Low Level Laser Therapy Research: Dental

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A summary of Low Level Laser Therapy Research
Dentistry

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Introduction

Types of laser

Most dentists will be familiar with the wide range of lasers that are used in modern dentistry. The Erbium:YAG laser has a potential of replacing the drill in selected situations; the carbon dioxide laser is a valuable tool in oral surgery; the Argon laser is used in minor surgery and composite curing and the Nd:YAG is used in pocket debridement, tissue retraction and more.

These lasers use or have the potential to use “high powers” ranging from fractions of a watt to 25 watts or more.

This document will help introduce evidence for the clinical use of a significantly different type of dental laser – the low level laser.

Low level lasers

Compared to high level lasers, low level lasers (LLL) are generally smaller and operate in the milliwatt range, 1-2,000 milliwatts.

The therapy performed with such lasers is often called Low Level Laser Therapy (LLLT) or sometimes just laser therapy and the lasers are classified as therapeutic lasers.

Other terms that may be encountered to describe these are soft laser, low intensity level laser, cold laser, and low-power laser. Additionally the treatments or therapy have also been referred to as laser acupuncture, biostimulation, biomodulation and photobiomodulation.

These therapeutic lasers generally operate in the visible (red) and the infrared spectrum, 600-900 nm wavelength. However, other wavelengths have been successfully used in laser therapy.

History

Not long after the invention of the laser in 1960, interest in its use in medicine started and reports appeared suggesting beneficial physiological effects of low level laser light. The use of lasers specifically designed for medical use began in 1967 and as each new type of laser light source was introduced (ruby, neon, diode) similar results were reported. When infrared lasers appeared the deeper penetration of their particular wavelength appeared to give improved results.

However, initially, commercial LLL were so low powered as to be virtually useless but as models with higher powers have appeared the results has improved and the treatment times reduced.

Determining the dose

The energy used in a particular therapeutic session is measured in Joule (J).

A Joule is output of the laser in milliwatts x the length of the treatment (seconds of irradiation).

Thus, 100 mW x 60 seconds produces an energy of 6,000 millijoules, or 6 J.

Suitable therapeutic energies range from 1-10 J per application point.

The other main variable is the area of treatment that is irradiated. When taking this into account a dosage for the treatment can be calculated.

The dose is expressed in J/cm². 1 J over an area of 1 cm² = 1 J/cm². 2 J over an area of 0.2 cm² = 10 J/cm². There is generally no heat sensation or tissue heating involved in this therapy.
Risks, side effects and contraindications

The only risk in laser therapy is the potential for an eye damage. Direct light beams have the most potential for harm but reflected light should also be considered. While never reported to have occurred, the risk of an eye damage must be considered, and notice taken of any local laws or Australian standards regarding eye protection. This will usually include the wearing of protective eyewear by the patient and others in the treatment area particularly for extra oral therapy in the face.

In fact, ocular damage from LLLT is extremely low with some animal studies suggesting therapeutic healing effects by LLLT on the eye.

Since the therapeutic lasers are well above the ionizing spectrum there is no risk of cancerous changes and studies have shown that they can be used where malignancy exists.

Some reported rare side effects include

- Temporary increase of pain in chronic pain conditions possibly associated with a transition from a chronic to an acute phase.
- Tiredness after treatment to reduce chronic pain possibly because the pain had previously prevented normal sleep patterns.
- Redness and a feeling of warmth in the irradiated area resulting from an increase in capillary circulation.

Interpreting the scientific literature

To date more than 2,500 scientific papers have been published in the area of laser therapy. This includes at least one hundred double blind clinical trials that report positive therapeutic benefits. Dentistry features in more than 300 of these studies from a large number of research facilities in many countries. Despite a range of modalities, quality of experiment design, patient numbers and treatments investigated 90% report a positive effect of laser therapy.

However, there are a large number of parameters than can be selected when designing these studies (time, intensity, wavelength, area, pulsing, number of applications). This can help explain a number of negative studies that have also been released. These should not necessarily be taken to mean that LLL therapy in ineffective but that the parameters chosen in those studies were not successful.

There are a large number of indications of interest to dentists arising from these studies possibly reflecting the varied effects on a number of physiologic systems that can be achieved with laser therapy.

This document will highlight the most significant areas of treatment indications for modern dentistry. A short overview is given of current thinking and a list of peer-reviewed literature (in reverse chronological order). While some studies are hard to evaluate given the lack of standardisation of parameters in use and their reporting, an overall foundation for clinical use is presented.

In all cases, proper clinical assessment and judgment should be used no matter how impressive the results described – LLLT is not a universal remedy and has specific indications for use. Always use care to use the proper type of treatment technique and interval with a sufficient dosage to provide a desirable result.
General Dentistry and Restorative

Therapeutic laser therapy can be used as part of a large range of treatment regimes in general dentistry.

There are three main classifications of treatment outcomes for LLLT:

1. to improve would repair (including iatrogenic wounds) and preventing cell and tissue death;
2. to reduce inflammation and oedema in an existing condition (caused by an injury or chronic disease); and
3. analgesia plus some other neurological conditions.

So LLLT is suitable for any aspect of dentistry that can benefit for one or more of these outcomes.

The treatment can be for a pre-existing condition, as part of a total treatment regime or to help prevent or reduce these as post operative sequelae.

LLLT is effective in reducing or removing pain from many causes. Surgical discomfort for example can be reduced by irradiating the area post treatment before the local anesthesia wears off. Further details of these effects are shown in specific sections below.

Dentine hypersensitivity

As far back as 1994 studies were showing that dentinal hypersensitivity can be successfully treated with LLLT. More recent studies have expanded the range of applications to include the placement of Class V restorations and combining the treatment with various fluoride compounds. The studies suggest that one treatment to the tooth neck can be enough with multiple does required for cases with mild pulpitis. LLLT has been show to be more effective in this treatment than the traditional Stannous Fluoride (SnF2) regime.

Preventing dental erosion

Low level laser irradiation of exposed root dentine tubules has been shown to reduce dentinal chemical composition and prevention of demineralisation without causing any adverse thermal side effects.

Xerostomia

LLLT is reported to have a stimulatory and regenerative effect on salivary glands with salivation increasing linearly over time with the number of treatments. When applied to the patient’s major salivary glands it stimulates them to produce more saliva with good antimicrobial properties. It has been suggested as the treatment of choice for dry mouth conditions.

Compensation for cytotoxic effects of bleaching

The use of bleaching gels containing up to 35% hydrogen peroxide can have the undesirable side effect of pulpitis. The application of LLLT to affected teeth can compensate for this toxic side effect.

Developments in low level light therapy (LLLT) for dentistry.

The potential benefits of LLLT that have been demonstrated in many healthcare fields and include improved healing, reduced inflammation and pain control, which suggest considerable potential for its use in oral tissues.


Carroll JD1, Milward MR2, Cooper PR2, Hadis M3, Palin WM4.
A randomized clinical trial of the effect of low-level laser therapy before composite placement on postoperative sensitivity in class V restorations.

Low-level laser therapy (LLLT) before placement of resin composite could be suggested as a suitable approach to reduce postoperative sensitivity in class V restorations.


Comparative evaluation of diode laser, stannous fluoride gel, and potassium nitrate gel in the treatment of dentinal hypersensitivity.

The aim of the present study was to compare the efficacy of diode laser (DL) with stannous fluoride and potassium nitrate gels in the treatment of dentinal hypersensitivity (DH). The 940 nm DL was not only efficacious, but also brought about improved immediate relief as compared to stannous fluoride and potassium nitrate gels in the reduction of DH.


Treatment of dentine hypersensitivity by diode laser: a clinical study.

Dentine hypersensitivity (DH) is characterized by pain after stimuli that usually provoke no symptoms. This study compared the effectiveness of GaAlAs diode laser alone and with topical sodium fluoride gel (NaF). Conclusion. Diode laser is a useful device for DH treatment if used alone and mainly if used with NaF gel.


Laser in dentistry: An innovative tool in modern dental practice

Laser technology for hard tissue application and soft tissue surgery is at a high state of refinement, having had several decades of development, up to the present time, and further improvements can occur. The field of laser-based photochemical reactions holds great promise for additional applications, particularly for targeting specific cells, pathogens, or molecules. A further area of future growth is expected to be a combination of diagnostic and therapeutic laser techniques. Looking to the future, it is expected that specific laser technologies will become essential components of contemporary dental practice over the next decade.


Increasing rates of non-carious cervical lesions due to dental erosion, exposure of dentinal tubules, and hypersensitivity to environmental stimuli have led to the development of new prevention strategies. This study evaluated the effects of a low-intensity diode laser (λ = 808 nm) on the dentinal chemical composition and prevention of demineralization. These results suggest that dentin irradiation, using a diode laser with levels set at 60 J/cm(2), may induce inhibitory effects on root dentin demineralization without causing any harmful thermal effects.

Laser physics and a review of laser applications in dentistry for children.

It has become clear from a review of the literature that specific laser applications in paediatric dentistry have gained increasing importance. It can be concluded that children should be considered as amongst the first patients for receiving laser-assisted dentistry.


The effect of low-level laser therapy on salivary glands in patients with xerostomia.

The results of our study indicate that the effects of low-level laser therapy on salivary glands are not only stimulating, but also regenerative to a degree since the glandular response to the same amount of applied laser energy increased linearly over time.


In vitro effect of low intensity laser on the cytotoxicity produced by substances released by bleaching gel.

The phototherapy with low intensity laser in defined parameters is able to compensate the cytotoxic effects of substances released by 35 % hydrogen peroxide bleaching gel.


Effects of low-level laser treatment on mouth dryness.

Statistical tests revealed significant salivation improvement quantitatively and qualitatively, i.e. increase in the quantity of saliva and sIgA. VAS score was also significantly improved and no side effects were observed. Conclusions: According to the results of this study, application of LLLT to xerostomic patients’ major salivary glands stimulates them to produce more saliva with better antimicrobial characteristics and improves the difficulties that are associated with MD. This simple non-invasive method could be used in everyday clinical practice for the treatment of MD.


Lasers and pediatric dental care.

Lasers are extremely safe and effective when the user has a proper understanding of laser physics. Using lasers for caries removal, bone removal, and soft tissue treatment can reduce postoperative discomfort and infection and make it possible for dentists to provide safe, simple treatments.


The current status of laser applications in dentistry.

*Aust Dent J.* 2003 Sep;48(3):146-55; quiz 198. Walsh LJ.

A range of lasers is now available for use in dentistry. This paper summarizes key current and emerging applications for lasers in clinical practice. Used in conjunction with or as a replacement for traditional methods, it is expected that specific laser technologies will become an essential component of contemporary dental practice over the next decade.

Low level laser therapy for dentinal tooth hypersensitivity


Gerschman J.A. Ruben J., Gebart-Eaglemont J
A comparative double blind study testing low level laser therapy (Gallium/Aluminium/Arsenide laser [GaAlAs]) against placebo was carried out in the management of dentinal tooth hypersensitivity. Results demonstrate that the GaAlAs laser is an effective method for the treatment of both thermal and tactile dentinal hypersensitivity. There were no reported adverse reactions or instances of oral irritation.

### Third-molar surgery

Numerous studies have concluded that the application of LLLT immediately following the removal of third molars provides the most comfortable postoperative quality of life for the patient by reducing trismus, reducing swelling and reducing pain.

Many studies have shown the benefits to healing on wounds resulting from various surgical procedures. This combines with the beneficial effects of reduced an oedema and pain reduction.

#### Effect of low-level laser therapy after extraction of impacted lower third molars.

This study has demonstrated that LLLT, with these parameters, is useful for the reduction of postoperative discomfort after third-molar surgery.


#### Comparison of the influence of ozone and laser therapies on pain, swelling, and trismus following impacted third-molar surgery.

This study demonstrates that ozone and laser therapies are useful for the reduction of postoperative pain and they increase quality of life after third-molar surgery. Although the ozone therapy had no effect on postoperative swelling and trismus after surgical removal of impacted lower third molars, LLLT had a positive effect.


#### The effect of low level laser therapy on pain reduction after third molar surgery.

The result of this study verifies the positive effect of the soft-laser therapy in the postoperative complication after third molar extraction.

_Saber K, Chiniforush N, Shahabi S_.

#### Placebo-controlled randomized clinical trial of the effect two different low-level laser therapies (LLLT)-intraoral and extraoral-on trismus and facial swelling following surgical extraction of the lower third molar.

This study demonstrates that extraoral LLLT is more effective than intraoral LLLT for the reduction of postoperative trismus and swelling after extraction of the lower third molar.

_Aras MH, Güngörmiş M_.

#### Use of therapeutic laser after surgical removal of impacted lower third molars.

The use of therapeutic laser in the postoperative management of patients having surgical removal of impacted third molars, using the protocol of this study, decreases postoperative pain, swelling, and trismus, without statistically significant differences.

_Aras MH, Güngörmiş M_.
The effect of low-level laser therapy on trismus and facial swelling following surgical extraction of a lower third molar.

Within the limitations of this study it can be concluded that LLLT can be beneficial for the reduction of postoperative trismus and swelling after third molar surgery.

Effectiveness of dexamethasone and low-power laser in minimizing oedema after third molar surgery: a clinical trial.

LPL irradiation after lower third molar surgery can be recommended to minimize swelling. The effect is enhanced by simultaneous local intramuscular use of dexamethasone.

Postoperative analgesia after lower third molar surgery: contribution of the use of long-acting local anesthetics, low-power laser, and diclofenac.

Provided that basic principles of surgical practice have been achieved, the use of long-acting local anesthetics and low-power laser irradiation enables the best postoperative analgesic effect and the most comfortable postoperative course after surgical extraction of LTMs.

General surgery

General surgical procedures are one of the main indications for the use of low level lasers in dentistry. The therapy is particularly useful when applied immediately after surgery to help reduce inflammation, swelling and pain.

One of the other main areas of benefit from LLLT is that of improving wound healing with specific results applicable to dentistry including faster bone repair after tooth extraction and endodontic surgery and general improved tissue repair.

Does low-level laser therapy decrease swelling and pain resulting from orthognathic surgery?

This study verified the efficacy of an LLLT protocol to reduce swelling and pain after orthognathic surgery. This LLLT protocol can improve the tissue response and reduce the pain and swelling resulting from orthognathic surgery.

830 nm light-emitting diode low level light therapy (LED-LLLT) enhances wound healing: a preliminary study.

Background and aims: The application of light-emitting diodes in a number of clinical fields is expanding rapidly since the development in the late 1990s of the NASA LED. Wound healing is one field where low level light therapy with LEDs (LED-LLLT) has attracted attention for both accelerating wound healing and controlling sequelae. Conclusions: 830 nm LED-LLLT successfully brought about accelerated healing in wounds of different etiologies and at different stages, and successfully
controlled secondary infection. LED-LLLTT was easy and pain-free to apply, and was well-tolerated by all patients. The good results warrant the design of controlled studies with a larger patient population.

*Minn PK*, *Goo BL*.

**Low level laser effect after micro-marsupialization technique in treating ranulas and mucoceles: a case series report.**

The use of InGaAsP diode lasers, within the parameters tested, appears to present a good alternative treatment to reduce pain and heal oral ranulas and selected mucoceles associated with micro-marsupialization.

*Amaral MB*, Freitas IZ, Pretel H, Abreu MH, Mesquita RA.

**The influence of low-intensity laser therapy on bone healing.**

Based on the results of the reviewed articles, low intensity laser therapy can accelerate bone healing in extraction sites, bone fracture defects and distraction osteogenesis, provided proper parameters were applied.

*Ebrahimi T*, Moslemi N, Rokn A, Heidari M, Nokhbatolfaghehie H, Fekrazad R.

**Influence of superpulsed laser therapy on healing processes following tooth extraction.**

This study suggests that superpulsed laser irradiation may be a treatment of choice for patients scheduled for tooth extraction, as it provides clinical efficacy, is safe and well tolerated, and is able to prevent inflammation.


**Biostimulation effects of low-power laser in the repair process.**

Laser biostimulation appears to influence the behavior of the repair process. This paper aims at reviewing the most interesting aspects of the use of low-power laser in the tissue-repair process.

*Lins RD*, Dantas EM, Lucena KC, Catão MH, Granville-Garcia AF, Carvalho Neto LG.

**The association of low and high laser treatments on self-inflicted lip injury: a case report.**

The association of different laser therapies to remove and heal a lip lesion owing to self-injurious behavior was effective and promoted improvement in the patient's quality of life by establishing painless mastication.

*Santos MT*, de Souza Merli LA, Guare RO, Ferreira MC.

**Comparison of analgetic effect of magnetic and laser stimulation before oral surgery procedures.**

Conclusion of this analysis is that laser stimulation and alternating magnetic field applied directly before oral surgery procedure are effective antipain agents that decrease intra and postoperative sensations. It was observed that patients with high level of stomatological fear had more pain sensations but even in this group laser and magnetic stimulation significantly lowered these complaints.
Efficacy of low level laser therapy in reducing postoperative pain after endodontic surgery - a randomized double blind clinical study.

Low level laser therapy can be beneficial for the reduction of postoperative pain. Its clinical efficiency and applicability with regard to endodontic surgery, however require further investigation. This is in particular true for the optimal energy dosage and the number of laser treatments needed after surgery.

TMD

An increasing number of reputable institutions have published research that demonstrates the effectiveness of laser therapy in the treatment of a range of problems associated with the temporomandibular joint region. Treatments for myogenic cases typically involve LLLT to muscular insertions and trigger points while arthritic cases the treatment is more directly associated with the joint area. Studies have reported significant reductions in symptoms in almost all cases and improved functioning in many especially myogenic disorders.

Successful treatment regimens have been reported for chronic and acute cases and for other head and neck disorders such as myofascial pain (MP) dysfunction syndrome and trigeminal neuralgia (also see Orofacial Pain page 14.

The efficacy of low-level laser therapy for the treatment of myogenous temporomandibular joint disorder.

LLLT can produce a significant improvement in pain level and mouth opening in patients affected with myogenic TMD.

Effectiveness of occlusal splints and low-level laser therapy on myofascial pain.

The present study was designed to evaluate the effects of low-level laser (Nd:YAG) therapy and occlusal splints in patients with signs and symptoms of temporomandibular disorders (TMD) characterized with myofascial pain (MP). There was no significant difference between LLLT and OS groups after treatment (p > 0.05). OS and LLLT are

Evaluation of orofacial function in temporomandibular disorder patients after low-level laser therapy.

There was a significant increase in the pressure pain threshold of the examined muscles. Mandibular movements were significantly improved in all patients. There was also a significant decrease in pain by palpation after laser exposure. However, no significant change was found in the maximum bite force, occlusal contact area or occlusal pressure after the treatment and also the values after the treatment were still significantly lower than those of the healthy individuals. This particular type of LLLT is effective at relieving pain but does not provide physical improvement.

Low-level laser therapy can be considered as an alternative physical modality or supplementary approach for management of acute and chronic myogenic temporomandibular disorder; however, patients with acute disease are likely to have a better outcome.

Effect of low-level laser therapy on pain levels in patients with temporomandibular disorders: a systematic review.

Most papers showed that LLLT seemed to be effective in reducing pain from TMD.

Low level laser therapy as an adjunctive technique in the management of temporomandibular disorders.

It was concluded that the use of low level laser increased the mean mandibular range of motion and reduced painful symptoms in the groups that received effective treatment, which did not occur in the placebo group.

Effectiveness of physiotherapy and GaAlAs laser in the management of temporomandibular joint disorders.

The laser therapy was effective in the improvement of the range of temporomandibular disorders (TMD) and promoted a significant reduction of pain symptoms.


The present study was designed to compare the effects of low-level laser with occlusal splints in patients with signs and symptoms of myofascial pain (MP) dysfunction syndrome. This particular type of low-level laser therapy (820 nm, 3 J/cm², 300-mW output power) is as effective as occlusal splint in pain release and mandibular movement improvement in MP.

Effects of superpulsed low-level laser therapy on temporomandibular joint pain.

Mandibular function improved in all SLLLT patients proving the effectiveness in the treatment of pain, as demonstrated by a significant improvement in clinical signs and symptoms of temporomandibular joint disc displacement without reduction and osteoarthritis at the end of treatment and stability over a period of 1 month.
EMG analysis after laser acupuncture in patients with temporomandibular dysfunction (TMD).

Implications for practice.

The laser therapy in specific acupuncture points promoted improvement of symptoms and it may be used as complementary therapy for TMD.


Measurements of jaw movements and TMJ pain intensity in patients treated with GaAlAs laser.

Laser application can be a supportive therapy in the treatment of TMD, since it resulted in the immediate decrease of painful symptoms and increased range of mandibular movements in the treated group. The same results were not observed in the placebo group.

*Braz Dent J.* 2010;21(4):356-60. Mazzetto MO, Hotta TH, Pizzo RC.

Low intensity laser therapy in temporomandibular disorder: a phase II double-blind study.

The purpose of this study was to evaluate the analgesic effect of Low Intensity Laser Therapy (LLLT) and its influence on masticatory efficiency in patients with temporomandibular dysfunction (TMD). Low intensity laser application is effective in reducing TMD symptoms, and has influence over masticatory efficiency.


Effectiveness of low-level laser therapy in temporomandibular joint disorders: a placebo-controlled study.

The results suggest that LLLT (application of 10 J/cm(2) and 15 J/cm(2)) can be considered as a useful method for the treatment of TMD-related pain, especially long lasting pain.


Low intensity laser application in temporomandibular disorders: a phase I double-blind study.

In conclusion, the results show that low intensity laser is an effective therapy for the pain control of subjects with TMD.


Based on the results of this placebo-controlled report, LLLT is an appropriate treatment for TMD and should be considered as an alternative to other methods.


Arthralgia of the temporomandibular joint and low-level laser therapy.

This study showed the effectiveness of complex non-invasive treatment in patients with arthralgia of the TMJ. The analgesic and anti-inflammatory effects of LLLT were confirmed by infrared thermography.


The aim of this study was to evaluate the effectiveness of low-level laser therapy (LLLT) and transcutaneous electrical neural stimulation (TENS) on the improvement of mouth opening in patients with temporomandibular disorder (TMD). Both methods are effective to improve mouth opening. Comparing the two methods, LLLT was more effective than TENS applications.


Effectiveness of low-level laser therapy in temporomandibular disorder.

Low-level laser therapy can be considered as an alternative physical modality in the management of temporomandibular disorder.


Orofacial Pain

Repeated double blind placebo controlled studies have shown that LLLT can be a significant benefit in the treatment of patients with a variety of head and neck pains including potentially debilitating conditions such as the variously named Myofascial Pain Syndrome (Disorder) and other syndromes of unknown aetiology.

Treatment of persistent idiopathic facial pain (PIFP) with a low-level energy diode laser.

An average pain reduction of 43.87% (ranging from 9.3% to 91.8%) was achieved. The pain remained unchanged at a lower level for up to 12 months. Low-level energy diode laser may be an effective treatment for PIFP. Low-level energy diode laser may be an effective treatment for PIFP.


Comparison of the effects of low energy laser and ultrasound in treatment of shoulder myofascial pain syndrome: a randomized single-blinded clinical trial.

This study introduces laser as one of the preferred treatments of myofascial pain syndrome in the shoulder.


Low-level laser therapy and myofascial pain dysfunction syndrome: a randomized controlled clinical trial.

According to this study, this type of LLLT was the effective treatment for pain reduction in MPDS patients.


Efficacy of low level laser therapy in myofascial pain syndrome: an algometric and thermographic evaluation.

LLLT seemed to be beneficial for pain in MPS by using algometry and thermography.

Low-level laser therapy is an important tool to treat disorders of the maxillofacial region.

These results confirm that LLLT is an effective tool and is beneficial for the treatment of many disorders of the maxillofacial region. The disorders included temporomandibular joint (TMJ) pain, trigeminal neuralgia, muscular pain, aphatae, inflammation, and tooth hypersensitivity postoperatively and in small hemangiomas.


Can low reactive-level laser therapy be used in the treatment of neurogenic facial pain? A double-blind, placebo controlled investigation of patients with trigeminal neuralgia.

It is concluded that the present study clearly shows that LLLT treatment, given as described, is an effective method and an excellent supplement to conventional therapies used in the treatment of trigeminal neuralgia.


Eckerdal A, Lehmann Bastian H.

Implants

The scope for use of LLLT with implants is broad. Treatment can begin with the promotion of healing and the reduction in oedema, inflammation and pain at the surgical site. Of more specific interest is the in vitro demonstration of a beneficial effect on bone regrowth and osseointegration and more recent clinical studies in support of this. The various effects that LLLT has been shown to have on tissues contribute to promoting a positive implant outcome.

Photobiomodulation and implants: implications for dentistry.

The use of laser technology with implants has a fascinating breadth of applications, beginning from their precision manufacturing to clinical uses for surgical site preparation, reducing pain and inflammation, and promoting osseointegration and tissue regeneration. This latter aspect is the focus of this review, which outlines various studies of implants and laser therapy in animal models. The use of low level light therapy or photobiomodulation has demonstrated its efficacy in these studies.


Tang E, Arany P.

Biomechanical effect of one session of low-level laser on the bone-titanium implant interface.

Thus, it could be suggested that a single session of irradiation with LLL was beneficial to improve bone-implant interface strength, contributing to the osseointegration process.


Boldrini C1, de Almeida JM, Fernandes LA, Ribeiro FS, Garcia VG, Theodoro LH, Pontes AE


It could be concluded that LLLT may offer advantages in terms of periodontal and bone functional recovery and biomaterial osseointegration.

Obradović RR, Kesić LG, Pesevska S.


The application of the LLL influenced the expression of OPG, RANKL, and RANK, and resulted in the expansion of metabolic bone activity and increased the activity of bone tissue cells.


Laser therapy accelerates initial attachment and subsequent behaviour of human oral fibroblasts cultured on titanium implant material. A scanning electron microscope and histomorphometric analysis.

It is concluded that in vitro LLLT enhances the attachment and proliferation of HGF on titanium implant material.


Determining optimal dose of laser therapy for attachment and proliferation of human oral fibroblasts cultured on titanium implant material.

It is concluded that, in this cellular model, the attachment and proliferation of human gingival fibroblasts are enhanced by LLLT in a dose-dependent manner.


Infrared laser light reduces loading time of dental implants: a Raman spectroscopic study.

The process of maturation of the bone is important for the success of dental implants, as it improves the fixation of the implant to the bone, allowing the wearing of a prosthesis. LLLT has been suggested as a mean of improving bone healing because of its biomodulatory capabilities. It is concluded that LLLT does improve bone healing, and this can be safely assessed by Raman spectroscopy.


The following conclusions are drawn from the results of these five studies: LLLT can promote bone healing and bone mineralization and thus may be clinically beneficial in promoting bone formation in skeletal defects. It may be also used as additional treatment for accelerating implant healing in bone. LLLT can modulate the primary steps in cellular attachment and growth on titanium surfaces. Multiple doses of LLLT can improve LLLT efficacy, accelerate the initial attachment and alter the behaviour of human gingival fibroblasts cultured on titanium surfaces. The use of LLLT at the range of doses between 1.5 and 3 J/cm2 may modulate the activity of cells interacting with an implant, thereby enhancing tissue healing and ultimate implant success.


Khadra M.

Low-level laser therapy stimulates bone-implant interaction: an experimental study in rabbits.

The aim of the present study was to investigate the effect of low-level laser therapy (LLLT) with a gallium-aluminium-arsenide (GaAlAs) diode laser device on titanium implant healing and attachment in bone. The findings suggest that LLLT might have a favourable effect on healing and attachment of titanium implants.
Osseointegration of endosseous ceramic implants after postoperative low-power laser stimulation: an in vivo comparative study.

An in vivo model was used for the present study to evaluate whether Ga-Al-As (780 nm) LPL stimulation can improve biomaterial osseointegration. The results suggest that LPL postoperative treatment enhances the bone-implant interface.

Orthodontic

Orthodontic treatment can benefit from the analgesic and healing properties of LLLT. Laser application can reduce pain by a significant degree at various stages of treatment including, arch wire placement, appliance removal, separator placement and other adjustment phases.

LLLT can also be used as an adjunct to various surgical orthodontic procedures including palatal expansion to improve healing, reduce pain and minimise neurosensory disruption. Further studies have also shown that the therapy successfully accelerates the velocity of tooth movement via stimulation of alveolar bone remodelling.

Influence of low-level laser on bone remodeling during induced tooth movement in rats.

Low-level laser application significantly increased the osteoclastic but not the osteoblastic activity during the initial phases of tooth movement. In addition, the osteoclastic activity was dose-dependent.

Effect of frequent laser irradiation on orthodontic pain. A single-blind randomized clinical trial.

Frequent LLLT decreased the perception of pain to a nonsignificant level throughout the week after separator placement, compared with pain perception in the placebo and control groups. Therefore, LLLT might be an effective method of reducing orthodontic pain.

Effect of low-level laser therapy on pain following activation of orthodontic final archwires: a randomized controlled clinical trial.

Low intensity laser application reduces pain induced by archwires used during the final stage of orthodontic treatment, without any interference regarding the kind of bracket, as reported by patients.

Analgesic effect of a low-level laser therapy (830 nm) in early orthodontic treatment.

LLLT at these parameters can reduce pain in patients following placement of orthodontic rubber separators.
Efficiency of low-level laser therapy in reducing pain induced by orthodontic forces.

The significant reductions in both pain intensity and PGE(2) levels revealed that LLLT was efficient in reducing orthodontic post-adjustment pain.

Bicakci AA¹, Kocoglu-Altan B, Toker H, Mutaf I, Sumer Z.

Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: a clinical investigation.

Low-intensity laser therapy is a good option to reduce treatment duration and pain.

Doshi-Mehta G¹, Bhad-Patil WA.

Low-level laser therapy effects in traumatized permanent teeth with extrusive luxation in an orthodontic patient.

Treatments with low-level laser applications may be evaluated as noninvasive alternative treatment options in comparison with endodontic treatment for teeth with extrusive luxation more than 2 mm, especially for those who have orthodontic treatment needs.

Görür I¹, Orhan K, Can-Karabulut DC, Orhan Al, Oztürk A.

Infrared laser therapy after surgically assisted rapid palatal expansion to diminish pain and accelerate bone healing.

These findings suggest that laser therapy can accelerate bone regeneration of the median palatal suture in patients who have undergone SARPE.

Abreu ME¹, Viegas VN, Pagnoncelli RM, de Lima EM, Farret AM, Kulczynski FZ, Farret MM.

Low-energy laser irradiation accelerates the velocity of tooth movement via stimulation of the alveolar bone remodeling.

The amount of tooth movement in the LELI group was significantly greater than in the non-irradiation group by the end of the experimental period. These findings suggest that LELI accelerates the velocity of tooth movement via stimulation of the alveolar bone remodeling.

Yoshida T¹, Yamaguchi M, Utsunomiya T, Kato M, Arai Y, Kaneda T, Yamamoto H, Kasai K.

Low-level laser therapy for pain caused by placement of the first orthodontic archwire: a randomized clinical trial.

Based on these findings, we concluded that LLLT efficiently controls pain caused by the first archwire.

Tortamano A, Lenzi DC, Haddad AC, Bottino MC, Dominguez GC, Vigorito JW.

Pain relief by single low-level laser irradiation in orthodontic patients undergoing fixed appliance therapy.

LLLT immediately after multibandig reduced the prevalence of pain perception at 6 and 30 hours. LLLT might have positive effects in orthodontic patients not only immediately after multibanding, but also for preventing pain during treatment.
Low-level laser effect on neurosensory recovery after sagittal ramus osteotomy.

This study demonstrates that neurosensory recovery after bilateral sagittal split osteotomy procedures can be significantly improved, both in terms of time course and magnitude of return of function, with the adjunctive use of LLL therapy.


Inferior alveolar nerve damage

LLLT has been used to reduce the incidence of post oral surgery paraesthesia. It has also been shown to provide a subjective and objective improvement in mechanical sensory perception where there is a long-standing neurosensory deficit.

Low-level laser effect in patients with neurosensory impairment of mandibular nerve after sagittal split ramus osteotomy. Randomized clinical trial, controlled by placebo.

Objective: Evaluate the effect on the application of low level laser therapy, in patients that have been previously intervened with a sagittal ramus split osteotomy and present neurosensory impairment due to this surgery, compared with placebo. Conclusion: Low-level laser therapy was beneficial for this group of patients on recovery of neurosensory impairment of mandibular nerve, compared to a placebo.


Lower-level laser therapy improves neurosensory disorders resulting from bilateral mandibular sagittal split osteotomy: A randomized crossover clinical trial.

Bilateral sagittal split osteotomy (BSSO) is a technique commonly used to correct mandibular disproportion but many patients experience hypoaesthesia of the inferior alveolar nerve (IAN). The purpose of this study was to verify the effectiveness of using a low-level laser therapy protocol after BSSO. On the treated side, recovery was faster and was almost complete at the time of the last evaluation. We suggest that this lower-level laser therapy protocol can improve tissue response and accelerate the recovery of neurosensory disorders following BSSO.


Laser therapy and pain-related behavior after injury of the inferior alveolar nerve: possible involvement of neurotrophins.

These results indicate that BDNF plays a locally crucial role in pain-related behavior development after IAN injury, increasing after lesions (in parallel to the installation of pain behavior) and decreasing with laser therapy (in parallel to the improvement of pain behavior).


Treatment modalities of neurosensory deficit after lower third molar surgery: a systematic review.

Four surgical treatments and 2 nonsurgical treatments were identified in the management of neurosensory disturbance after lower third molar surgery. Most treatments showed an improvement
Efficacy of low level laser therapy on neurosensory recovery after injury to the inferior alveolar nerve.

Low level laser therapy seemed to be conducive to the reduction of long-standing sensory nerve impairment following third molar surgery. Further studies are worthwhile regarding the clinical application of this treatment modality.

Effect of low-level laser treatment on neurosensory deficits subsequent to sagittal split ramus osteotomy.

In conclusion GaAlAs low-level laser treatment results in both a subjective and objective improvement in mechanical sensory perception in long-standing neurosensory deficit in the inferior alveolar nerve.

Preliminary study of low-level laser for treatment of long-standing sensory aberrations in the inferior alveolar nerve.

It was concluded that LLL can improve mechanoreceptor perception in long-standing sensory aberrations in the IAN.

Also see - Low-level laser effect on neurosensory recovery after sagittal ramus osteotomy.

Mucosal

LLLT can be of significant benefit in the treatment of a number of conditions of the oral mucosa. HSV 1 (Herpes Simplex) both oral and perioral has been successfully treated with LLLT with best results when treatment is in the early prodromal phase. Results include an immediate reduction in pain levels with blisters disappearing in a few days. Repeated treatment can lower the incidence of recurrence.

Cancer therapy induced mucositis is a debilitating condition that has been difficult to treat. Numerous studies have shown that LLLT can significantly reduce pain, severity and the duration of symptoms in patients and can partly prevent the development of the condition. Many envisage that LLLT will soon become part of routine oral supportive care in cancer.

LLLT has also been shown to be effective in relieving pain and reducing the healing time during the treatment of aphthous ulcers. Many authors report the therapy as being extremely effective.

The treatment regime has also been suggested as an adjunct to treatment to a number of other conditions that are traditionally difficult to effectively treat. These include oral lichen planus, oral and cutaneous pemphigus vulgaris, denture stomatitis, and burning mouth syndrome.
Recurrent aphthous stomatitis and pain management with low-level laser therapy: a randomized controlled trial.

LLLT reduced the pain and the inconvenience of eating, drinking, and brushing teeth for patients with recurrent aphthous stomatitis RAS, compared with placebo.


Chemotherapy-induced oral mucositis: effect of LED and laser phototherapy treatment protocols.


Over the last few decades, many studies have focused on the effect of lasers on the management of oral mucositis in oncologic patients treated with chemotherapy and/or radiotherapy. However, the effect of light-emitting diode (LED) has been poorly studied, and was not compared with that of laser phototherapy (LPT). For this reason, the aim of the present study was to clinically compare the effect of these two therapies on chemotherapy-induced oral mucositis (CIOM) and pain. Conclusion: These findings suggest that LED therapy is more effective than LPT in the treatment of COIM, with the parameters used in the present study.

Efficacy of low-level laser therapy in treatment of recurrent aphthous ulcers - a sham controlled, split mouth follow up study.

Immediately, post the LLLT application, complete pain relief was observed in 28 of the 30 patients of the active group. Conclusion: LLLT was effective in relieving pain and reducing the healing time during the treatment of aphthous ulcers.


Clinical evaluation of the efficiency of low-level laser therapy for oral lichen planus: a prospective case series.

This study suggests that LLLT could be a possible treatment choice for patients with unresponsive symptomatic OLP, also reducing the possible invasiveness correlated with other therapies.


Effect of low level laser therapy in the reduction of oral complications in patients with cancer of the head and neck submitted to radiotherapy.

The aim of this study was to assess the effect of low level laser therapy on reducing the occurrence and severity of oral complications in patients with head and neck cancer undergoing radiotherapy. Better outcomes were observed in the laser group when compared with the control in the follow-up sessions, indicating lower degrees of oral mucositis, pain and higher salivary flow (p < .05). These findings support the use of laser therapy as an adjuvant treatment for the control of oral complications.

Low level laser therapy in the treatment of aphthous ulcer.

According to the results of this study, low level laser therapy can decrease the healing time, pain intensity, size, and recurrence of the lesion in patients with minor RAS, and hence can be considered the most appropriate treatment modality for minor RAS, with greatest clinical effectiveness.


Anand V, Gulati M, Govila V, Anand B.

Comparative evaluation of low-level laser and CO₂ laser in treatment of patients with oral lichen planus.

The present study showed that LLLT displayed better results than CO(2) laser therapy as alternative or additional therapy, but further investigations in comparison with standard treatment modalities with a prolonged follow-up period will be necessary to confirm the efficacy of laser therapy in the treatment of OLP.


Agha-Hosseini F, Moslemi E, Mirzaii-Dizgah I.


We observed prompt analgesic effect in oral lesions and accelerated healing of oral and cutaneous wounds. Therefore, the present report suggests LLLT as a noninvasive technique that should be considered as an adjuvant therapy in oral and skin disorders in patients with PV.

Low-level laser therapy in the prevention and treatment of cancer therapy-induced mucositis: 2012 state of the art based on literature review and meta-analysis.

No adverse side effects of LLLT were reported; hence, we recommend red or infrared LLLT with diode output between 10-100 mW, dose of 2-3 J/cm²/cm² for prophylaxis and 4 J/cm² (maximum limit) for therapeutic effect, application on single spot rather than scanning motion. Lesions must be evaluated by a trained clinician and therapy should be repeated daily or every other day or a minimum of three times per week until resolution. There is moderate-to-strong evidence in favor of LLLT at optimal doses as a well tolerated, relatively inexpensive intervention for cancer therapy-induced oral mucositis. It is envisaged that LLLT will soon become part of routine oral supportive care in cancer.


Bensadoun RJ, Nair RG.

Amelioration of oral mucositis pain by NASA near-infrared light-emitting diodes in bone marrow transplant patients.

Phototherapy demonstrated a significant reduction in patient-reported pain as measured by the WHO criteria in this patient population included in this study. Improvement trends were noted in most other assessment measurements.

The effect of 670-nm low laser therapy on herpes simplex type 1.

LLLT of herpes simplex virus 1 (HSV-1) appears to be an effective treatment modality without any observed side effects.

Low-level laser therapy during radiotherapy was found to be effective in controlling the intensity of mucositis and pain.

A systematic review with meta-analysis of the effect of low-level laser therapy (LLLT) in cancer therapy-induced oral mucositis.

There is consistent evidence from small high-quality studies that red and infrared LLLT can partly prevent development of cancer therapy-induced OM. LLLT also significantly reduced pain, severity and duration of symptoms in patients with cancer therapy-induced OM.

660 AsGaAl laser to alleviate pain caused by cryosurgical treatment of oral leukoplakia: a preliminary study.

LLLT is an important strategy used to reduce post-surgical pain caused by cryosurgical treatment of OL.

Low level laser therapy in oral mucositis: a pilot study.

LLLT, one of the most recent and promising treatment therapies, has been shown to reduce the severity and duration of mucositis and to relieve pain significantly. In the present study similar effects were obtained with the GaAlAs 830nm diode laser. It became clear that using the latter diode device, new guidelines could be developed as a function of the WHO-OM grades i.e. the lower the grade, the less energy needed. Immediate pain relief and improved wound healing resolved functional impairment that was obtained in all cases.

Treatment of burning mouth syndrome with a low-level energy diode laser.

Low-level energy diode laser may be an effective treatment for burning mouth syndrome.

Improvement in quality of life of an oncological patient by laser phototherapy.

Normal oral function and consequent improvements in the quality of life of this oncologic patient were observed with LPT.

After low level laser treatment, the reduction of yeast colonies on the agar plates was observed and palatal inflammation was diminished. LLLT is effective in the treatment of denture stomatitis.

*Maver-Biscanin M*, *Mravak-Stipetic M*, *Jerolimov V*.

Low-level laser for prevention and therapy of oral mucositis induced by chemotherapy or radiotherapy.

On the basis of literature data, it is reasonable to conclude that the evidence that low-level laser therapy may be useful in decreasing the severity of chemotherapy-associated or radiotherapy-associated mucositis is substantial, even though there have been few controlled studies in the field of prevention.

*Curr Opin Oncol.* 2005 May;17(3):236-40.
*Genot MT*, *Klastersky J*.

Low-intensity laser therapy is an effective treatment for recurrent herpes simplex infection. Results from a randomized double-blind placebo-controlled study.

In conclusion, we demonstrated that a total of 10 irradiations with low-intensity laser therapy significantly lowers the incidence of local recurrence of herpes simplex infection. Since this athermic phototherapeutic modality represents a safe, noninvasive treatment, it might be considered as an alternative to established therapeutic regimens in this indication.

*Schindl A*, *Neumann R*.

Osteonecrosis

LLLT has shown to be effective in preventing osteonecrosis of the jaw after tooth extraction in patients undergoing bisphosphonate therapy.

Reports also suggest that early intervention with LLLT can improve the success rate of treating patients who develop this condition. In addition LLLT is effective in producing a remission in the painful symptoms and improving the healing rate.


Our experience supports the hypothesis that the association of antibiotic treatment and LLLT can be effective in preventing (osteonecrosis of the jaw) ONJ after tooth extractions in patients under BPT (bisphosphonates therapy).


Early surgical laser-assisted management of bisphosphonate-related osteonecrosis of the jaws (BRONJ): a retrospective analysis of 101 treated sites with long-term follow-up.

In our experience, the percentage of success obtained with a combined approach based on medical therapy, surgical (including laser-assisted) therapy, and LLLT (G4) is significantly higher than the percentage of improvement obtained in G1, G2, and G3.

Laser GaAlAs (λ860 nm) photobiomodulation for the treatment of bisphosphonate-induced osteonecrosis of the jaw.


The therapeutic protocol used in this study had a positive effect on tissue healing and remission of painful symptoms, resulting in better oral health and quality of life for the patient.

Bisphosphonate-related osteonecrosis: laser-assisted surgical treatment or conventional surgery?

Laser surgery is a beneficial alternative in the treatment of patients with this situation. Further randomized studies with larger patient numbers may also improve our understanding of treatment protocols for this situation.


Low-level laser therapy supported teeth extractions of two patients receiving IV zolendronate.

LLLT application combined with atraumatic surgical interventions under antibiotics prophylaxis is a preferable approach in patients with a risk of BRONJ development. Adjunctive effect of LLLT in addition to careful infection control on preventing BRONJ was reported and concluded.


Kan B, Altay MA, Tasar F, Akova M.


This pilot study suggests that LLLT may be a valid technique to support the treatment of BRONJ-related pain, even though the low number of cases in this study does not permit any conclusive consideration.


Effect of low-level laser irradiation on bisphosphonate-induced osteonecrosis of the jaws: preliminary results of a prospective study.

This study suggests that LLLT would appear to be a promising modality of treatment for patients with ONJ-BP, providing that clinical efficacy is safe and well tolerated, especially by those patients who require conservative treatment. Of course, this needs to be addressed further in larger and randomly controlled studies in different clinical settings.


Scoletta M, Arduino PG, Reggio L, Dalmasso P, Mozzati M.

Osteitis

Alveolar osteitis (AO) is an extraction wound healing disorder with a presence of severe pain. Low level laser therapy has been shown to reduce the pain associated with the condition through its pronounced analgesic, anti-oedematous and anti-inflammatory effects. In addition it shortens the length of the symptoms by leading to a faster wound healing time.
Assessment of the effectiveness of low level laser in the treatment of alveolar osteitis.

This study suggested that the reduction of pain was more pronounced in the patients with alveolar osteitis whose extraction wounds were subjected to low level laser radiation in comparison to those in which extraction wounds were treated with zinc oxide eugenol paste.

Jovanović G1, Urić N, Krunić N, Tijanić M, Stojanović S.

Comparison of alvogyl, SaliCept patch, and low-level laser therapy in the management of alveolar osteitis.

Within the limitations of the present study, it can be concluded that acemannan in the form of the SaliCept patch is an acceptable alternative to alvogyl as a dressing for the management of alveolar osteitis. However, low-level laser therapy treatment at 7.64 J/cm² (0.1 W × 60 seconds = 6 J) performed superiorly to both SaliCept and alvogyl in managing alveolar osteitis in our study population.

Kaya GŞ1, Yapici G, Savas Z, Gümüş M.

Periodontal

The quality of life for a patient recovering from periodontal surgery is improved by post-surgical LLLT to decrease pain and reduce swelling and trismus. More directly, better results have been obtained after complex flap surgery when LLLT has been part of the treatment.

Numerous clinical studies have shown that LLLT is a successful physical adjuvant method of treatment, that, together with traditional periodontal therapy, leads to better and longer-lasting therapeutic results. The cellular mechanisms for these results have also been shown in various in vitro studies.

The effect of an 810-nm diode laser on postoperative pain and tissue response after modified Widman flap surgery: a pilot study in humans.

Sanz-Moliner JD1, Nart J, Cohen RE, Ciancio SG.

The use of an 810-nm diode laser provided additional benefits to MWF surgery in terms of less edema and postoperative pain.

Short-term clinical and osteoimmunological effects of scaling and root planing complemented by simple or repeated laser phototherapy in chronic periodontitis.

The aim of this study was to evaluate the clinical, anti-inflammatory, and osteoimmunological benefits of the single (PT) and repeated laser phototherapy (rPT) as an adjunctive treatment of inflamed periodontal tissue. PT exerts a biostimulative effect on the periodontal tissue. Multiple sessions of PT showed a faster and greater tendency to reduce proinflammatory mediators and RANKL/OPG ratio.

Calderín S1, García-Núñez JA, Gómez C.

Low-level lasers as an adjunct in periodontal therapy in patients with diabetes mellitus.

It can be concluded that LLLT as an adjunct in periodontal therapy reduces gingival inflammation in patients with DM and periodontitis.

Low power laser efficacy in the therapy of inflamed gingiva in diabetics with periodontopathy.

**Obradović R**, **Kesić L**, **Jovanović G**, **Antić S**, **Brkić Z**

Low level laser therapy is efficient in gingival inflammation elimination and can be proposed as an adjuvant tool in basic periodontal therapy of diabetic patients.

**Coronally advanced flap adjunct with low intensity laser therapy: a randomized controlled clinical pilot study.**

**Ozturan S**, **Durukan SA**, **Ozcelik O**, **Seydaoglu G**, **Haytac MC**

Coronally advanced flap (CAF) technique and its modifications have been proposed in the literature. Low-power laser therapy (LILT) is shown to increase wound healing. The aim of this split-mouth randomized controlled pilot study was to assess the effects of LILT with respect to root coverage after CAF procedure for the treatment of multiple-recession type defects (MRTD). Within the limitations of this study, the results indicated that LILT may improve the predictability of CAF in multiple recessions.

**The effect of low-level laser therapy as an adjunct to non-surgical periodontal treatment.**

LLLTT as an adjunctive therapy to non-surgical periodontal treatment improves periodontal healing.


**The effects of low level laser irradiation on gingival inflammation.**

A general conclusion can be drawn that low level laser irradiation (semiconductor, 670 nm) can be used as a successful physical adjuvant method of treatment, which, together with traditional periodontal therapy, leads to better and longer-lasting therapeutic results.


**Pejčić A**, **Kojović D**, **Kesić L**, **Obradović R**

**Periodontal treatment with a low-level diode laser: clinical findings.**

These findings suggest that a low-level diode laser can have a beneficial effect for treating inflammatory chronic advanced periodontitis.


**Angelov N**, **Pesevska S**, **Nakova M**, **Gjorgoski I**, **Ivanovski K**, **Angelova D**, **Hoffmann O**, **Andreana S**

**Effect of soft laser and bioactive glass on bone regeneration in the treatment of infra-bony defects (a clinical study).**

Our results have confirmed the positive effect of soft laser in accelerating periodontal wound healing.


**Improved wound healing by low-level laser irradiation after gingivectomy operations: a controlled clinical pilot study.**

Within the limitations of this study, the results indicated that LLLT may enhance epithelization and improve wound healing after gingivectomy and gingivoplasty operations.
Low Level Laser Therapy Research Summary

Ozcelik O1, Cenk Haytac M, Kunin A, Seydaoglu G.

Effect of low-level Er:YAG laser irradiation on cultured human gingival fibroblasts.

Low-level laser irradiation has been reported to enhance wound healing. Activation of gingival fibroblasts (GF) has a potential for early wound healing in periodontal treatment. Our results showed that the low-level Er:YAG laser irradiation stimulates the proliferation of cultured gingival fibroblasts. The optimal stimulative energy density was found to be 3.37 J/cm². This result suggests that Er:YAG laser irradiation may be of therapeutic benefit for wound healing.


Effect of low-level GaAlAs laser irradiation on the proliferation rate of human periodontal ligament fibroblasts: an in vitro study.

A cellular effect of the soft laser application is clearly discernible. Clinical studies are needed to evaluate whether the application of low-level laser therapy might be beneficial in regenerative periodontal therapy.


Low level 809-nm diode laser-induced in vitro stimulation of the proliferation of human gingival fibroblasts.

A cellular effect of the soft laser irradiation on HGF is evident. Its duration, however, seems to be limited. These findings might be clinically relevant, indicating that repeated treatments are necessary to achieve a positive laser effect in clinical applications.


Neck Pain

The efficacy of LLLT in the treatment of neck pain has been shown in a number of studies. Usually pain is seen to reduce in the short-term upon application of the laser and also over longer periods for chronic conditions. In addition increased mobility is seen in results in the studies.


LLLT gave more effective short-term relief of arm pain and increased range of neck extension in patients with acute neck pain with radiculopathy in comparison to the placebo procedure.

Konstantinovic LM1; Cutovic MR, Milovanovic AN, Jovic SJ, Dragin AS, Letic MDj, Miler VM.

Efficacy of low-level laser therapy in the management of neck pain: a systematic review and meta-analysis of randomised placebo or active-treatment controlled trials.

We show that LLLT reduces pain immediately after treatment in acute neck pain and up to 22 weeks after completion of treatment in patients with chronic neck pain.

Chow RT1, Johnson MI, Lopes-Martins RA, Bjordal JM.
The effect of 300 mW, 830 nm laser on chronic neck pain: a double-blind, randomized, placebo-controlled study.

Low-level laser therapy (LLLT), at the parameters used in this study, was efficacious in providing pain relief for patients with chronic neck pain over a period of 3 months.


Systematic review of the literature of low-level laser therapy (LLLT) in the management of neck pain.

This review provides limited evidence from one RCT for the use of infrared laser for the treatment of acute neck pain (n = 71) and chronic neck pain from four RCTs (n = 202). Larger studies are required to confirm the positive findings and determine the most effective laser parameters, sites and modes of application.


Efficacy of 904 nm gallium arsenide low level laser therapy in the management of chronic myofascial pain in the neck: a double-blind and randomize-controlled trial.

This study revealed that short-period application of LLLT is effective in pain relief and in the improvement of functional ability and QoL in patients with MPS.


Mechanism of action

The exact mechanism of achieving therapeutic effects with LLLT has not been precisely determined. This is partly due to the wide range of effects at different levels such as the molecular level, on individual cells and on tissues as a whole. Most accept that the cellular actions result from an increase in the production of adenosine triphosphate (ATP), a modulation of reactive oxygen species (ROS) and an induction of transcription factors. Important events result subsequent to these changes such as protein synthesis that then leads to increased cell proliferation, cell migration, and alteration to cytokines, growth factors and inflammatory mediators as well as increased oxygenation of tissues.

Immune cells especially mast cells that play an important part in modulation of inflammation are affected by near infrared light with specific wavelengths leading to degranulation. Fibroblast are also affected with LLLT seen to cause increased levels of proliferation, maturation and motility with fibroblast growth factor produced. Also affected are lymphocytes (activated and faster proliferation), epithelial cells (more motile leading to faster wound closure) and macrophages (enhanced phagocytosis).

At a molecular level, a photon of light is absorbed by a chromoreceptors or photoacceptors in the mitochondria of a cell. This can allow an electron to become excited and jump from a low energy orbit to a higher energy orbit. This energy is stored energy and can then be used by the within the cell to power various processes. Research has shown that this directly increased the production of ATP in the cell but the affect expends far beyond this with oxygen acting as the final electron receptor in the chain converting it to water. This increase in oxygen metabolism leads to increased ROS production causing the activation of transcription factors and upregulating stimulatory and protective genes. These genes relate to proliferation of cells, cell migration plus cytokine and growth factor production.
Additional effects shown in research result from other actions including vasodilation caused by the relaxation of the smooth muscle of the endothelium. This is especially important in joint inflammation as the vasodilation increases oxygen availability and access of immune cells to the treatment area.

**Protein conformational modulation by photons: a mechanism for laser treatment effects.**

Responsiveness to low-level laser treatment (LLTT) at a wavelength of 450-910 nm has established it as an effective treatment of medical, veterinary and dental chronic pain, chronic inflammation conditions (arthritis and macular degeneration), wound repair, and lymphoedema, yet the mechanisms underlying the effectiveness of LLLT remain unclear. However, there is now sufficient evidence from recent research to propose an integrated model of LLLT action. The hypothesis presented in this paper is that external applications of photons (through laser at an appropriate dose) modulates the nervous system through an integrated mechanism. This stimulated mechanism involves protein-to-protein interaction, where two or more proteins bind together to facilitate molecular processes, including modification of proteins by members of SUMO (small ubiquitin-related modifier proteins) and also protein phosphorylation and tyrosination. SUMO has been shown to have a role in multiple nuclear and perinuclear targets, including ion channels, and in the maintenance of telomeres and the post-translational modification of genes. The consequence of laser application in treatment, therefore, can be seen as influencing the transmission of neural information via an integrated and rapid modulation of ion channels, achieved through both direct action on photo-acceptors (such as cytochrome c-oxidase) and through indirect modulation via enzymes, including tyrosine hydroxylase (TH), tyrosine kinases and tyrosine kinase receptors. This exogenous action then facilitates an existing photonic biomodulation mechanism within the body, and initiates ion channel modulation both in the periphery and the central nervous system (CNS). Evidence indicates that the ion channel modulation functions predominately through the potassium channels, including two pore leak channels (K2P), which act as signal integrators from the periphery to the cortex. Photonic action also transforms SUMOylation processes at the cell membrane, nucleus and telomeres via signalling processes from the mitochondria (which is the main target of laser absorption) to these targets. Under the hypothesis, these observed biological effects would play a part in the bystander effect, the abscopal effect, and other systemic effects observed with the application of low level laser (LLLT). The implications of the hypothesis are important in that they point to mechanisms that can account for the effectiveness of laser in the treatment and prevention of inflammatory diseases, chronic pain and neurodegenerative disorders.

**Body contouring using 635-nm low level laser therapy.**

Noninvasive body contouring has become one of the fastest-growing areas of esthetic medicine. Many patients appear to prefer nonsurgical less-invasive procedures owing to the benefits of fewer side effects and shorter recovery times. Increasingly, 635-nm low-level laser therapy (LLLT) has been used in the treatment of a variety of medical conditions and has been shown to improve wound healing, reduce edema, and relieve acute pain. Within the past decade, LLLT has also emerged as a new modality for noninvasive body contouring. Research has shown that LLLT is effective in reducing overall body circumference measurements of specifically treated regions, including the hips, waist, thighs, and upper arms, with recent studies demonstrating the long-term effectiveness of results. The treatment is painless, and there appears to be no adverse events associated with LLLT. The mechanism of action of LLLT in body contouring is believed to stem from
photoactivation of cytochrome c oxidase within hypertrophic adipocytes, which, in turn, affects intracellular secondary cascades, resulting in the formation of transitory pores within the adipocytes' membrane. The secondary cascades involved may include, but are not limited to, activation of cytosolic lipase and nitric oxide. Newly formed pores release intracellular lipids, which are further metabolized. Future studies need to fully outline the cellular and systemic effects of LLLT as well as determine optimal treatment protocols.

The nuts and bolts of low-level laser (light) therapy.


Advances in design and manufacturing of LLLT devices in the years to come will continue to widen the acceptability and increase adoption of the therapy among the medical profession, physical therapists and the general public. While the body of evidence for LLLT and its mechanisms is still weighted in favor of lasers and directly comparative studies are scarce, ongoing work using non-laser irradiation sources is encouraging and provides support for growth in the manufacture and marketing of affordable home-use LED devices. The almost complete lack of reports of side effects or adverse events associated with LLLT gives security for issues of safety that will be required.

We believe that LLLT will steadily progress to be better accepted by both the medical profession and the general public at large. The number of published negative reports will continue to decline as the optimum LLLT parameters become better understood, and as reviewers and editors of journals become aware of LLLT as a scientifically based therapy. On the clinical side, the public's distrust of big pharmaceutical companies and their products is also likely to continue to grow. This may be a powerful force for adoption of therapies that once were considered as alternative and complementary, but now are becoming more scientifically accepted. LLLT is not the only example of this type of therapy, but needle acupuncture, transcranial magnetic stimulation and microcurrent therapy also fall into this class. The day may not be far off when most homes will have a light source (most likely a LED device) to be used for aches, pains, cuts, bruises, joints, and which can also be applied to the hair and even transcranially to the brain.

Evaluation of mitochondrial respiratory chain activity in wound healing by low-level laser therapy.

Laser therapy is used in many biomedical sciences to promote tissue regeneration. Many studies involving low-level laser therapy have shown that the healing process is enhanced by such therapy. In this work, we evaluated mitochondrial respiratory chain complexes II and IV and succinate dehydrogenase activities in wounds after irradiation with low-level laser. The animals were divided into two groups: group 1, the animals had no local nor systemic treatment and were considered as control wounds; group 2, the wounds were treated immediately after they were made and every day after with a low-level laser (AsGa, wavelength of 904 nm) for 10 days. The results showed that low-level laser therapy improved wound healing. Besides, our results showed that low-level laser therapy significantly increased the activities of complexes II and IV but did not affect succinate dehydrogenase activity. These findings are in accordance to other works, where cytochrome c oxidase (complex IV) seems to be activated by low-level laser therapy. Besides, we showed, for the first time, that complex II activity was also activated. More studies are being carried out in order to evaluate other mitochondrial enzymes activities after different doses and irradiation time of low-level laser.

Evidence of changes in sural nerve conduction mediated by light emitting diode irradiation.

The introduction of light emitting diode (LED) devices as a novel treatment for pain relief in place of low-level laser warrants fundamental research on the effect of LED devices on one of the potential explanatory mechanisms: peripheral neurophysiology in vivo. A randomised controlled study was conducted by measuring antidromic nerve conduction on the peripheral sural nerve of healthy subjects \( n=64 \). One baseline measurement and five post-irradiation recordings (2-min interval each) were performed of the nerve conduction velocity (NCV) and negative peak latency (NPL).

Interventional set-up was identical for all subjects, but the experimental group \( (=32) \) received an irradiation (2 min at a continuous power output of 160 mW, resulting in a radiant exposure of 1.07 J/cm(2)) with an infrared LED device (BIO-DIO preprototype; MDB-Laser, Belgium), while the placebo group was treated by sham irradiation. Statistical analysis (general regression model for repeated measures) of NCV and NPL difference scores, revealed a significant interactive effect for both NCV \( (P=0.003) \) and NPL \( (P=0.006) \). Further post hoc LSD analysis showed a time-related statistical significant decreased NCV and an increased NPL in the experimental group and a statistical significant difference between placebo and experimental group at various points of time. Based on these results, it can be concluded that LED irradiation, applied to intact skin at the described irradiation parameters, produces an immediate and localized effect upon conduction characteristics in underlying nerves. Therefore, the outcome of this in vivo experiment yields a potential explanation for pain relief induced by LED.

Vinck E1, Coorevits P, Cagnie B, De Muynck M, Vanderstraeten G, Cambier D.

Low level laser irradiation stimulates mitochondrial membrane potential and disperses subnuclear promyelocytic leukemia protein.

Low level laser irradiation (LLLI) is used to promote wound healing. Molecularly it is known to stimulate mitochondrial membrane potential (MMP), cytokine secretion, and cell proliferation. This study was designed to determine the influence of LLLI on the kinetics of MMP stimulation and decay, specific cytokine gene expression, and subcellular localization of promyelocytic leukemia (PML) protein on HaCaT human keratinocytes. These changes reflect a biostimulative boost that causes a shift of the cell from a quiescent to an activated stage in the cell cycle heralding proliferation and suppression of inflammation. Further characterization of MMP kinetics may provide a quantitative basis for assessment of the effect of LLLI in the clinical setting.

Gavish L1, Asher Y, Becker Y, Kleinman Y.

Effects of pulse frequency of low-level laser therapy (LLLT) on bone nodule formation in rat calvarial cells.

The purpose of this study was to determine the effect of pulse frequencies of low-level laser therapy (LLLT) on bone nodule formation in rat calvarial cells in vitro.

Since low-frequency pulsed laser irradiation significantly stimulates bone formation in vitro, it is most likely that the pulse frequency of LLLT an important factor affecting biological responses in bone formation.

Ueda Y1, Shimizu N.