EFFECTS OF ADJUNCTIVE LASER PHOTOBIOMODULATION IN THE CLASSICAL TREATMENT OF PERIODONTAL DISEASE

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The objective of our work was to study the photobiomodulatory effects of low level laser therapy in addition to classic treatment of various periodontal diseases. Low level laser therapy is commonly used with good results in many medical domains, but the underlying mechanisms have not entirely been elucidated and 'gold standard' optimum working protocols have not yet been established in dentistry. The laser beam parameters and the application techniques are very important, as the clinical results depend entirely upon them. The bleeding time, pain relief time, and the bone recovery time in the treatment of periodontal disease were measured, and other non-quantifiable results (e.g. reduction of inflammation and oedema) were followed in two groups: the control group who underwent classic treatment of periodontal diseases, and the experimental group where LLLT was applied in addition to the classic treatment. In all cases, the measured parameters were less severe or shorter for the experimental group then for the control group. Very good results were obtained for the patients suffering from diabetes. In conclusion, in all cases, LLLT as adjunctive therapy to classical treatment led to better results in the treatment of periodontal diseases, but the results also depended upon the age and general health of the patients, and existence of any metabolic problems.

Key words: LLLT, periodontal disease, adjunctive laser therapy

Introduction

Since 1970, some 10 years after the development of the first laser, there was evidence that laser irradiation could result in modulation (stimulation or inhibition) of biological processes.(1) At its very beginnings, low level laser therapy (LLLT), to follow the terminology of Ohshiro and Calderhead,(2) was mostly empirical in nature, and was not firmly based on *in vitro* studies, so that the mechanisms of interaction between low incident levels of laser energy and living mater were unknown. This empirical character of the clinical investigations lasted a long time, especially because many laser therapy users did not fully understood the principles of lasers, the characteristics of the laser beam, and the interaction mechanisms. As a consequence, many of the published works concerning the beneficial effects of laser irradiation did not mention the laser parameters, so that systematization was very difficult. The question of laser beam parameters is therefore of very great importance, because the effects depend, sometimes critically, on them.(3,4) We studied the effects of low level laser therapy in addition to conventional treatment of periodontal disease.

Periodontal disease, in both its acute and chronic forms, is an infection that attacks the periodontium (the ligaments around the teeth), the gingival tissue, the root, and the alveolar (or jaw) bone that supports the tooth. Left untreated, periodontal disease can result in tooth loss. The main cause of periodontal disease is a bacterial plaque, but there several other factors that contribute to the disease process: genetic – 30% of the population; traumatic occlusion; specific medication; hormonal dysregulation, systemic diseases; some renal or hepatic conditions; diabetes; osteoporosis; metabolic calcium dysfunction; immune system deficiency; lack of vitamins; use of excessive medication; anemia, and so on.

The present study was designed to assess the possible beneficial effect of LLLT as an adjunctive therapy together with classical treatment methodology,

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compared with the application of classical treatment on its own, in a variety of conditions and patients of different age groups.

Materials and methods

Patient selection

We enrolled 55 patients suffering from marginal to profound periodontal disease, grade 2 to 3. All these patients where treated in two ways (on the upper and, respectively, lower maxilla): with classical treatment of the periodontal diseases (representing the control group), and with LLLT in addition to the classical treatment (experimental group).

The patients were also divided into two age groups: young adults, 18–40 years (34), and mature adults, 41–70 years (21); each of these groups was further divided into four sub-groups (Table 1): Healthy (12, respectively 5); with toxic pathology concerning hepatic and renal diseases (9, respectively 5); with a calcium metabolic related disorder – osteoporosis (7, respectively 4); and with nutrition pathology – diabetes (6, respectively 7).

Classical Treatment

The applied classic periodontal disease treatment began with the initial steps: local and general anti-inflammatory prophylaxis; elimination of the acute complaints, such as pain, mastication problems, and edema; prophylaxis and hygiene of the oral cavity; oral rehabilitation and rebalance of the bite, oral dysfunctions, incorrect prosthetics or existing indentation, parodontium and bone nutrition. This was followed by elimination, as much as possible, of the main causes of, and of the predisposing factors to the disease, such as immune system deficiency, lack of vitamins, use of excessive medication, anemia, and so on. Biotherapy was also indicated with vaccines, vitamins and other steps for improving the immune system.

The surgery protocol consisted of sub-gingival curettage, i.e. removing the edema, the exudates, the inflammation, and the elimination of the periodontal pockets, which lead to an edematous plague with moderate bleeding. In those cases when it was possible, we performed hydroxyapatite and collagen implantation.

After the surgical intervention, anti-inflammatory treatment continued daily. Patients were monitored and called every 3 to 6 months for consulting, cleaning and other procedures.

Laser Parameters

We used an infrared diode laser(5) type BF (EN 60 601-1, BTL Company Ltd., Czech Republic), class 3B, safety class 1, with two laser beams, one infrared with a wavelength $\lambda = 830$ nm, and another visible red beam with a wavelength $\lambda = 630$ nm, convergent beam, energy between 0.5 and 3.0 J, applied continuously or in pulsed mode with a frequency of 4.68 Hz or 9.12 Hz. The parameters were adjusted depending upon the necessary penetration depth (2.5 – 12 mm).

Low Level Laser Therapy Protocol

We conceived the irradiation protocol following the data in the literature,(6,7) and our own experience.(8)

During surgery: Immediately after surgical curettage, we applied laser irradiation onto the bone, into the interdental spaces, with no contact with the surgical plaque, 0.5 J/cm^2 for each application, in pulsed mode. Before the suture, we irradiated again, into the external plan, in contact with the skin, with 2 J/cm^2, by scanning the entire operated area. Thirty minutes after suturing, we applied 1–4 J/cm^2 on each hemi-arcade area, the total dose being 4–16 J/cm^2. The protocol was individualized according to the diagnosis.

Post surgery protocol: In the first three days, we irradiated the external cheek over the area of interest at the same dose every day. In acute forms, we applied a dose of 4 J/cm^2 every two days, in the first and second week for two sessions/week, followed by one session in the third week. In the following six months, we applied one irradiation session monthly, at the same dose. In the chronic cases, the treatment was longer, performing more irradiation sessions but at smaller doses. The protocol was individualized depending on the age and the heath status of the patients. Fewer sessions were required in the young patient group, because they responded better. In the case of those with hepatic or renal toxicity, the treatment per session was longer with more sessions required, and did not depend on the age of the patient.

Maintenance: Laser irradiation was repeated every six months, preferably in autumn and spring, in addition to the conventional local and general treatments used in periodontal disease prophylaxis and for boosting the immune system. We reevaluated the results from the X-ray findings after six months, one year, and two years. Enzymatic sterilization of all instruments was performed preoperatively. During laser irradiation, the patient, as well as the entire medical personal in the room, wore protective goggles of an appropriate optical density for the wavelengths being used, to avoid accidental optical exposure.

Evaluation Parameters and Measurement Methods

The evaluations parameters were gingival bleeding time; pain relief time; and bone recovery time.

Gingival bleeding time: We considered the gingival bleeding time as the time interval from the end of the curettage until the formation of a blood clot, established with

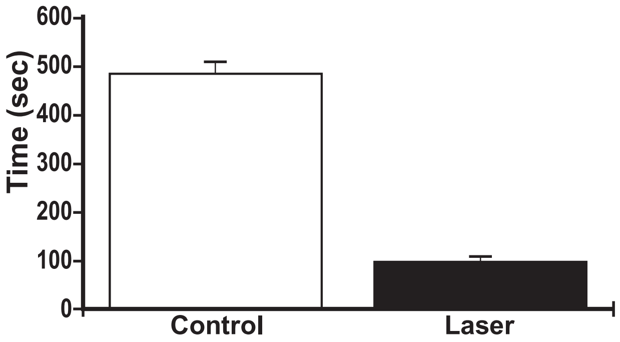

Fig 1: Bleeding control time compared between the young and mature adult groups.

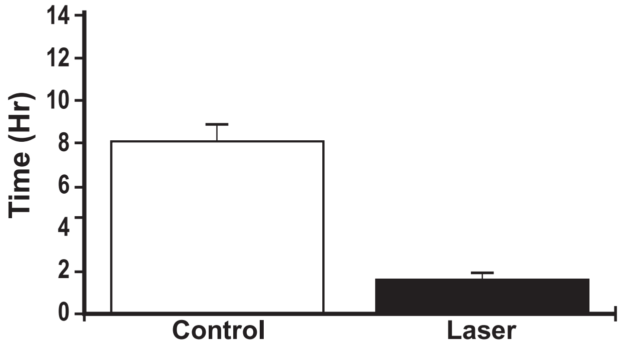

Fig 2: Pain relief time compared between the young and mature adult groups.

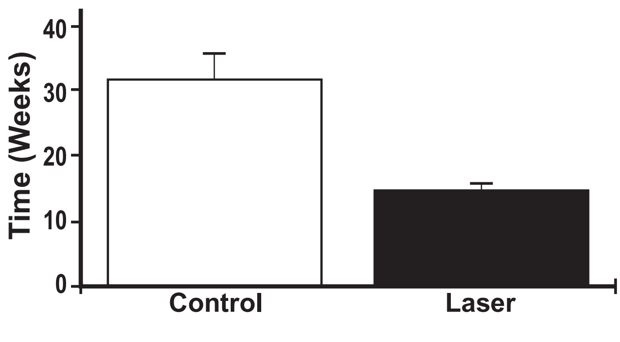

Fig 3: Bone recovery time compared between the young and mature adult groups.

the paper test. The time was measured precisely with a digital stopwatch. The measurement was performed in one location, for the control group, and in four locations, in the case of the laser irradiation group, calculating the mean time of the four.

Pain relief time: Pain is a physiological consequence of the surgery trauma, accompanied by sterile inflammation. We asked the patients to note the evolution of the pain intensity, and if he could use the maxillaries for normal mastication. We considered the time interval (in hours) indicated by the patient until the complete relief of the pain. We did not administrate medication or antibiotics, except in the case of some patients from the control group, where it was absolutely necessary. The presence of any inflammation and edema produced by bacterial over-infection or caused by other agents, resulting in pain, was considered as a post surgery complication.

Bone recovery time: We followed the bone regeneration both subjectively and objectively by observing the evolution of the healing plaque (disappearance of dental mobility i.e., looseness of the teeth; improvement of the gingival color; recuperation of the masticator function; and the subjective comfortable state of the patient) and with X-rays. In the moment when clinical parameters indicate bone recovery, we made radiography. We considered as bone regeneration time (in days) the interval until the X-rays confirmation.

Results

Mean values and standard deviations were calculated using the Microcal Origin Program.

First, we considered gingival bleeding time, pain relief time and bone recovery time for the groups as a whole. As can be seen in Figs. 1–3, all three parameters improved in the case of LLLT: the bleeding time diminished to 25% (Figure 1), the pain relief time to 18% (Figure 2), and the bone recovery time to 50% (Figure 3) of the values for the control group. At the same time, in the experimental group, the bone recovery was more compact.

Next, we compared each of the three parameter by the sub-groups seen in Table 1.

Bleeding time. For young and healthy patients (Figure 4), in the experimental group the bleeding

Table 1: Patient sub-groups arranged by presence or absence of pathological conditions.

Group	No pathology	Toxic pathology	Osteoporosis	Diabetes
Young	12	9	7	6
Mature	5	5	4	7

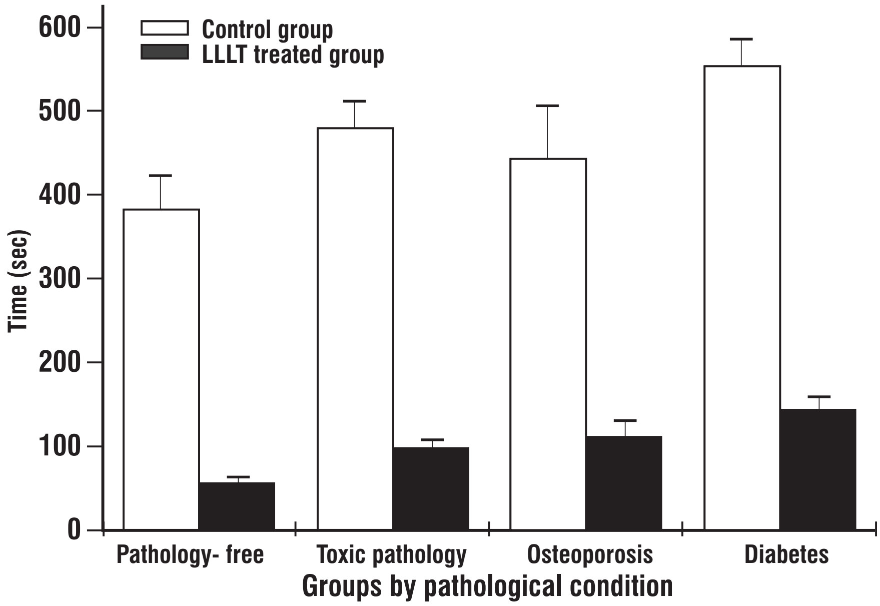

Fig 4: Bleeding control time in the young patients group compared by the absence or presence of any pathologic condition.

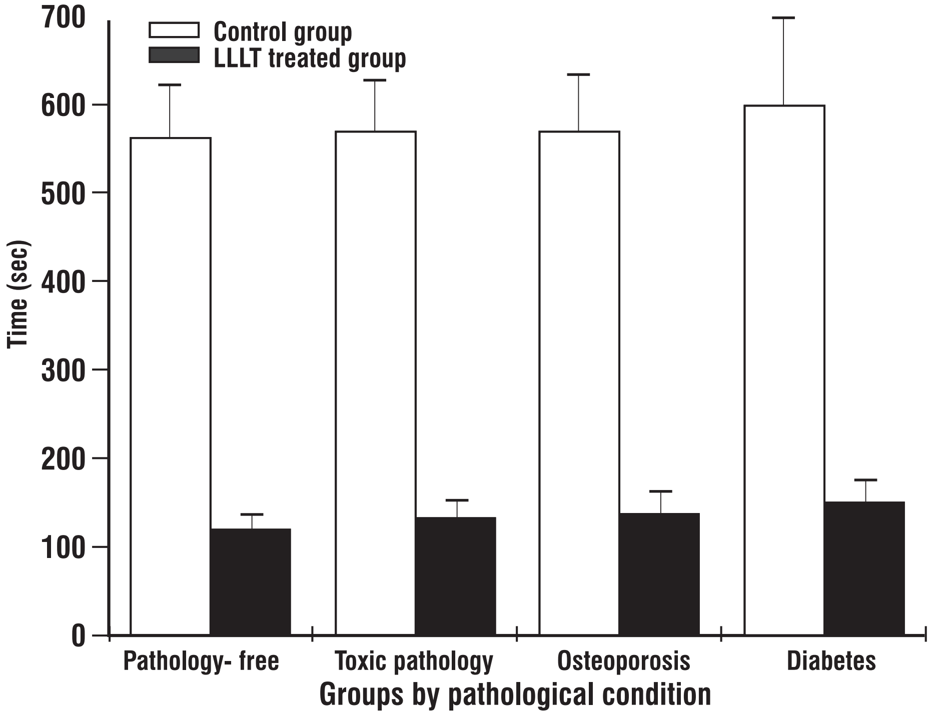

Fig 5: Bleeding control time in the mature patients group compared by the absence or presence of any pathologic condition.

time was only 10% of that of the control group. The same rate appeared also in the young patients with toxicity problems, but at greater values. For the young patients with osteoporosis, the bleeding time after LLLT was only 20% of that of the control group. The bleeding time of the young patients with diabetes was about 30% longer than for the healthy ones, but it diminished to 17% when they were treated with LLLT. In the case of mature patients (Fig. 5), the hemostasis was achieved in a longer time then for the young adults (about 10%), but it diminished to about 20% with LLLT, depending very little on the health status of the patient.

Pain relief. In the control group, there are important differences between the health patients and they

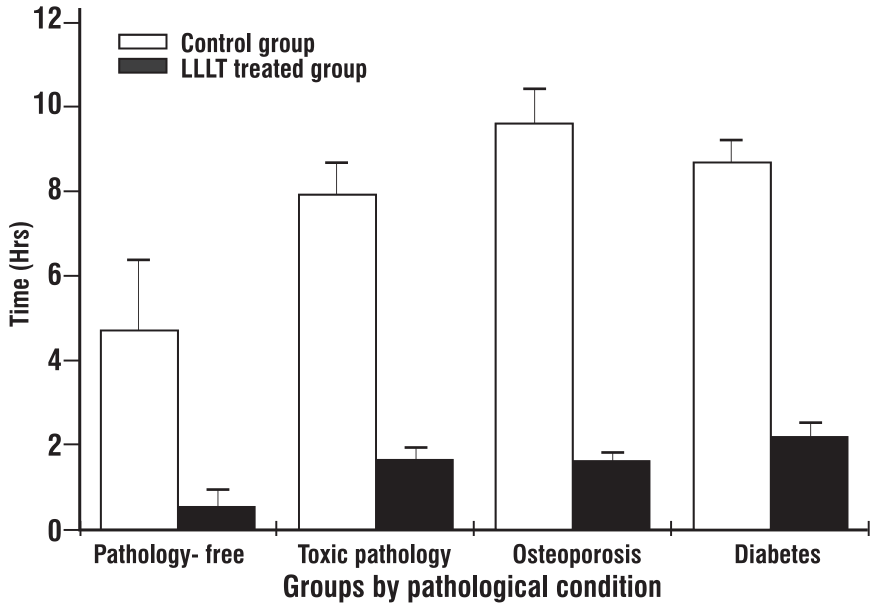

Fig 6: Pain relief time in the young patients group compared by the absence or presence of any pathologic condition.

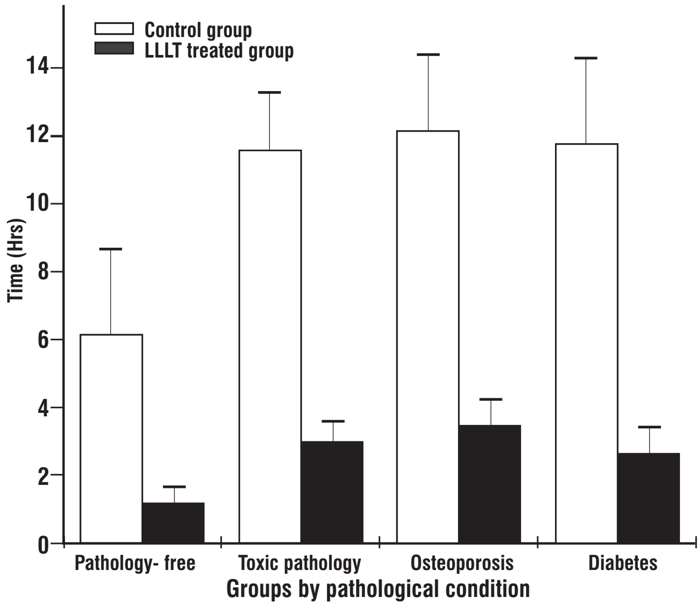

Fig 7: Pain relief time in the mature patients group compared by the absence or presence of any pathologic condition.

suffering different diseases (Figures 6 and 7). For the young (Figure 6), the pain relief time is dependent upon the diseases; for the mature patients (Figure 7), the pain lasts about two times more, indifferent on the diseases. The most important effect of the laser therapy appears in the case of health young patients: the pain interval diminishes to about 12%. For the mature health persons, the pain time decreases only to 27%. The more important effect of laser irradiation was in the case of mature patients with diabetes: the lowering of pain time is up to 22%. For the other two diseases, the pain relief shortens with LLLT up to 23–25% for young, and 26–30% for matures.

As mentioned above, medication or antibiotics were not used, except for some patients from the control group, where it was absolutely necessary. That means that in those few cases the pain relief time would have been longer, so that the difference between the control group and the experimental group would be more evident. The fact that pain relief medication was not necessary in those patients receiving laser therapy indicates, once more, the efficiency of the irradiation.

Bone recovery. For the control group, the bone recov-

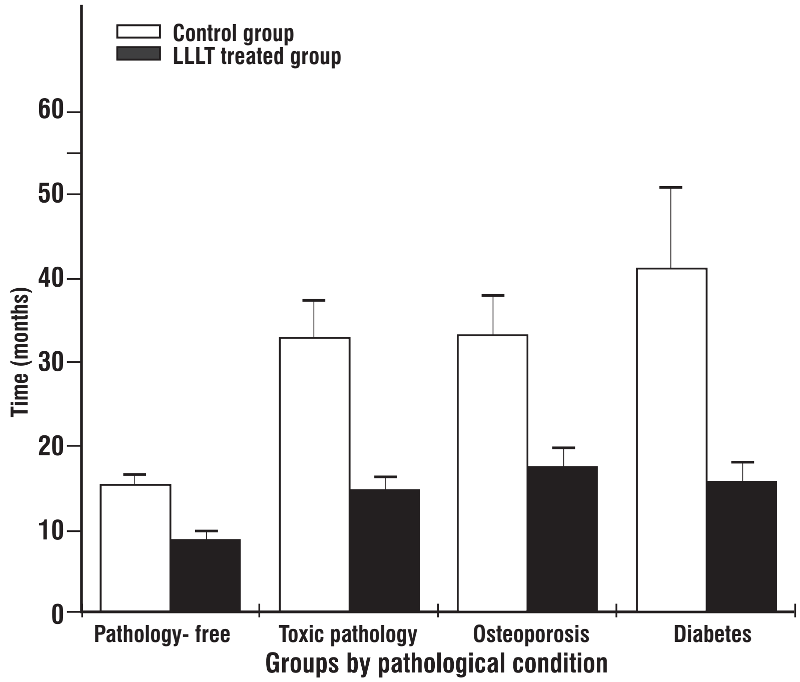

Fig 8: Bone repair time in the young patients group compared by the absence or presence of any pathologic condition.

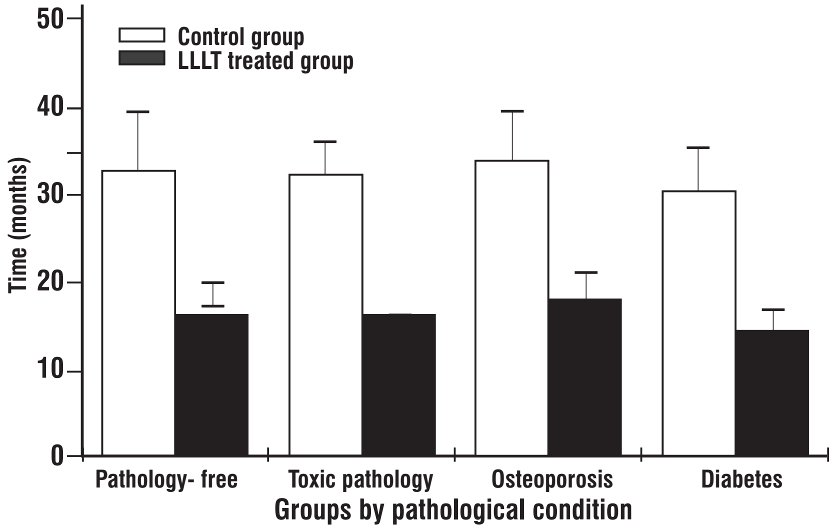

Fig 9: Bone recovery time in the mature patients group compared by the absence or presence of any pathologic condition.

ery was significantly more rapid in the case of young healthy patients then for those affected by different diseases (Figure 8). For mature patients (Figure 9), the bone recovery was similar, regardless of their pathological condition status. In all cases, LLLT resulted in a recovery time which was shorter by about 50%.

We also followed, the recurrence rate. It was 27% for the control group, and only 10% for the experimental one (data not shown).

Laser irradiation also resulted in non-quantifiable effects: reduction of inflammation and edema, maintenance of the masticator and physiologic functions, and, very important, a normal social life. Finally, There were no adverse effects from laser therapy.

Clinical Cases

In order better to illustrate our results, we present some clinical cases.

Figures 10 – 16 illustrate the steps and laser protocol during surgery for a mature patient, 60-years-old, diagnosed as having marginal

Fig 10: The findings before treatment.

Fig 11: Surgery consisting of sub-gingival curettage.

Fig 12: Irradiation of the treated area, on the bone, with the infrared laser beam ($\lambda = 830$ nm).

Fig 13: . Irradiation on the gum, after the suture, with the red laser beam ($\lambda = 630$ nm).

Fig 14: . Irradiation after the surgery, in the external plane by scanning the entire surface of the surgical area, with the infrared laser beam ($\lambda = 830$ nm).

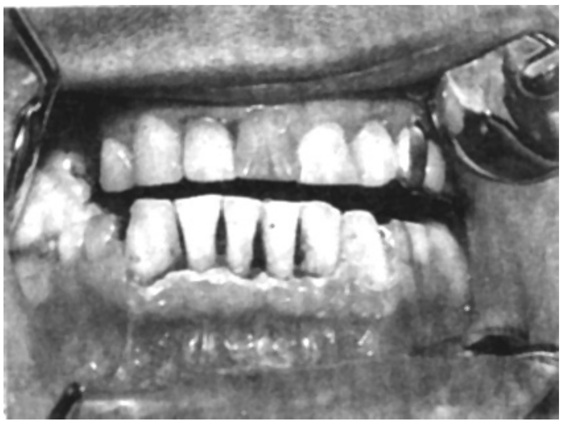

Fig 15: . Immediately after the end of the surgical procedure and laser irradiation.

chronic profound periodontosis (Figure 10). The classic surgical treatment consists of sub-gingival curettage (Figure 11). The plaque was irradiated on the bone (Figure 12), with the infrared laser beam ($\lambda = 830$ nm). After suturing, the gum was irradiated (Figure 13) with the red laser beam ($\lambda = 630$ nm). After surgery, infrared laser beam ($\lambda = 830$ nm) irradiation was applied to external plane, by scanning the entire surface of the surgical area (Figure 14). Figure 15 represents the image immediately after the end of the surgical procedure and laser irradiation. The inflammatory process was no

Fig 16: Final result 6 months after the final session. The patient also had a general clean-up of upper and lower teeth..

longer present and the bleeding was completely stopped. The wound looks like a one-day-old wound following surgery. The X-ray images in Figures 17 and 18 illustrate the long-term bone recovery in this case of LLLT-assisted treatment of marginal chronic profound periodonthosis.

To our surprise, we noticed some incidental complementary effects. In one 28-year-old patient, the patient's facial acne disappeared during the laser treatment for the gums. In another patient, candidosis (oral thrush), conventionally treated for 20 years, disappeared after periodontal laser treatment. In the case of a 44-year-old male patient, acute pain during articulation, possible of temporomandibular joint origin, disappeared after a few sessions of laser therapy for his gums. Although we cannot present any direct evidence, when we take other reports in the literature into account it is highly probable that these beneficial healing-related effects were related to the laser therapy with which these patients were treated.

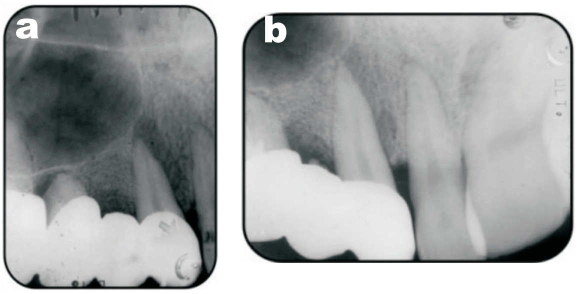

Fig 17: X-ray images illustrating the long-term bone recovery in a case of marginally chronic profound periodontosis in a 48-year-old patient**. a:** before surgery, with a clearly visible reorption pocket around the root of the tooth on the right of the radiograph; **b:** 1.5 years after surgery. The radio-opacity of the bone is much netter, and the resorption pocket has filled in, correcting the tooth mobility problem and improving masticatory function.

Discussion

Our results are in concordance with data from literature concerning the LLLT effects in other domains.[6,-10] This suggests that the interaction mechanisms are the same. These mechanisms have not yet been completely elucidated, but it is known that the effects are non-thermal.[11,12]

The hemostatic effect, evidenced in our work, is largely used in many surgical specialties.[13-15] The pain attenuation and relief by low level laser irradiation is also used by other authors.[6] Many mechanisms of interaction have been proposed:[15] the pain threshold is increased by electrolytic blocking of the nerve fibers; the cell membrane permeability for Na^+ and K^+ diminishes, resulting in membrane hyperpolarization, and blocking, thus bringing about the neurotransmitter release; the ATP production is stimulated.

The bone recovery and the enhanced and shortened wound healing are related to the laser stimulation of the enzymatic activity, protein synthesis, cell proliferation and differentiation, and collagen synthesis.[5,10,16-18] Stimulation of blood circulation influences cellular proliferation.

Probably the main target of the laser beam action is the photobiomodulation of the cell cycle.[19,20] Formation of singlet oxygen stimulates cytochrome oxdiase proliferation, particularly in the case of the interaction between visible red light and cytochrome-c oxidase, with increased ATP synthesis as the consequence. This results in the modification of the energy balance of the nervous system. At the same time, the local circulation is reinforced, which favors the oxygen supply to hypoxic cells. The fact that better results were obtained for

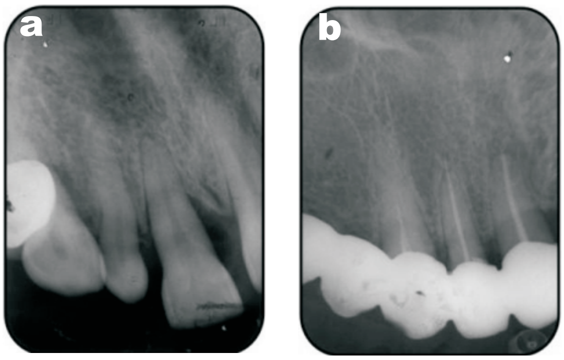

Fig 18: X-ray images illustrating the long-term bone recovery in a case of marginally chronic profound periodontosis in a 33-year-old patient. **a:** before surgery; **b:** 1 year after surgery. Similar findings can be seen as in Fig. 17.

young patients and for those with diabetes may probably also be explained photobiomodulatory effects at the cellular level, and a more efficient energy utilization. The reduction of the inflammatory process and of the edema is probably related to the fact that low levels of laser irradiation stimulate local and general blood and lymph flow.[2,21,22]

Our findings concerning the influence of the general health status of the patient confirm the fact that laser irradiation has not only local, but also systemic effects, stimulating the immune system[23] and modifying the energy balance of the nervous system.

Conclusions

In the entire experimental group low level laser therapy, as an adjunctive approach to the classical treatment of periodontal disease, increased the rate and quality of healing and shortened the healing time.

Immediate effects were a decrease in the bleeding and resolution of pain; no post surgery complications (edema, inflammation, infection, pain); quick formation and maintenance of the clot; and maintainance of the masticatory function. There was no post surgical alteration, permitting the patient an un-interrupted social life.

Long term effects were: rapid formation of an esthetic scar; excellent healing of the soft tissue; rapid recovery of a more compact bone tissue; fixation of the teeth; and complete restoration and maintenance of the masticatory and esthetic functions, with healthier gingival tissue.

The results depended on the age, general health and metabolic problems of the patient. Interestingly, very good results were obtained in persons suffering from diabetes, where, generally, wound healing is a great problem.

Recurrence rate was low, and in no situation did laser therapy have any adverse effects. Finally, we noticed some complementary effects, such as disappearing of facial acnes, of candidosis, and of acute pain in articulation after laser treatment in periodontosis. These latter points merit further detailed study to help elicit the mechanisms

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