOndaPiana) The energy density corresponding to an exposure time of 150 seconds was150J/cm^2, (every second the fluence is 1J/cm^2).

To assess the amount of increasing keratinized gingiva every months, measurement were made using a periodontal probe before (T0) and after laser irradiation (months 1, 2, 3, 4, 5, and 6); each measurement was taken twice and it was used the average value. The experimental periods for observation were set at 1, 2, 3, 4, 5 and 6 months after irradiation. At the time T0 the measurement of keratinized gingiva was 0 mm because the teeth analyzed were erupted in ectopic site in oral mucosa [Table 1].

Statistical analysis

Descriptive statistics, including the mean and standard deviation (SD) were calculated for each patient and for each monthly measurement.

Statistical analysis of data was performed using the analysis of variance (ANOVA) with software for Windows (ver. 5.0). Values that were not significant were defined as $P > 0.05$.

Table 1: Measurement of increasing keratinized gingiva using a periodontal probe before (T0) and after laser irradiation (months 1, 2, 3, 4, 5, and 6)

T0	T1	T2	T3	T4	T5	T6
0,00	0,54	1,08	1,57	1,92	2,54	3,13
0,00	0,50	0,98	1,47	1,98	2,67	3,02
0,00	0,60	1,15	1,63	1,92	2,72	3,24
0,00	0,62	1,09	1,61	2,02	2,55	2,96
0,00	0,40	0,88	1,52	1,94	2,57	2,98
0,00	0,54	1,06	1,57	1,92	2,65	3,10
0,00	0,42	1,15	1,66	2,02	2,73	3,12
0,00	0,40	0,89	1,30	1,83	2,52	2,97
0,00	0,36	0,98	1,47	1,92	2,64	2,90
0,00	0,62	1,06	1,57	2,12	2,67	3,23
0,00	0,50	0,79	1,31	1,96	2,58	3,35
0,00	0,56	1,09	1,60	2,15	2,69	3,27
0,00	0,59	1,14	1,69	2,18	2,71	3,27
0,00	0,45	0,94	1,45	1,95	2,50	3,05
0,00	0,61	0,88	1,39	1,98	2,55	2,73
0,00	0,48	0,92	1,43	1,92	2,53	2,72
0,00	0,38	1,01	1,47	1,94	2,58	2,80
0,00	0,52	1,07	1,56	2,06	2,72	3,43
0,00	0,43	0,96	1,42	1,92	2,58	3,06
0,00	0,47	1,09	1,59	2,12	2,65	3,45
0,00	0,56	1,02	1,54	2,13	2,63	3,37
0,00	0,37	0,88	1,46	1,91	2,57	3,02
0,00	0,40	0,90	1,42	1,98	2,58	3,42
0,00	0,47	0,78	1,38	1,93	2,65	2,82
0,00	0,42	0,82	1,33	1,92	2,53	2,74
0,00	0,55	1,06	1,58	2,22	2,71	3,35
0,00	0,53	0,98	1,53	2,15	2,64	3,15

Addiction - 83,65 mm, Average - 3,10 mm, Standard deviation - 0,225048 mm; Figures in table are in mm

RESULTS

The average keratinized gingiva at the end of the study is 3.1 mm and the mean increasing at each month is 0,49mm [Figure 3]. The effect of laser biostimulation was evident from the first month. There weren't significantly differences between males and females neither for age.

Figure 3: 3,45 mm of attached gingiva around the crown of 25, after 6 month of Self- Ligating orthodontic therapy and LLT Biostimulation as discussed in the paper

DISCUSSION

Passive self-ligation offers the most direct transmission of force from archwire to tooth with very low friction, secure ligation, and excellent control of tooth position. All contemporary modalities of orthodontic treatment can achieve tooth alignment; passive self-ligation, however, does achieve results effectively, and in a way that corresponds with patient wishes. In addition, practitioners experienced with the technique perceive that additional, unexpected patient benefits occur that are not traditionally associated with conventional orthodontic treatment.

Teeth can moved with or through bone depending on the strain generated in the surrounding periodontium.[13,14] The force system applied attempted to generate a maximum distribution of low forces, thus avoiding local necrosis and ischemia of the periodontal ligament. In addition it can be assumed that the patient's oral hygiene was maintained during treatment.

In order to improve the effects of low friction in bone remodeling, we have tested the combined use of laser, in particular the low energy laser therapy.

While much of the initial work with LLLT used the helium-neon gas laser (λ = 632.8 nm), nowadays most LLLT clinical procedures are undertaken using semiconductor diode lasers operating (at λ = 830 nm or λ = 980 nm wavelengths), as the one we have used in this study. Since wavelength is the most important factor in any type of phototherapy, the clinician must consider which wavelength are capable of producing the desired effects within living tissues.

The typical power output for a low level laser device used for this therapy is of the order of 10-50 mW, and total irradiances at any point are of the order of several Joules. Thermal effects of LLLT on dental tissues are not significant, and do not contribute to the therapeutic effects seen. The wavelengths used for LLLT have a low absorption coefficient in hemoglobin and water, and consequently, a high penetration depth in the irradiated soft and hard tissue from 3 mm to up to 15 mm. The extensive penetration of red and near-infrared light into tissues has been documented by several investigators. As the energy penetrates tissues, there is multiple scattering by both erythrocytes and microvessels, and so both blood rheology and the distribution of microvessels in the tissue influence the final distribution pattern.

Laboratory studies of low level laser effects[15] have demonstrated a range of bio-stimulation effects: For fibroblasts, increased proliferation, maturation and locomotion have been noted, as well as transformation to myofibroblasts, reduced production of pro-inflammatory prostaglandin E_2, and increased production of basic fibroblast growth factor. These effects have been reported for fibroblasts from the skin, buccal mucosa and gingival, all of which show increased proliferation at low doses (e.d. 1,8 J/cm^2). Of note, high dose LLLT suppresses both fibroblast proliferation and autocrine production of basic fibroblast growth factor. Several studies have been conducted to understand how different approaches on implant surface can influence survival of the same.[16-22] Histological studies in oral mucosal wound healing[23-25] have demonstrated that laser irradiation improves wound epithelialization, cellular content, granulation tissue formation, and collagen deposition in laser-treated wounds, compared to untreated sites.

In conclusion patients with teeth erupted in ectopic position get benefit from combined use of LLLT and self ligating orthodontic appliance in order to improve the formation of new area of keratinized gingival in particular in this study we obtained about 3,1 mm of this one.

In the field of orthodontics, low energy laser irradiation is utilized for several different types of orthodontic treatment, such as reduction of post adjustment pain or treatment of traumatic ulcers in the oral mucosa caused by the appliance. However, scant information is available concerning the effects of LLLT on bone remodelling during orthodontic tooth movement. This might be a method to enhance tooth movement.

CONCLUSION

Low friction in addition to LLLT can stimulate keratinized gingiva under maintenance of good oral hygiene in patients with teeth erupted in oral mucosa completely without keratinized gingival.

Low forces can stimulate the periodontal remodelling instead low energy laser irradiation can enhance the differentiation of periodontal undifferentiated cells into fibroblastic lineage in order to form keratinized gingiva.

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