Cells have the ability to transform and accumulate laser energy with the help of mitochondria. The chief absorption pigments are hemoglobin (oxidized and non-oxidized) and melanin. Specific functional antenna pigments allow the movement of electrons in the reduction-oxidization system which — incited by the absorption of irradiation and the result of this laser-electron activation — influence the energy production. Laser irradiation also activates some of the cell contents, such as cytochrome (iron-containing protein that works as an oxygen carrier) and the chymotrexpin enzyme (deals with the polypeptide chains).

Electron microcircuits are situated in the inner membrane of each mitochondrion. In each microcircuit, the molecules are arranged to form a highly effective transport bridge for electrons and act as energy transformers; the two proton pumps on the inner mitochondrion membrane (ATP propelled, electron propelled) can work inward (matrix) and outward (intermembrane space) (Fig 1). Laser absorption leads to a photochemical cycle and electrochemical proton gradient, resulting in:

- increase in transmembranic proton exchange
- a forced ATP synthesis based on the increased proton gradient
- increase of the oxygen partial pressure.20

**Wound Healing Process**

The wound healing process (regeneration) shows high energy/high oxygen consumption in the following phases:

- high phagocytosis activation (directly after injury)
- high distribution of glycoproteins (exsudative phase) after 5 days
- high rate of collagen synthesis (proliferative phase) after 10 days
- delocation and consolidation of newly formed tissue (reparative phase).

Laser stimulates the formation of ATP which provides the necessary energy for these phases.

**Abstract:** Ten patients with TMJ disorder without any structural (bony) abnormality or distraction complained of different levels of pain. All cases were treated by diode laser (980 nm wavelength; Biolitec, smile-pro) with the use of the bleaching handpiece (noncontact, defocussed mode) at 1 W in continuous mode for 30 s per appointment, over a total of 6 visits in 3 weeks. Eight further patients with aphthous ulcers of different sizes and locations were treated with the same laser as above using the bleaching handpiece almost contacting the lesion (continuous mode) at 1W power for 3 s, which was repeated on the second day. Eight more patients with hypersensitive tooth cervices at different levels of severity were treated with Er:YAG laser with a special head designed for this purpose (Erwin AdvErl, J. Morita USA) at 30 mJ, 10 pps for 2 appointments. Only one patient needed a third visit. Finally, 2 patients with herpes labialis were treated with the same diode laser and parameters as above for 4 to 6 s for three sessions. All patients were satisfied after treatment and reported pain relief.

Low-level laser irradiation (LLLI) inhibits the production of prostaglandin E2 and interleukin 1 beta, which are both involved in inducing pain and inflammation.8 LLLI encourages macrophages to release the mediators that stimulate fibroblast proliferation.2 Low-level laser therapy (LLLT) reduces the inflammation reaction by inhibiting the factors such as PA (plasminogen activator), which is responsible for collagen breakdown and thus increasing collagen deposition and enhancing proliferation.1,3

Many authors have discussed the effect of laser on fibroblast proliferation. Proliferation is greatly enhanced by many types of laser.4-6,9 Even research on diabetic mice has shown an improved wound epithelization, cellular content, granulation tissue formation, and collagen deposition when using LLLI.7 Clinical research has shown that when using the proper dose and application technique, LLLI will improve wound healing and pain relief.10

It should also be mentioned that LLLI improves microcirculation by causing dilation in arterioles, due to the effect on the smooth muscle cells of the arteriole walls11,29 and the effect on the mast cells.32

**Effects of LLLT on Bone**

In bony tissue, LLLT increases the level of SLRP (small leucine-rich proteoglycan), also called the osteo-inductive factor, which plays a major role in bone formation.12 LLLT significantly increases in the calcium accumulation and improves calcium transport during new bone formation.13,14 When using LLLI, many gene expression levels change in osteoblasts, including ATP synthesis, DNA replication, signal transduction, enzymes, structural protein and other genes of yet unknown function.25

Other studies provided evidence of faster osteointegration with implants when using LLLT.15,16 In other studies on LLLI effects, organic and inorganic bone grafts showed faster vascularization, manifest 15 days postoperatively as an increased amount of collagen fibers, osteoblastic activity, and bone trabeculae formation, resulting in complete repair of bone defects.26,28

**Effects of LLLT on Muscles**

In muscles, LLLT reduces the inflammatory response and blocks the effect of reactive oxygen species (ROS) and nuclear factor kappa B (NF-kB), both involved in the inflammatory process (pathogenesis) in muscles.17 LLLT also reduces the histological abnormalities existing at the trauma site (NF-kB, iNOS).18

Research on rat muscle substantiated the ability of LLLT to prevent development of muscular fatigue during repeated tetanic contractions.19

**ANALGESIA**

One of the most important fields of LLLT application is pain control, which is based on enhanced ATP synthesis in neurons. When ATP synthesis reduced, a faint depo-
larization results, lowering the threshold of triggering and action potential. In contrast, enhanced ATP synthesis by LLLT leads to hyperpolarization and blockage of stimuli, which thus decreases induction of pain stimuli. In addition, the inhibition of prostaglandin E2 (as a paracrine signal) and interleukin 1 beta (activates TH cells and also paracrine signals) will reduce pain induction (PG increases pain by sensitizing the receptors via lowering their threshold). The improvement of circulation in the peripheral blood vessels also plays a role in reducing pain.

A clinical study on patients after third molar extraction concluded that LLLI could decrease the pain level and duration; a low infection rate was also reported. Other studies on improving the outcome of patients with painful TMJ problems suggest the good effectiveness of LLLT in pain control. In an important study by Takashi et al, clearly reversible inhibition of conduction of nerve fiber action potential was demonstrated. The authors postulated that the inhibition was not caused by simple damage to the nerve, but rather by some reversible conformational changes in voltage-gate ion channels, possibly the same mechanism as local anesthesia. Another clinical study evaluating laser surgery for implantation showed high satisfaction in most patients (without local anesthesia), although some patients mentioned a different level of pain sensation. Patients with trigeminal neuralgia were satisfied with the pain relief provided by LLLT.

**CASE REPORT AND METHODS**

It should be mentioned that the power of the laser used here (smile-pro 980 BioLetic; Jena, Germany) is not in the range of LLLT, but the usage of the bleaching handpiece and noncontact defocussed mode leads to an expansion in the diameter of the irradiated spot and lowers the energy applied to tissues to the level needed (Figs 2 and 3).

**Group A**

Ten patients with TMJ disorder without any structural (bony) abnormality or distraction complained of different levels of pain (Figs 4 to 7). All cases were treated by diode laser (980-nm wavelength; Biolitec, smile-pro; Biolitec; Jena, Germany) with the bleaching handpiece (noncontact, defocussed mode) at 1 W in continuous mode for 30 s per appointment, over a total of 6 visits in 3 weeks.

Figures 2 and 3 illustrate the use of the bleaching handpiece in the TMJ region without contact and by moving the handpiece in a circular motion on the previously determined sensitive areas.

**Group B**

Eight patients with aphthous ulcers of different sizes and locations were treated with the same laser as above using the bleaching handpiece almost contacting...
Figs 4 to 6  The three figures show the normal structure of the joints.
the lesion (continuous mode) at 1W power for 3 s, which was repeated on the second day.

**Group C**

Eight patients with hypersensitive tooth cervicis at different levels of severity were treated with Er:YAG laser with a special head designed for this purpose (Erwin AdvErl; J. Morita USA; Irvine, CA, USA) at 30 mJ, 10 pps for 2 appointments. Only one patient needed a third visit.

**Group D**

Two patients with herpes labialis were treated with the same diode laser and parameters as in group A for 4 to 6 s for three sessions.

**RESULTS**

In group A, all patients showed good results after the 3rd visit, although 2 patients mentioned a persistent lower level of pain. After the 6th visit, all patients reported high satisfaction. The radiographs shown in Figs 4 to 7 depict some of the TMJ cases.
In group B, all patients (Figs 8 to 11) were satisfied and experienced pain relief directly after irradiation, although two patients came back with recurrence in different places.

In group C, 5 patients reported satisfaction and pain relief over a long time period. One patient experienced recurrence after 6 months but with less severity. One needed a third visit to attain complete relief from hypersensitivity.
Fig 10a 1st day.

Fig 10b After irradiation.

Fig 10c Two days later.

Fig 11a 1st day.

Fig 11b After irradiation.

Fig 11c Two days later.
In group D, the 2 patients showed an improvement after the first visit with less pain. After the second visit, the patients were satisfied, although the lesion persisted for 2 days after the second visit, but with no pain and dried lesions.

DISCUSSION

Group A

Many studies have been done on the effects of LLLT on myofacial pain and TMJ disorders, and the results mentioned the benefits of laser in improving the cases even when using different wavelengths.33-38

In group A, the 10 cases were diagnosed as myofacial pain. After the first visit, the patients were satisfied with less tenderness and pain while movement improved. At the end of the fourth visit, all patients were satisfied, four patients needed occlusal modification, one patient needed orthodontic treatment to avoid traumatic occlusion. One patient experienced no pain but the limitation in mouth opening still existed (Fig 7). The antiinflammatory effects, the improvement of blood circulation, analgesia, and the effect of LLLT on the muscles cells were the main reasons for these results.

Group B

At present, there are not many reports in the literature on the effects of LLLT on aphthous ulcers, but it is mentioned that there is an effect preventing recurrence and improving the existing cases.39 The analgesic effect was the reason for improvement, and the sterilization of the site stopped the progression of the ulcers.

Group C

The Er:YAG laser alters the contents of the dentinal tubules, coagulates protein, and causes accumulation of insoluble salts, which partially block the tubules.40,42,43 Clinically, the 8 patients improved due to the partial blockage, although with one case of recurrence at a less sensitive level. Some research has shown complete blockage of the dentinal tubules when using fluoride gel with a different type of laser than used here, which provided a long-term solution in such cases.41 The following figure illustrates the shape of the special head (supplied by J. Morita USA; Irvine, CA, USA).

Group D

Many authors have shown the effectiveness of LLLT in treating herpes simplex.44-46 The sterilization property of laser and the analgesic effects improved the 2 cases in this study.

CONCLUSION

LLLT can be an effective treatment method for pain relief and healing in many cases in the dental clinic, especially those which are difficult to treat with other methods or are not responsive to the conventional treatments.

REFERENCES


