



## LLLT studies & wound healing

### Effects of low-level laser therapy on collagen expression and neutrophil infiltrate in 5-fluorouracil-induced oral mucositis in hamsters. [Lasers Surg Med.](#) 2010 Aug;42(6):546-52.

[Lopes NN](#), [Plapler H](#), [Lalla RV](#), [Chavantes MC](#), [Yoshimura EM](#), [da Silva MA](#), [Alves MT](#).

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#### Abstract

##### BACKGROUND AND OBJECTIVES:

Several studies have suggested that low-level laser therapy (LLLT) can ameliorate oral mucositis; however, the mechanisms involved are not well understood. The aim of this study was to investigate the mechanisms of action of LLLT on chemotherapy-induced oral mucositis, as related to effects on collagen expression and inflammation.

##### MATERIALS AND METHODS:

A hamster cheek pouch model of oral mucositis was used with all animals receiving intraperitoneal 5-fluorouracil, followed by surface irritation. Animals were randomly allocated into three groups, and treated with an InGaAlP diode laser at a wavelength of 660 nm and output power of 35 or 100 mW laser, or no laser. Clinical severity of mucositis was assessed at four time-points by a blinded examiner. Buccal pouch tissue was harvested from a subgroup of animals in each group at four time-points. Collagen was qualitatively and quantitatively evaluated after picrosirius staining. The density of the neutrophil infiltrate was also scored.

##### RESULTS:

Peak clinical severity of mucositis was reduced in the 35 mW laser group as compared to the 100 mW and control groups. The reduced peak clinical severity of mucositis in the 35 mW laser group was accompanied by a decrease in the number of neutrophils and an increase in the proportion of mature collagen as compared to the other two groups. The total quantity of collagen was significantly higher in the control (no laser) group at the day 11 time-point, as compared to the 35 mW laser group, consistent with a more prolonged inflammatory response in the control group.

##### CONCLUSION:

This study supports two mechanisms of action for LLLT in reducing mucositis severity. The increase in collagen organization in response to the 35 mW laser indicates that LLLT promotes wound healing. In addition, LLLT also appears to have an anti-inflammatory effect, as evidenced by the reduction in neutrophil infiltrate.

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## **Cyclooxygenase-2 and vascular endothelial growth factor expression in 5-fluorouracil-induced oral mucositis in hamsters: evaluation of two low-intensity laser protocols.**

[Lopes NN](#), [Plapler H](#), [Chavantes MC](#), [Lalla RV](#), [Yoshimura EM](#), [Alves MT](#). [Support Care Cancer](#). 2009 Nov;17(11):1409-15. Epub 2009 Feb 22.

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### **Abstract**

#### **GOAL OF WORK:**

The aim of this study was to investigate the mechanisms whereby low-intensity laser therapy may affect the severity of oral mucositis.

#### **MATERIALS AND METHODS:**

A hamster cheek pouch model of oral mucositis was used with all animals receiving intraperitoneal 5-fluorouracil followed by surface irritation. Animals were randomly allocated into three groups and treated with a 35 mW laser, 100 mW laser, or no laser. Clinical severity of mucositis was assessed at four time-points by a blinded examiner. Buccal pouch tissue was harvested from a subgroup of animals in each group at four time-points. This tissue was used for immunohistochemistry for cyclooxygenase-2 (COX-2), vascular endothelial growth factor (VEGF), and factor VIII (marker of microvessel density) and the resulting staining was quantified.

#### **MAIN RESULTS:**

Peak severity of mucositis was reduced in the 35 mW laser group as compared to the 100 mW laser and control groups. This reduced peak clinical severity of mucositis in the 35 mW laser group was accompanied by a significantly lower level of COX-2 staining. The 100 mW laser did not have an effect on the severity of clinical mucositis, but was associated with a decrease in VEGF levels at the later time-points, as compared to the other groups. There was no clear relationship of VEGF levels or microvessel density to clinical mucositis severity.

#### **CONCLUSION:**

The tissue response to laser therapy appears to vary by dose. Low-intensity laser therapy appears to reduce the severity of mucositis, at least in part, by reducing COX-2 levels and associated inhibition of the inflammatory response. PMID:19234862[PubMed - indexed for MEDLINE]

## **Low-intensity red laser on the prevention and treatment of induced-oral mucositis in hamsters.** [J Photochem Photobiol B](#). 2009 Jan

9;94(1):25-31. Epub 2008 Sep 30. [França CM](#), [França CM](#), [Núñez SC](#), [Prates RA](#), [Noborikawa E](#), [Faria](#)

[MR](#), [Ribeiro MS](#). Professional Master Lasers in Dentistry, IPEN-CNEN/SP, Avenida Lineu Prestes, 2242, 05508-000 São Paulo, Brazil.

#### **OBJECTIVE:**



The purpose of this study was to investigate the effects of laser phototherapy as preventive and therapeutic regime on induced-oral mucositis in hamsters.

#### **DESIGN:**

The animals were divided into four groups: preventive cryotherapy, preventive laser, therapeutic laser and therapeutic control group. Mucositis was induced in hamsters by intraperitoneal injection of 5-fluorouracil (5-FU) and superficial scratching. All preventive treatment was performed on the right cheek pouch mucosa. The left pouch mucosa was used for a spontaneous development of mucositis and did not receive any preventive therapy. Laser parameters were:  $\lambda=660\text{nm}$ ,  $P=30\text{mW}$ ,  $D=1.2\text{J/cm}^2$ ,  $\Delta t=40\text{s}$ , spot size  $3\text{mm}^2$ ,  $I=1\text{W/cm}^2$ . Cryotherapy was done positioning ice packs in the hamster mucosa 5min before 5-FU infusion and 10min afterward. To study the healing of mucositis, the left pouch mucosa of each of the hamsters in the TLG received laser irradiation on the injured area. Irradiation parameters were kept the same as abovementioned. The control hamsters in the TCG did not receive any treatment. The mucositis degree and the animal's body mass were evaluated. An assessment of blood vessels was made based on immunohistochemical staining.

#### **RESULTS:**

The CG animals lost 15.16% of their initial body mass while the LG animals lost 8.97% during the first 5 days. The laser treated animals had a better clinical outcome with a faster healing, and more granulation tissue. The quantity of blood vessels at both LG and CG were higher than in healthy mucosa. Regarding the therapeutic analysis, the severity of the mucositis in the TLG was always lower than TCG. TLG presented higher organization of the granulation tissue, parallel collagen fibrils, and increased angiogenesis.

#### **CONCLUSION:**

The results suggest that laser phototherapy had a positive effect in reducing mucositis severity, and a more pronounced effect in treating established mucositis. PMID:18976931[PubMed - indexed for MEDLINE]

## **Light-emitting diode therapy in chemotherapy-induced mucositis.** [Sacono NT](#), [Costa CA](#), [Bagnato VS](#), [Abreu-e-Lima FC](#). *Lasers Surg Med*. 2008 Nov;40(9):625-

33. Department of Orthodontics and Pediatric Dentistry, São Paulo State University, Araraquara School of Dentistry, Araraquara, SP, Brazil.

#### **Abstract**

##### **BACKGROUND AND OBJECTIVE:**

Mucositis is the most common oral complication of cancer chemotherapy, which causes pain on mastication and swallowing, impairs patients' ability to eat and take oral drugs and may determine interruption of the treatment. The aim of this study was to evaluate the effect of light-emitting diode (LED) therapy on chemotherapy-induced mucositis in hamsters.

##### **STUDY DESIGN/MATERIALS AND METHODS:**

Animals of both experimental (Group I;  $n = 32$ ) and positive control (Group II;  $n = 32$ ) groups received intraperitoneal injections of 5-fluorouracil on days 0 and 2. All animals had their right and left cheek pouch irritated by superficial scratching on days 3 and 4. In Group I, LED irradiation ( $630\text{nm} \pm 10\text{nm}$ ,  $160\text{mW}$ ,  $12\text{J/cm}^2$ ) was applied during 37.5 seconds at days 3, 4, 6, 8, 10, 12, and 14. In Group II, mucositis was induced, but LED therapy was not performed. The oral mucosa was photographed from day 4 to 14 at 2-day intervals. Photographs were randomly scored according to the severity of induced mucositis (0 to 5). In the negative control group (Group III;  $n = 6$ ), no mucositis was induced. Biopsies of the cheek pouches



of 8 animals (Group I and Group II) were surgically obtained on days 5, 9, 13 and 15 and processed for histological examination.

#### **RESULTS:**

The statistical analysis showed significant differences between irradiated and non-irradiated groups ( $P < 0.05$ ). However, muscular degeneration was observed in 18% of the samples of Group I.

#### **CONCLUSION:**

It may be concluded that the LED therapy protocol established for this in vivo study was effective in reducing the severity of oral mucositis, although the oral lesions were not completely prevented.

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## **Chemotherapy- and radiotherapy-induced oral mucositis: review of preventive strategies and treatment.**

[Saadeh CE. \*Pharmacotherapy\*. 2005 Apr;25\(4\):540-54.](#)

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#### **Abstract**

Oral mucositis is a frequently encountered and potentially severe complication associated with administration of chemotherapy and radiotherapy. Although many pharmacologic interventions have been used for the prevention and treatment of oral mucositis, there is not one universally accepted strategy for its management. Most preventive and treatment strategies are based on limited, often anecdotal, clinical data. Basic oral hygiene and comprehensive patient education are important components of care for any patient with cancer at risk for development of oral mucositis.

Nonpharmacologic approaches for the prevention of oral mucositis include oral cryotherapy for patients receiving chemotherapy with bolus 5-fluorouracil, and low-level laser therapy for patients undergoing hematopoietic stem cell transplantation. Chlorhexidine, amifostine, hematologic growth factors, pentoxifylline, glutamine, and several other agents have all been investigated for prevention of oral mucositis. Results have been conflicting, inconclusive, or of limited benefit. Treatment of established mucositis remains a challenge and focuses on a palliative management approach. Topical anesthetics, mixtures (also called cocktails), and mucosal coating agents have been used despite the lack of experimental evidence supporting their efficacy. Investigational agents are targeting the specific mechanisms of mucosal injury; among the most promising of these is recombinant human keratinocyte growth factor. PMID:15977916 PubMed - indexed for MEDLINE



## **Title: Low-level laser Therapy (LLLT) in Caesarean wound healing in normal healthy women: (A single-blinded placebo controlled study)**

Mokmeli S. MD, Kazemi N. MD, Khalil Abbasi BSc, Niromanesh Sh. MD, Seadat molanakiiae P. MD Laser Department of Milad Hospital. dr.mokmeli@yahoo.com International European Medical Laser Association (EMLA) congress CZE 2007

### **Objective:**

Wound healing acceleration in women underwent Cesarean surgery could help them to return to their normal functioning, especially to begin breastfeeding their newborns as one of the most important aspects of newborns care.

Low level laser Therapy (LLLT) have been introduced as one of treatment modalities for non-healing wounds; and several indications have been described for their use in wound healing processes. However, the effect in a healthy individual is limited and the prime indication for laser therapy in wound healing is for individuals or tissues with a compromised state. The aim of this study is to evaluate the effects of low level laser irradiation on inflammatory response of healing tissue in normal healthy subjects underwent Cesarean surgery.

**Materials and Methods:** 17 healthy women underwent Cesarean operation were divided in to 2 groups, 10 as case and 7 age matched controls ( $p = 0.092$ ). All cases and controls have no systemic or dermatological illness, and are generally well. LLLT was delivered as: irradiation with 980 nm ( $P=100\text{mW}$ ,  $3.3 \text{ J/cm}^2$ , J) and 650 nm ( $P=30\text{mW}$ ,  $1.5\text{J/cm}^2$ ) over the incision line, on 3 consecutive post-operative days. Except for LLLT, all the therapeutic conditions (routine dry dressing) in the both groups were the same. On day 10 of wound healing, after removing the stitches, one tissue sample was taken from each subject's wound margin for histological evaluation.

**Results:** There was statistically significant difference in mean values of lymphocyte count and counted lumen of vessels per high power field (/HPF) between two groups in favor of the LLLT group (Fischer's exact test,  $p = 0.035$  and  $0.005$ , respectively). However, mean values for red blood cell (RBC), polymorph nuclear (PMN), large fibroblast and small fibroblast count per HPF were not significantly different in two groups (Fischer's exact test,  $p = 0.102$ ,  $0.303$ ,  $0.862$  and  $0.065$ , respectively).

**Conclusion:** Based on the healing stages, lower lymphocyte count and vascular lumina on 10<sup>th</sup> postoperative day in laser group showed that wounds' healing in laser group got ahead of control group and was in advanced stage in compare to control group. The results of tissue samples revealed that LLLT could improve and facilitated wound healing after caesarian surgery obviously.

**Keywords:** Cesarean wound, Pfanschtil section, low-level laser therapy, wound stage, normal healthy women, and breastfeeding.



## Low-Level Laser Irradiation Stimulates Tenocyte Migration with Up-Regulation of Dynamin II Expression.

[Tsai WC](#), [Hsu CC](#), [Pang JH](#), [Lin MS](#), [Chen YH](#), [Liang FC](#). *PLoS One*. 2012;7(5):e38235. Epub 2012 May 30.

Department of Physical Medicine and Rehabilitation, Chang Gung Memorial Hospital, Taoyuan County, Taiwan.

### Abstract

Low-level laser therapy (LLLT) is commonly used to treat sports-related tendinopathy or tendon injury. Tendon healing requires tenocyte migration to the repair site, followed by proliferation and synthesis of the extracellular matrix. This study was designed to determine the effect of laser on tenocyte migration. Furthermore, the correlation between this effect and expression of dynamin 2, a positive regulator of cell motility, was also investigated. Tenocytes intrinsic to rat Achilles tendon were treated with low-level laser (660 nm with energy density at 1.0, 1.5, and 2.0 J/cm<sup>2</sup>). Tenocyte migration was evaluated by an in vitro wound healing model and by transwell filter migration assay. The messenger RNA (mRNA) and protein expressions of dynamin 2 were determined by reverse transcription/real-time polymerase chain reaction (real-time PCR) and Western blot analysis respectively.

Immunofluorescence staining was used to evaluate the dynamin 2 expression in tenocytes. Tenocytes with or without laser irradiation was treated with dynasore, a dynamin competitor and then underwent transwell filter migration assay. In vitro wound model revealed that more tenocytes with laser irradiation migrated across the wound border to the cell-free zone. Transwell filter migration assay confirmed that tenocyte migration was enhanced dose-dependently by laser. Real-time PCR and Western-blot analysis demonstrated that mRNA and protein expressions of dynamin 2 were up-regulated by laser irradiation dose-dependently. Confocal microscopy showed that laser enhanced the expression of dynamin 2 in cytoplasm of tenocytes. The stimulation effect of laser on tenocytes migration was suppressed by dynasore. In conclusion, low-level laser irradiation stimulates tenocyte migration in a process that is mediated by up-regulation of dynamin 2, which can be suppressed by dynasore. PMID:22666495[PubMed - in process] PMCID:PMC3364209

## The influence of red laser irradiation timeline on burn healing in rats. [Lasers Med Sci](#). 2012 May 23. [Epub ahead of print][Núñez SC](#), [França CM](#), [Silva](#)

[DF](#), [Nogueira GE](#), [Prates RA](#), [Ribeiro MS](#). Centro de Lasers e Aplicações, IPEN-CNEN/São Paulo, São Paulo, SP,

Brazil.

### Abstract

Low-level laser therapy (LLLT) promotes biomodulation of wound healing and literature reports that light delivery during the inflammation could play a different role compared with latter phases of the healing process. The objective of this study was to investigate whether single dose of a red laser ( $\lambda = 660$  nm) is different from fractionated delivery protocol in full thickness burns. Two lesions





were inflicted on the back of 36 rats. In the fractionated dose group (FG), the lesions were irradiated with 1 J/cm<sup>2</sup> on days 1, 3, 8, and 10 post-wounding. In the single dose group (SG), the lesions were irradiated with 4 J/cm<sup>2</sup> on day 1, immediately after injury. Control lesions (CG) received no light and were left to heal spontaneously. Blood flow was measured on days 1, 3, 8, 10, 15, and 21 using laser Doppler flowmetry. Animals were killed on days 3, 8, 10, 15, and 21. Skin specimens were obtained and routinely processed for hematoxylin and eosin. The specimens were evaluated according to differential leukocyte counting and angiogenesis. Statistical analysis was performed, and significance was accepted at  $p < 0.05$ . Irradiated groups showed a peak of new vessels on day 15 while, for CG, the peak was on day 21. On day 21, FG exhibited a significantly greater number of cumulative neutrophils while SG showed a higher number of mononuclear cells. Our results confirm that both protocols used accelerate angiogenesis and stimulate leukocyte chemotaxis on burn treatment. In addition, this work suggests that a single-dose LLLT accelerates the inflammatory phase of skin repair. PMID:22618156[PubMed - as supplied by publisher]

## **Effect of low-level laser therapy on mast cells in second-degree burns in rats.** [Photomed Laser Surg.](#) 2008 Feb;26(1):1-5. [Vasheghani MM](#), [Bayat M](#), [Rezaei F](#), [Bayat A](#), [Karimipour M](#).

Paramedical Faculty, Shaheed Beheshti University, M.C., Tehran, Iran.

### **Abstract**

#### **OBJECTIVE:**

This study sought to investigate whether low-level laser therapy (LLLT) with a helium-neon (He-Ne) laser would affect mast cell number and degranulation in second-degree burns in rats. Background Data: LLLT has been recently applied to stimulate the wound healing process.

#### **MATERIALS AND METHODS:**

Sixty-five rats were randomly allocated to one of five groups. A deep second-degree burn was inflicted on all rats except those in the control group. In the sham-exposed group burns remained untreated. In the two laser-treated groups, the burns were irradiated every day by LLLT, with energy densities of 1.2 and 2.4 J/cm<sup>2</sup>. In the fifth group the burns were treated topically with 0.2% nitrofurazone cream every day. The unburned skin of the rats in the control group were used for baseline study. The effects on mast cell number and degranulation were assessed by counting the number of intact and degranulated mast cells in sections fixed in formalin and stained with toluidine blue.

#### **RESULTS:**

On the seventh and 16th days post-burn, the type 1 mast cell count in the 2.4-J/cm<sup>2</sup> laser-treated group was significantly higher than that of the control group. On the 30th day, the total numbers of mast cells in the laser-treated groups were lower than those in the control and sham-exposed groups.

#### **CONCLUSION:**

LLLT of deep second-degree cutaneous burns in rats significantly increased the number of intact mast cells during the inflammatory and proliferative phases of healing, and decreased the total number of mast cells during the remodeling phase. PMID:18248153[PubMed - indexed for MEDLINE]

## **Effect of low-level treatment with an 80-Hz pulsed infrared diode laser on mast-cell numbers and degranulation in a rat**



**model of third-degree burn.** [Photomed Laser Surg.](#) 2011 Sep;29(9):597-604. Epub 2011 Apr 1. [Khoshvaghti A](#), [Zibamanzarmofrad M](#), [Bayat M](#).

Anatomy Department, Medical Faculty, Artesh University of Medical Sciences, Tehran, Iran.

### **Abstract**

#### **BACKGROUND DATA:**

Low-level laser therapy (LLLT) has been reported to be capable of changing mast cell numbers and degranulation in experimental burns in rats.

#### **OBJECTIVE:**

We conducted a study of the influence of LLLT on mast cells in a rat model of third-degree burn.

#### **METHODS:**

In this study we divided 48 rats equally into two groups of 24 rats each. Third-degree burns were inflicted at three different locations on each rat in each group. The first burn site on rats in group I was treated with 890-nm pulsed laser, 75W peak, 80 Hz, 180 ns, average power 1mW, illuminated area 1 cm(2), 1 mW/cm(2), 856 sec, 0.924 J/cm(2). The second burn site on both groups of rats was treated with 0.2% nitrofurazone cream. Mast cell numbers and degranulation at each burn site on each group of rats were then assessed at 4, 8, 13, and 20 days after the infliction of burns.

#### **RESULTS:**

Analysis of variance on day 4 showed that the total numbers of mast cells were significantly lower at the laser-treated burn sites than at other burn sites on both groups of rats. On day 8 the total numbers of mast cells were again significantly lower at the laser-treated burn sites than at other burn sites, and on day 13, the numbers of both types 1 and 2 mast cells were significantly lower at the laser-treated burn sites than at other burn sites.

#### **CONCLUSIONS:**

We conclude that LLLT can significantly decrease total numbers of mast cells during the proliferation and remodeling phases of healing in a rat model of third-degree burn. PMID:21456947[PubMed - indexed for MEDLINE]

## **Effects of a low level laser on the acceleration of wound healing in rabbits.**

[N Am J Med Sci.](#) 2011 Apr;3(4):193-7. [Hussein AJ](#), [Alfars AA](#), [Falih MA](#), [Hassan AN](#). Department of Anatomy & Histology, College of Veterinary, Basrah University, Basrah, Iraq.

### **Abstract**

#### **BACKGROUND:**

Tissue healing is a complex process that involves local and systemic responses. The use of low level laser therapy for woundhealing has been shown to be effective in modulating both local and systemic response.

#### **AIM:**

The aim of this study was to accelerate and facilitate wound healing and reduce scar formation and wound contraction of an open wound by a low level laser. MATERIALS #ENTITYSTARTX00026;

#### **METHODS:**

Twenty adult male rabbits, *Lepus cuniculus domesticus*, were brought from a Basrah local market and raised under proper management conditions in Basrah Veterinary Medicine College. The age of these rabbits ranged between 8-10 months and their body weight was 1.5-2 Kg. The rabbits were divided into two groups, group I (Control) and group II (Treated). General anesthesia was provided by a mixture of Xylazine and Ketamine at a ratio of 1:0.5m intramuscularly. Selected sites were shaved, cleaned and disinfected. A wound of 4-cm length and 3-cm depth was made on the gluteal region; six hours later, the wound was treated with gallium aluminum and an arsenide diode laser with a power output of 10m at





a wavelength of 890nm in pulsed mode, with a frequency of 20 KLTZ. The wound exposure to the laser was once a day at 890 nm wavelength for 5 minutes over a 7-day period. Histopathological study was obtained regarding the wound depth and edge of the skin on the 3<sup>rd</sup>, 7<sup>th</sup> and 14<sup>th</sup> days.

#### **RESULTS:**

The histopathological finding of group I at three days postoperative showed hemorrhage with inflammatory cell infiltration, mainly neutrophils as well as congested blood vessels in the gap. At seven days, the gap contained necrotized neutrophils together with hemolysis and granulation tissue under the dermis tissue. Hemolysis was seen between the muscle fibers. At 14 days, there was irregular fibrous connective tissue proliferation with congested blood vessels seen in the gap with mononuclear cell infiltration. In group II at three days postoperative, severe inflammatory cell infiltration was observed, mainly neutrophils with proliferation of fibroblasts from a few fibrous connective tissues. On the 7<sup>th</sup> day, the main lesion was characterized by severe granulation tissue that consisted of proliferation of fibrous connective tissue and congested blood vessels in the gap of the incision with mononuclear cell infiltration.

#### **CONCLUSIONS:**

The study found that low level laser therapy (II) was effective in open wounds, which showed better regeneration and faster restoration of structural and functional integrity as compared to the control group. PMID:22540090[PubMed - in process] PMCID:PMC3336911

## **Effect of gallium-arsenide laser, gallium-aluminum-arsenide laser and healing ointment on cutaneous wound healing in Wistar rats.** [Braz J Med Biol Res.](#) 2010

Apr;43(4):350-5. Epub 2010 Mar 19. [Gonçalves RV](#), [Mezêncio JM](#), [Benevides GP](#), [Matta SL](#), [Neves CA](#), [Sarandy MM](#), [Vilela EF](#).

Departamento de Biologia Geral, Universidade Federal de Viçosa, Edifício Shotaro Shymoa, Avenida PH Rolfs, s/n, 35570-000 Viçosa, MG, Brasil. [reggysvilela@yahoo.com.br](mailto:reggysvilela@yahoo.com.br)

#### **Abstract**

This study determined the effects of gallium-aluminum-arsenide laser (GaAlAs), gallium-arsenide laser (GaAs) and Dersani healing ointment on skinwounds in Wistar rats. The parameters analyzed were: type I and III collagen fiber concentrations as well as the rate of wound closure. Five wounds, 12 mm in diameter, were made on the animals' backs. The depth of the surgical incision was controlled by removing the epithelial tissue until the dorsal muscular fascia was exposed. The animals were anesthetized with ketamine and xylazine via intraperitoneal injection. The rats were randomly divided into five groups of 6 animals each, according to the treatment received. Group 1 (L4): GaAs laser (4 J/cm<sup>2</sup>); group 2 (L30): GaAlAs laser (30 J/cm<sup>2</sup>); group 3 (L60): GaAlAs laser (60 J/cm<sup>2</sup>); group 4 (D): Dersani ointment; group 5 (control): 0.9% saline. The applications were made daily over a period of 20 days. Tissue fragments were stained with picrosirius to distinguish type I collagen from type III collagen. The collagen fibers were photo-documented and analyzed using the Quantum software based on the primary color spectrum (red, yellow and blue). Significant results for wound closing rate were obtained for group 1 (L4), 7.37 mm/day. The highest concentration of type III collagen fibers was observed in group 2 (L30; 37.80 ± 7.10%), which differed from control (29.86 ± 5.15%) on the 20<sup>th</sup> day of treatment. The type I collagen fibers of group 1 (L4; 2.67 ± 2.23%) and group 2 (L30; 2.87 ± 2.40%) differed significantly from control (1.77 ± 2.97%) on the 20<sup>th</sup> day of the experiment.

PMID:20445949[PubMed - indexed for MEDLINE]



## Effects of low-power laser irradiation (LPLI) at different wavelengths and doses on oxidative stress and fibrogenesis parameters in an animal model of wound healing.

[Lasers Med Sci](#). 2011 Jan;26(1):125-31. Epub 2010 Sep 24. [Silveira PC](#), [Silva LA](#), [Freitas TP](#), [Latini A](#), [Pinho RA](#). Exercise Biochemistry and Physiology Laboratory, Postgraduate Program in Health Sciences, Health Sciences Unit, University of Southern Santa Catarina, Criciúma, SC, Brazil.

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### Abstract

Gallium-arsenide (GaAs) and helium-neon (HeNe) lasers are the most commonly used low-energy lasers in physiotherapy for promoting woundhealing and pain modulation. The aim of this study was investigate the effect of low-power laser irradiation (LPLI) at different wavelengths and doses on oxidative stress and fibrogenesis parameters in an animal model of wound healing. The animals were randomly divided into five groups (n=6): Controls (skin injured animals without local or systemic treatment), skin injury treated with HeNe 1 J/cm<sup>2</sup> (two seg); skin injury treated with HeNe 3 J/cm<sup>2</sup> (six seg); skin injury treated with GaAs 1 J/cm<sup>2</sup> (three seg); skin injury treated with GaAs 3 J/cm<sup>2</sup> (nine seg). A single circular woundmeasuring 8 mm in diameter was surgically created on the back of the animal. The rats were irradiated at 2, 12, 24, 48, 72, 96, and 120 h after skin injury. The parameters, namely hydroxyproline content, activities of the antioxidant enzymes superoxide dismutase (SOD) and catalase (CAT), and lipid (TBARS) and protein oxidation (carbonyl groups) measurements were assessed. In addition, wound size regression was also analyzed. The results showed an improvement in the wound healing reflected by the reduction in wound size and increased collagen synthesis. Moreover, a significant reduction in TBARS levels, carbonyl content, and SOD and CAT activities were observed after laser irradiation, particularly with the treatments HeNe laser 1 and 3 J/cm<sup>2</sup> dose and GaAs 3 J/cm<sup>2</sup> dose. The data strongly indicate that LPLI therapy is efficient in accelerating the skin wound healing process after wounding, probably by reducing the inflammatory phase and inducing collagen synthesis. PMID:20865435[PubMed - indexed for MEDLINE]

## Development and evaluation of fiber optic probe-based helium-neon low-level laser therapysystem for tissue regeneration--an in vivo experimental study.

[Prabhu V](#), [Rao SB](#), [Rao NB](#), [Aithal KB](#), [Kumar P](#), [Mahato KK](#). [Photochem Photobiol](#). 2010 Nov-Dec;86(6):1364-72. doi: 10.1111/j.1751-1097.2010.00791.x. Biophysics Unit, Manipal Life Sciences Centre, Manipal University,

Manipal, India.

### Abstract



We report the design and development of an optical fiber probe-based Helium-Neon (He-Ne) low-level laser therapy system for tissue regeneration. Full thickness excision wounds on Swiss albino mice of diameter 15 mm were exposed to various laser doses of 1, 2, 3, 4, 6, 8 and 10 J cm<sup>-2</sup> of the system with appropriate controls, and 2 J cm<sup>-2</sup> showing optimum healing was selected. The treatment schedule for applying the selected laser dose was also standardized by irradiating the wounds at different postwounding times (0, 24 and 48 h). The tissue regeneration potential was evaluated by monitoring the progression of wound contraction and mean wound healing time along with the hydroxyproline and glucosamine estimation on wound ground tissues. The wounds exposed to 2 J cm<sup>-2</sup> immediately after wounding showed considerable contraction on days 5, 9, 12, 14, 16 and 19 of postirradiation compared with the controls and other treatment schedules, showing significant ( $P < 0.001$ ) decrease in the healing time. A significant increase in hydroxyproline and glucosamine levels was observed for the 2 J cm<sup>-2</sup> irradiation group compared with the controls and other treatment groups. In conclusion, the wounds treated with 2 J cm<sup>-2</sup> immediately after the wounding show better healing compared with the controls.

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PMID:20735808[PubMed - indexed for MEDLINE]

## Laser photobiomodulation of wound healing: a review of experimental studies in mouse and rat animal models.

[Peplow PV](#), [Chung TY](#), [Baxter GD](#). [Photomed Laser Surg](#). 2010 Jun;28(3):291-325. Department of Anatomy & Structural Biology, University of Otago, Dunedin, New Zealand.

### Abstract

#### OBJECTIVES:

This investigation reviewed experimental studies of laser irradiation of wound healing in mice and rats published from 2003 to August 2008, respectively, to assess putative stimulatory effects of this treatment.

#### BACKGROUND:

Animal models, including rodents, attempt to reflect human wound healing and associated problems such as dehiscence, ischemia, ulceration, infection, and scarring. They have played a key role in furthering understanding of underlying mechanisms involved in impaired wound healing, and in testing new therapeutic strategies including laser irradiation.

#### METHOD:

Original research papers investigating effects of laser or monochromatic light therapy on wound healing in mice and rats and published from January 2003 to August 2008 were retrieved from library sources, PubMed and Medline databases, reference lists from retrieved papers, and hand searches of relevant journals. Papers were selected for this review with regard to specific inclusion and exclusion criteria. Studies were critically reviewed in terms of study design, methodology, and appropriateness of laser irradiation parameters.

#### RESULTS:

The literature search identified eight studies in mice and 39 in rats. A variety of wound models were investigated, including acute-wound, impaired-healing, and chronic-wound models. Considerable variation was observed in research design, methodology, and irradiation parameters employed, limiting comparison of research findings between studies. Inadequate reporting of key experimental details, or errors in specification and/or calculation of key irradiation parameters was also found. Evidence from the studies reviewed suggested that use of red or infrared wavelength at a range of dosage parameters (median 4.2 J cm<sup>-2</sup>) results in significant benefits in measured parameters of wound healing.



Interestingly, coherence does not seem essential to the photobiomodulatory effects of 'laser' phototherapy.

**CONCLUSION:**

Studies reviewed consistently demonstrated the ability of laser or monochromatic light to photobiomodulate wound healing processes in experimental wounds in rats and mice, and strongly support the case for further controlled research in humans. PMID:19995230[PubMed - indexed for MEDLINE]

**Photodynamic modulation of wound healing: a review of human and animal studies.** [Photomed Laser Surg.](#) 2012 Mar;30(3):118-48. Epub 2012 Jan 27. [Peplow PV](#), [Chung TY](#), [Baxter GD](#).

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**Abstract**

**OBJECTIVE:**

The purpose of this study was to review studies of photodynamic therapy (PDT) on wound healing and cells in vitro, to assess the effects of such therapy.

**BACKGROUND DATA:**

PDT is used to treat tumors. When activated by light of a specific wavelength, the photosensitizer produces reactive oxygen species (ROS) that kill tumor cells. Low levels of ROS may induce cellular proliferation.

**METHODS:**

Research articles investigating PDT on wound healing and cells in vitro published up to August 2010 were retrieved from library sources, PubMed and Medline databases, reference lists of articles, and searches of relevant journals.

**RESULTS:**

The studies indicated that use of various photosensitizers combined with laser irradiation led to improved wound outcomes. For most in vitro studies, there was a decrease in cell growth or viability.

**CONCLUSIONS:**

PDT improved healing outcomes in several animal wound models, but mainly had an inhibitory effect on cells in vitro. These findings strongly support PDT for wound healing PMID:22283621[PubMed - indexed for MEDLINE]

[J Photochem Photobiol B.](#) 2012 Jun 4;111:1-8. doi: 10.1016/j.jphotobiol.2012.03.001. Epub 2012 Mar 16.

**Effects of pulsed infra-red low level-laser irradiation on open skin wound healing of healthy and streptozotocin-induced diabetic rats by biomechanical evaluation.**

[Dadpay M](#), [Sharifian Z](#), [Bayat M](#), [Bayat M](#), [Dabbagh A](#).

Department of Pathology, Army University of Medical Sciences, Tehran, Iran. dadpay\_m@yahoo.com

**Abstract**



Diabetes is one of the most common causes of delayed wound healing. Low-level laser therapy (LLLT) are one of the therapeutic modalities used for the treatment of wounds. The aim of present study is to evaluate the effect of LLLT in experimentally-induced diabetic rats. Two full thickness skin incisions were made on dorsal regions of each rat. The wounds were randomly divided into laser-treated and placebo. Laser-treated wounds of the healthy (non-diabetic) animals were submitted to a pulsed-infrared 890nm laser with an 80Hz frequency and 0.03J/cm<sup>2</sup> for each wound point in the first healthy group and 0.2J/cm<sup>2</sup> in the second healthy group. Laser-treated wounds of the diabetic animals received the same pulsed-infrared lasertreatments as the second group for each wound point. On day 15, a sample from each wound was extracted and submitted for tensile strength evaluation. Laser irradiation with 0.03J/cm<sup>2</sup> significantly decreased the maximum load for wound repair in healthy rats ( $p=0.015$ ). Laser irradiation with 0.2J/cm<sup>2</sup> significantly increased the maximum load in wounds from the healthy control ( $p=0.021$ ) and diabetic ( $p<0.001$ ) groups. Lasertreatments with a pulsed infrared laser at 0.2J/cm<sup>2</sup> significantly accelerated wound healing in both healthy and diabetic rats.

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## Laser therapy in the tissue repair process: a literature review.

[da Silva JP](#), [da Silva MA](#), [Almeida AP](#), [Lombardi Junior I](#), [Matos AP](#). [Photomed Laser Surg](#). 2010 Feb;28(1):17-21.

Physiotherapy Department, Faculdade de Tecnologia e Ciências, Vitória da Conquista, Brazil. jacquepereira@gmail.com

### Abstract

#### OBJECTIVE:

Carry out a literature review on the use of laser therapy in the tissue repair process and address the different lasers and parameters used by the authors.

#### METHODS:

A review was carried out of the literature from 1960 to 2008 in the Lilacs, Medline, and PubMed databases using the following key words: Laser Therapy, Wound Healing, and Tissue repair.

#### RESULTS:

The most frequently used types of laser are helium neon (HeNe) lasers and diode lasers, including gallium-aluminum-arsenium (GaAlAs), arsenium-gallium (AsGa), and indium-gallium-aluminum-phosphide (InGaAlP) lasers. However, implementation of different protocols was found, with different materials and different activating wavelengths, thus making it difficult to compare results and choose the parameters of treatment.

#### CONCLUSIONS:

The majority of authors report that laser therapy speeds up the process of tissue repair, but further studies are suggested to determine the best parameters to be used.

PMID:19764898[PubMed - indexed for MEDLINE]

## Analysis of the systemic effect of red and infrared laser therapy on wound repair.

[Rodrigo SM](#), [Cunha A](#), [Pozza DH](#), [Blaya DS](#), [Morales JF](#), [Weber JB](#), [de Oliveira MG](#). [Photomed Laser Surg](#). 2009 Dec;27(6):929-35.

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## Abstract

### OBJECTIVE:

To evaluate, using histological analysis, the systemic action and repair process of wounds produced on the back of rats and treated with red, infrared, or both lasers applied directly or indirectly to the wounds.

### BACKGROUND DATA:

Skin tissue repair and wound healing are complex processes that involve a series of dynamic events. Many benefits are associated with biomodulation using laser therapy.

### METHODS:

Thirty-six male Wistar rats were divided into four groups: control (without laser), red laser (aluminium gallium indium phosphide (AlGaInP);  $\lambda=685$  nm;  $\phi=0.0314$  cm<sup>2</sup>; CW; P=30 mW; D=20 J, time of irradiation=667 sec), infrared laser (gallium-aluminum-arsenide (GaAlAs):  $\lambda=830$  nm;  $\phi=0.0314$  cm<sup>2</sup>; CW; P=50 mW; D=20 J, time of irradiation=401 sec), and both lasers (infrared laser: GaAlAs;  $\lambda=830$  nm;  $\phi=0.0314$  cm<sup>2</sup>; CW; P=50 mW; D=10 J, time of irradiation=201 sec+red laser: AlGaInP;  $\lambda=685$  nm;  $\phi=0.0314$  cm<sup>2</sup>; CW; P=30 mW; D=10 J, time of irradiation=334 sec; total dose=20 J). Three subgroups were formed according to observation time points. Three wounds were produced on the back of each animal. Only the wound closest to the head was irradiated in the experimental groups. For the evaluation of skin reaction and woundhealing, three animals of each group were killed at 3, 5, and 7 days postoperatively. The irradiation protocol established 48-hour intervals between applications, with the first application immediately after the surgical procedure.

### RESULTS:

In the red and infrared laser group, healing was more advanced in the wound located furthest from the point of laser application. The most effective healing of a proximal wound was verified in the control group on the 7th postoperative day.

### CONCLUSION:

The combined application of red and infrared lasers resulted in the most evident systemic effect on the repair of skin wounds produced in rats.

PMID:19708798[PubMed - indexed for MEDLINE]

## Low-level laser therapy (LLLT) efficacy in post-operative wounds.

[Herascu N](#), [Velciu B](#), [Calin M](#), [Savastru D](#), [Talianu C](#). *Photomed Laser Surg*. 2005 Feb;23(1):70-3.

National Institute of Research and Development for Optoelectronics INOE 2000, 1 Atomistilor St., PO Box MG5, 077125, Magurele-Bucharest, Romania. herascu@inoe.inoe.ro

**OBJECTIVE:** The aim of this paper was to investigate the efficacy of low-level laser radiation (LLLR) with wavelength of 904 nm on the stimulation of the healing process of postoperative aseptic wounds (early scar). **BACKGROUND DATA:** Low-level laser therapy (LLLT) has been increasingly used to treat many disorders, including wounds. However, despite such increased clinical usage, there is still controversy regarding the efficacy of this wound treatment in current clinical practice. **METHODS:** LLLT has been used to treat cutting plague in the right instep and on the left foot. Both resulted from sutured wounds. The clinical evaluation by semiquantitative methods is presented. **RESULTS:** Clinical evaluation showed that the healing process of these postoperatively treated wounds has occurred and that the functional recovery of the patients (i.e., return to their ordinary life)





was faster than without treatment. CONCLUSION: LLLR with wavelength of 904 nm to stimulate postoperative aseptic wounds (early scar) is efficient in both cases of cutting plague.

PMID: 15782037 [PubMed - indexed for MEDLINE]

1: [Photomed Laser Surg.](#) 2004 Jun;22(3):241-7. *Mary Ann Liebert,* [Links](#)

### The efficacy of laser therapy in wound repair: a meta-analysis of the literature.

[Woodruff LD](#), [Bounkeo JM](#), [Brannon WM](#), [Dawes KS](#), [Barham CD](#), [Waddell DL](#), [Enwemeka CS](#).

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OBJECTIVE: We determined the overall effects of laser therapy on tissue healing by aggregating the literature and subjecting studies meeting the inclusion and exclusion criteria to statistical meta-analysis. BACKGROUND DATA: Low-level laser therapy (LLLT) devices have been in use since the mid sixties, but their therapeutic value remains doubtful, as the literature seems replete with conflicting findings. MATERIALS AND METHODS: Pertinent original research papers were gathered from library sources, online databases and secondary sources. The papers were screened and coded; those meeting every inclusion and exclusion criterion were subjected to meta-analysis, using Cohen's d. statistic to determine the treatment effect size of each study. RESULTS: Twenty-four studies with 31 effect sizes met the stringent inclusion and exclusion criteria. The overall mean effect of laser therapy on wound healing was highly significant ( $d = +2.22$ ). Sub-analyses of the data revealed significant positive effects on wound healing in animal experiments ( $d = +1.97$ ) as well as human clinical studies ( $d = +0.54$ ). The analysis further revealed significant positive effects on specific indices of healing, for example, acceleration of inflammation ( $d = +4.45$ ); augmentation of collagen synthesis ( $d = +1.80$ ); increased tensile strength ( $d = +2.37$ ), reduced healing time ( $d = +3.24$ ); and diminution of wound size ( $d = +0.55$ ). The Fail-Safe number associated with the overall effect of laser therapy was 509; a high number representing the number of additional studies-in which laser therapy has negative or no effect on wound healing-required to negate the overall large effect size of +2.22. The corresponding Fail-Safe number for clinical studies was 22. CONCLUSION: We conclude that laser therapy is an effective tool for promoting wound repair.

PMID: 15315732 [PubMed - indexed for MEDLINE]

**The efficacy of low-power lasers in tissue repair and pain control: a meta-analysis study.** [Enwemeka CS](#), [Parker JC](#), [Dowdy DS](#), [Harkness EE](#), [Sanford LE](#), [Woodruff LD](#). : [Photomed Laser Surg.](#) 2004 Aug;22(4):323-9.

School of Health Professions, Behavioral and Life Sciences, New York Institute of Technology, Old Westbury, NY



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**OBJECTIVE:** We used statistical meta-analysis to determine the overall treatment effects of laser phototherapy on tissue repair and pain relief. **BACKGROUND DATA:** Low-power laser devices were first used as a form of therapy more than 30 years ago. However, their efficacy in reducing pain or promoting tissue repair remains questionable. **METHODS:** Following a literature search, studies meeting our inclusion criteria were identified and coded. Then, the effect size of laser treatment, that is, Cohen's  $d$ , was calculated from each study using standard meta-analysis procedures. **RESULTS:** Thirty-four peer-reviewed papers on tissue repair met our inclusion criteria and were used to calculate 46 treatment effect sizes. Nine peer-reviewed papers on pain control met the inclusion criteria and were used to calculate nine effect sizes. Meta-analysis revealed a positive effect of laser phototherapy on tissue repair ( $d = +1.81$ ;  $n = 46$ ) and pain control ( $d = +1.11$ ;  $n = 9$ ). The positive effect of treatment on specific indices of tissue repair was evident in the treatment effect sizes determined as follows: collagen formation ( $d = +2.78$ ), rate of healing ( $d = +1.57$ ), tensile strength ( $d = +2.13$ ), time needed for wound closure ( $d = +0.76$ ), tensile stress ( $d = +2.65$ ), number and rate of degranulation of mast cells ( $d = +1.87$ ), and flap survival ( $d = +1.95$ ). Further, analysis revealed the positive effects of various wavelengths of laser light on tissue repair, with 632.8 nm having the highest treatment effect ( $d = +2.44$ ) and 780 nm the least ( $d = 0.60$ ). The overall treatment effect for pain control was positive as well ( $d = +1.11$ ). The fail-safe number—that is, the number of studies in which laser phototherapy has negative or no effect—needed to nullify the overall outcome of this analysis was 370 for tissue repair and 41 for pain control. **CONCLUSIONS:** These findings mandate the conclusion that laser phototherapy is a highly effective therapeutic armamentarium for tissue repair and pain relief.

Publication Types: [Meta-Analysis](#) PMID: 15345176 [PubMed - indexed for MEDLINE]

1: [Photomed Laser Surg.](#) 2004 Dec;22(6):513-8. *Mary Ann Liebert,* [Links](#)

**A preliminary report on the effect of laser therapy on the healing of cutaneous surgical wounds as a consequence of an inversely proportional relationship between wavelength and intensity: histological study in rats.**

[do Nascimento PM](#), [Pinheiro AL](#), [Salgado MA](#), [Ramalho LM](#).

IPD, Univap, Sao Jose dos Campos, Sao Paulo, Brazil.

**OBJECTIVE:** The objective of the present investigation was to assess the histological effects of different wavelengths and intensities on the healing process of cutaneous wounds. **BACKGROUND DATA:** Tissue repair is a dynamic interactive process which involves mediators, cells and extra-cellular matrix. Several reports on the use of laser therapy have shown that the healing process is positively affected when the correct parameters are used. **METHODS:** Eighteen standardized wounds were surgically created on the dorsum of male and female Wistar rats, which were subsequently divided into two experimental groups according to wavelength used  $\lambda.670$  or  $\lambda.685$  nm) for lasertherapy (LLLT). Each group was divided into three subgroups of three animals according



to the intensity of the applied irradiation (2, 15, or 25 mW). Twelve animals were used as untreated controls and were not irradiated. The irradiation was carried out during seven consecutive days. The animals were sacrificed eight days after surgery. The specimens were removed, kept in 4% formaldehyde for 24 h, routinely prepared to wax, stained with H&E, and analyzed under light microscopy. RESULTS: For both groups, light microscopy showed a substitution repair process; however, when LLLT was used, a positive biomodulatory effect was detectable, chiefly associated with shorter wavelength and low intensity. CONCLUSIONS: The results of the present study indicate that LLLT improved cutaneous wound repair and that the effect is a result of an inversely proportional relationship between wavelength and intensity, with treatment more effective when combining higher intensity with short wavelength or lower intensity with higher wavelength.

PMID: 15684753 [PubMed - indexed for MEDLINE]

**Photo-infrared pulsed bio-modulation (PIPBM): a novel mechanism for the enhancement of physiologically reparative responses.** [Photomed Laser Surg.](#) 2005 Aug;23(4):416-24.

[Santana-Blank LA](#), [Rodriguez-Santana E](#), [Santana-Rodriguez KE](#).

Fundalas, Foundation for Interdisciplinary Research and Development, Caracas, Venezuela.  
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OBJECTIVE: The present manuscript describes the non-invasive, long-range, energy transport of a singular infrared pulsed laser device (IPLD) and the upstream components of the original action mechanism, designated photo-infrared pulsed bio-modulation (PIPBM). BACKGROUND DATA: Major strides have been taken in recent years towards scientifically acceptable clinical applications of low-energy lasers. Nevertheless, challenges still abound. For instance, the range of potential target tissues for laser therapy in medicine has been, until now, limited by the optical penetration of the beam or to sites accessible by fiberoptics. In addition, much needs to be learned about the action mechanisms of pulsed lasers, which can induce unique biological effects. METHODS: We present a review of the IPLD laser technology and the PIPBM mechanism. RESULTS: The studies reviewed suggest that the PIPBM enhances physiologically reparative processes in a non-toxic and selective manner through the activation and modulation of chaotic dynamics in water. These, in turn, lead not only to local, but also long-distance (systemic) effects. CONCLUSIONS: Though additional studies are necessary to fully explore the biological effects of the PIPBM induced by the IPLD, this mechanism may have multiple potential applications in medicine that are the subject of active current and future investigations.

Publication Types: [Review](#) PMID: 16144487 [PubMed - indexed for MEDLINE]

**Burn healing with a diode laser: 670 nm at different doses as compared to a placebo group.**

[Al-Watban FA](#), [Delgado GD](#). : [Photomed Laser Surg.](#) 2005 Jun;23(3):245-50.



Laser Medicine Section, Biological and Medical Research, King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia. watban@kfshrc.edu.sa

**OBJECTIVE:** A study on burn healing in rats was initiated using a diode laser at varied doses for determination of optimum dosimetry and treatment schedule. **MATERIALS AND METHODS:** A number of male Sprague-Dawley rats were randomly assigned to several groups. Anesthesia (a mixture of ketamine HCl and Xylocaine) was administered intraperitoneally. Burn on both flanks was created using a preheated metal probe and measured daily using a caliper. The right side of the treated rats was irradiated five times and three times per week. Slopes from the actual burn areas were obtained and compared against the control with the healing rate calculated and expressed in percent. **RESULTS:** In reference to the control group, no significant difference in healing was observed. In comparing both treatment schedules, there was likewise no significant difference at any day in both age-groups. Notably in younger rats, accelerated healing was observed with the highest rate in the lower range of doses (1 and 5 J/cm<sup>2</sup>), 12.4% and 11.6%, respectively. **CONCLUSION:** This experiment affirms that the beneficial effect on burn healing in rats is indeed affected by an interplay of several factors.

PMID: 15954810 [PubMed - indexed for MEDLINE]

#### **Contribution of phototherapy to the treatment of episiotomies.**

[Kymplova J, Navratil L, Knizek J. J Clin Laser Med Surg. 2003 Feb;21\(1\):35-9.](#)

Section of Radiobiology and Toxicology, Department of Radiology, University of South Bohemia, Ceske Budejovice, Czech Republic.

**OBJECTIVE:** The purpose of this study was an objective consideration of possible benefits of phototherapy implemented with therapeutic laser or possibly polarized light in treating episiotomy, which is the most frequent obstetric intervention. **MATERIALS AND METHODS:** In the present study, the authors treated a total of 2,436 women. The light sources were as follows: a laser of a wave length 670 nm, power 20 mW, with continuous alternations of frequencies 10 Hz, 25 Hz, and 50 Hz, a polarized light source of a 400-2,000 nm wavelength in an interval of power 20 mW and frequency 100 Hz and a monochromatic light source of a 660 nm wavelength and power 40 mW, with simultaneous application of a magnetic field at an induction 8 mT. **RESULTS:** The work demonstrated high healing effects with minimum secondary complications in the treatment of episiotomies using a therapeutic laser at an energy density of 2 J/cm<sup>2</sup>. The application of polarized light at an energy density of 5 J/cm<sup>2</sup> also exerted favorable therapeutic effects.

Publication Types: [Clinical Trial](#) [Controlled Clinical Trial](#)

PMID: 12614558 [PubMed - indexed for MEDLINE]



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

[Khadra M](#), [Lyngstadaas SP](#), [Haanaes HR](#), [Mustafa K](#).

Department of Oral Surgery and Oral Medicine, Faculty of Dentistry, University of Oslo, P.O. Box 1109 Blindern, N-0317 Oslo, Norway. [maawan@odont.uio.no](mailto:maawan@odont.uio.no)

The purpose of this study was to investigate the influence of single or multiple doses of low-level laser therapy (LLLT) on attachment and proliferation of human gingival fibroblasts in a standardized, reproducible in vitro model. Titanium discs were randomly allotted to one of three groups: group I served as a control, group II was exposed to a single laser dose of 3 J/cm<sup>2</sup>, and the three subgroups in group III were exposed to laser doses of 0.75, 1.5, and 3 J/cm<sup>2</sup>. To examine the possible thermal effects of laser exposure on the cell culture, the temperature in the Petri dish was measured for every dose used, before and during irradiation. For attachment assays, groups II and III were exposed to laser irradiation and then seeded onto titanium discs. In group III, the exposures were repeated after 3 and 6 h. Cells were cultured for 6 and 24 h and stained with Hoechst and Propidium. Attached cells were counted under a light microscope. To investigate the effect of LLLT on cell proliferation after 48 h, 72 h, and 7 days, cells were cultured on titanium discs for 24 h and then exposed to laser irradiation for 1 day and 3 consecutive days, respectively. Cell proliferation was determined by counting cells under the microscope and by a cell proliferation enzyme-linked immunosorbent assay system. No increase of temperature of the cell cultures occurred before or during laser exposure at any of the doses tested. Both single and multiple doses of LLLT significantly enhanced cellular attachment ( $p < 0.05$ ). The proliferation assays showed higher cell proliferation ( $p < 0.05$ ) in group III at doses of 1.5 and 3 J/cm<sup>2</sup> after 72 h and 7 days, with agreement between staining and enzyme-linked immunosorbent assay. 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. Copyright (c) 2005 Wiley Periodicals, Inc.

PMID: 15704112 [PubMed - indexed for MEDLINE]

**Effect of In-Ga-Al-P diode laser irradiation on angiogenesis in partial ruptures of Achilles tendon in rats.**

[Salate AC](#), [Barbosa G](#), [Gaspar P](#), [Koeke PU](#), [Parizotto NA](#), [Benze BG](#), [Foschiani D](#). : [Photomed Laser Surg](#). 2005 Oct;23(5):470-5. Department of Physiotherapy, Federal University of Sao Carlos, Sao Paulo, Brazil.

OBJECTIVE: This study was conducted to analyze the effect of different irradiances of low-level laser therapy (LLLT) on angiogenesis after partial rupture of Achilles tendon of rats. BACKGROUND DATA: METHODS: Ninety-six animals were divided into three groups subject to treatment during 3, 5, and 7 days post-lesion. Thirty-two animals were used in each group. The groups were further divided into four subgroups with eight animals in each,



receiving In-Ga-Al-P laser (660 nm) treatment at (1) mean output of 10 mW, (2) 40 mW during 10 sec, (3) a sham subgroup, and (4) a non-treatment subgroup. Each animal was subjected to a lesion of the Achilles tendon by dropping a 186-g weight from a 20-cm height over the tendon. Treatment was initiated 6 h post-injury for all the groups. Blood vessels were colored with India ink injection and were examined in a video microscope. RESULTS: Laser exposure promoted an increase in blood vessel count when compared to controls. The 40-mW group showed early neovascularization, with the greatest number of microvessels after three laser applications. The 10-mW subgroup showed angiogenesis activity around the same time as the sham laser group did, but the net number of vessels was significantly higher in the former than in the controls. After seven irradiations, the subgroup receiving 40 mW experienced a drop in microvessel number, but it was still higher than in the control groups. CONCLUSIONS: LLLT of different intensities seems to promote neovascularization in damaged Achilles tendons of rats after partial rupture compared to controls.

PMID: 16262576 [PubMed - indexed for MEDLINE]

: [J Clin Laser Med Surg](#). 2004 Feb;22(1):19-25. [Links](#)

#### **Dose and wavelength of laser light have influence on the repair of cutaneous wounds.**

[Mendez TM](#), [Pinheiro AL](#), [Pacheco MT](#), [Nascimento PM](#), [Ramalho LM](#). IP&D, Univap & School of Dentistry, Universidade do Vale do Paraiba, Sao Jose dos Campos, Sao Paulo, Brazil.

OBJECTIVE: The objective of the present study was to compare histologically the effect of GaAlAs (lambda 830 nm, phi approximately 2 mm<sup>2</sup>), 35 mW) and InGaAlP (lambda 685 nm, phi approximately 2 mm<sup>2</sup>), 35 mW) lasers, alone or in association with doses of 20 or 50 J/cm<sup>2</sup>) on cutaneous wounds in the dorsum of the Wistar rat. Background Data: The healing time of surgical wounds is of extreme importance and it is usually associated with a post-operative period free of infection and with less pain and inflammation. MATERIALS AND METHODS: Sixty Wistar rats were divided into seven groups: Group I - control (non-irradiated); Group II - lambda 685 nm, 20 J/cm<sup>2</sup>); Group III - lambda 830 nm, 20 J/cm<sup>2</sup>); Group IV - lambda 685 nm and lambda 830 nm, 20 J/cm<sup>2</sup>); Group V - lambda 685 nm, 50 J/cm<sup>2</sup>); Group VI - lambda 830 nm, 50 J/cm<sup>2</sup>); and Group VII - lambda 685 nm and 830 nm, 50 J/cm<sup>2</sup>). The animals were sacrificed 3, 5, and 7 days after surgery. RESULTS: Light microscopic analysis using H&E and Picrosirius stains showed that, at the end of the experimental period, irradiated subjects showed increased collagen production and organization when compared to non-irradiated controls. Inflammation was still present in all groups at this time. CONCLUSION: Group IV (lambda 830 nm and lambda 685 nm, 20 J/cm<sup>2</sup>) presented better results at the end of the experimental period. It is concluded that low-level light therapy (LLLT) can have a positive biomodulatory effect on the repair of cutaneous wounds.

PMID: 15117483 [PubMed - indexed for MEDLINE]





: [J Clin Laser Med Surg](#). 2004 Feb;22(1):19-25. [Links](#)

**Dose and wavelength of laser light have influence on the repair of cutaneous wounds.**

[Mendez TM](#), [Pinheiro AL](#), [Pacheco MT](#), [Nascimento PM](#), [Ramalho LM](#).

IP&D, Univap & School of Dentistry, Universidade do Vale do Paraiba, Sao Jose dos Campos, Sao Paulo, Brazil.

**OBJECTIVE:** The objective of the present study was to compare histologically the effect of GaAlAs (lambda 830 nm, phi approximately 2 mm(2), 35 mW) and InGaAlP (lambda 685 nm, phi approximately 2 mm(2), 35 mW) lasers, alone or in association with doses of 20 or 50 J/cm(2) on cutaneous wounds in the dorsum of the Wistar rat.

**Background Data:** The healing time of surgical wounds is of extreme importance and it is usually associated with a post-operative period free of infection and with less pain and inflammation. **MATERIALS AND METHODS:** Sixty Wistar rats were divided into seven groups: Group I - control (non-irradiated); Group II - lambda 685 nm, 20 J/cm(2); Group III - lambda 830 nm, 20 J/cm(2); Group IV - lambda 685 nm and lambda 830 nm, 20 J/cm(2); Group V - lambda 685 nm, 50 J/cm(2); Group VI - lambda 830 nm, 50 J/cm(2); and Group VII - lambda 685 nm and 830 nm, 50 J/cm(2). The animals were sacrificed 3, 5, and 7 days after surgery. **RESULTS:** Light microscopic analysis using H&E and Picrosirius stains showed that, at the end of the experimental period, irradiated subjects showed increased collagen production and organization when compared to non-irradiated controls. Inflammation was still present in all groups at this time. **CONCLUSION:** Group IV (lambda 830 nm and lambda 685 nm, 20 J/cm(2)) presented better results at the end of the experimental period. It is concluded that low-level light therapy (LLLT) can have a positive biomodulatory effect on the repair of cutaneous wounds.

PMID: 15117483 [PubMed - indexed for MEDLINE]

1: [Rozhl Chir](#). 2005 Aug;84(8):417-21. [Links](#)

**[Effect of laser irradiation of diode laser on healing of surgical wounds in rats]**

[Article in Czech]

[Vidinsky B](#), [Gal P](#), [Toporcer T](#), [Balogacova M](#), [Hutnanova Z](#), [Kilik R](#), [Bober J](#), [Sabo J](#), [Longauer F](#). Ustav lekarskej biofyziky, Lekarska fakulta Univerzity Pavla Jozefa Safarika v Kosiciach, Slovenska republika.

The aim of this work was to continue in previous study, which concerns biostimulation of skin wound healing evaluated after 24, 48, 120, 168 hours and so complete the chronological continuance of the process during the first seven days. Male, Sprague-Dawley rats (n=21) were used for the experiment. The rats were divided into 3 groups of 7 animals. In general anaesthesia (combination of xylazine, ketamine and tramadol) under aseptic condition two 3,5 cm long parallel skin incisions were performed on the left and right side of the rats spine and immediately sutured. The left wounds were daily stimulated with the diode laser (670 nm). The right wounds were not stimulated and served as control. The specimens of skin wounds were removed for histological evaluation 72, 96 and 144 hours after surgery. The biological specimens were stained with hematoxylin and eosin



and histopathologically evaluated. In summary, in our histomorphological study of the influence of laser irradiation on primary wound healing evaluated after 72, 96 and 144 hours was concluded, that the healing of stimulated wounds was accelerated in comparison with controls. The histological evaluation showed earlier regress of inflammatory phase, faster finishing of reepithelization and acceleration in maturation phase. Presented experimental study completes the previous study and achieves the positive effect of biostimulation on all phases of skin wound healing in vivo.

PMID: 16218351 [PubMed - indexed for MEDLINE]

### **[Effect of laser irradiation of diode laser on healing of surgical wounds in rats]**

[Article in Czech] [Rozhl Chir.](#) 2005 Aug;84(8):417-21

[Vidinsky B](#), [Gal P](#), [Toporcer T](#), [Balogacova M](#), [Hutnanova Z](#), [Kilik R](#), [Bober J](#), [Sabo J](#), [Longauer F](#).

Ustav lekarskej biofyziky, Lekarska fakulta Univerzity Pavla Jozefa Safarika v Kosiciach, Slovenska republika.

The aim of this work was to continue in previous study, which concerns biostimulation of skin wound healing evaluated after 24, 48, 120, 168 hours and so complete the chronological continuance of the process during the first seven days. Male, Sprague-Dawley rats (n=21) were used for the experiment. The rats were divided into 3 groups of 7 animals. In general anaesthesia (combination of xylazine, ketamine and tramadol) under aseptic condition two 3,5 cm long parallel skin incisions were performed on the left and right side of the rats spine and immediately sutured. The left wounds were daily stimulated with the diode laser (670 nm). The right wounds were not stimulated and served as control. The specimens of skin wounds were removed for histological evaluation 72, 96 and 144 hours after surgery. The biological specimens were stained with hematoxylin and eosin and histopathologically evaluated. In summary, in our histomorphological study of the influence of laser irradiation on primary wound healing evaluated after 72, 96 and 144 hours was concluded, that the healing of stimulated wounds was accelerated in comparison with controls. The histological evaluation showed earlier regress of inflammatory phase, faster finishing of reepithelization and acceleration in maturation phase. Presented experimental study completes the previous study and achieves the positive effect of biostimulation on all phases of skin wound healing in vivo.

PMID: 16218351 [PubMed - indexed for MEDLINE]



: [J Clin Laser Med Surg](#). 2002 Feb;20(1):37-40. [Links](#)

### Effects of 1047-nm neodymium laser radiation on skin wound healing.

[Ribeiro MS](#), [Silva DF](#), [Maldonado EP](#), [de Rossi W](#), [Zezell DM](#).

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Previous research in our laboratory has shown that the polarization component of the electrical field plays an important role on the healing process of inflammatory lesions created in the end of the spinal column of Lewis rats, using a He-Ne laser at  $\lambda = 632.8$  nm. It is well known that polarization is lost in a turbid medium, such as living tissue. However, the Nd:YLF wavelength ( $\lambda = 1,047$  nm) allows more polarization preservation than  $\lambda = 632.8$  nm, and the Nd:YLF laser beam has been used in clinical trials as a biostimulating agent. In this work, we investigated the influence of a low-intensity, linearly polarized Nd:YLF laser beam on skin wound healing, considering two orthogonal directions of polarization. We have considered a preferential axis as the animals' spinal column, and we aligned the linear laser polarization first parallel, then perpendicular to this direction. Burns of about 6 mm in diameter were created with liquid N<sub>2</sub> on the back of the animals, and the lesions were irradiated on days 3, 7, 10, and 14 postwounding,  $D = 1.0$  J/cm<sup>2</sup>. Lesions 1 and 2 were illuminated using Nd:YLF pulsed laser radiation. Lesion 1 was irradiated with linear polarization parallel with the rat spinal column. Lesion 2 was irradiated using the same protocol, but the light polarization was aligned with the perpendicular relative orientation. Control lesions were not irradiated. We have taken photographs from the wound areas on the 3rd, 7th, 10th, 14th, and 17th postoperative day for a biometrical analysis. The results have shown that lesion 1 healed faster than the control lesions ( $p < 0,05$ ), which presented a smaller degree of healing after 14 days postwounding.

PMID: 11902353 [PubMed - indexed for MEDLINE]

: [J Clin Laser Med Surg](#). 2004 Feb;22(1):59-66. [Links](#)

### Effects of low-intensity polarized visible laser radiation on skin burns: a light microscopy study.

[Ribeiro MS](#), [Da Silva Dde F](#), [De Araujo CE](#), [De Oliveira SF](#), [Pelegriani CM](#), [Zorn TM](#), [Zezell DM](#).


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**OBJECTIVE:** This study was carried out to investigate the influence of low-intensity polarized visible laser radiation on the acceleration of skin wound healing. **Background Data:** Low-level laser therapy (LLLT) at adequate wavelength, intensity, and dose can accelerate tissue repair. However, there is still unclear information about light characteristics, such as coherence and polarization. Some studies indicate that linearly polarized light can survive through long propagation distance in biological tissue. **MATERIALS AND METHODS:** Three burns about 6 mm in



diameter were created on the back of rats with liquid N<sub>2</sub>. Lesion "L(//)" was irradiated by He-Ne laser ( $\lambda = 632.8 \text{ nm}$ ),  $D = 1.0 \text{ J/cm}^2$ , with linear polarization parallel to the spinal column of the rat. Lesion "L(inverted v)" was irradiated using the same laser and dose, but the light polarization was aligned perpendicularly to the relative orientation. Lesion "C" was not irradiated in order to be considered as control. The animals were sacrificed at day 3-17 after lesion creation. Samples were collected and prepared for histological analysis. RESULTS: Histological analysis showed that the healing of irradiated wounds was faster than that of non-irradiated wounds. Moreover, it was observed that skin wound repair is dependent on polarization orientation with respect to a referential axis as the animal's spinal column. Consequently, "L(//)" was completely healed after 17 days, whereas "L (perpendicular)" showed a moderate degree of healing after the same period. CONCLUSIONS: These results indicate that the relative direction of the laser polarization plays an important role in the wound healing process when highly coherent He-Ne laser is used.

PMID: 15117489 [PubMed - indexed for MEDLINE]

1: [Lasers Med Sci](#). 2003;18(2):72-7.  SpringerLink Links  
FULL-TEXT ARTICLE

**Efficacy of low-level laser therapy in the management of stage III decubitus ulcers: a prospective, observer-blinded multicentre randomised clinical trial.**

[Lucas C](#), [van Gemert MJ](#), [de Haan RJ](#). Dept. Research and Innovation, University of Professional Education, Hogeschool van Amsterdam, The Netherlands.

Low-level laser therapy (LLLT) has been suggested as a promising treatment option for open wounds. In view of the absence of randomised studies with sufficiently large sample sizes, we assessed the efficacy of LLLT in the treatment of stage III decubitus ulcers. We performed a prospective, observer-blinded multicentre randomised clinical trial to assess the effect of LLLT as adjuvant to standard decubitus care. A total of 86 patients were enrolled into the study. Treatment was the prevailing consensus decubitus treatment ( $n=47$ ); one group ( $n=39$ ) had LLLT in addition, five times a week over a period of 6 weeks. The primary outcome measure was the absolute ( $\text{mm}^2$ ) and relative (%) wound size reduction at 6 weeks compared to baseline. Secondary outcome measures were the number of patients developing a stage IV ulcer during the study period, and the median change in Norton scores at 6 weeks compared to baseline. Based on the intention-to-treat principle, using last-observation-carried-forward analyses, Mann-Whitney U tests showed that the differences between the two groups in terms of absolute improvement ( $p=0.23$ ) and relative improvement ( $p=0.42$ ) were not significant. Because the wound size areas were non-normally distributed, we also analysed the data after logarithmic transformation of the wound size measurements. No significant difference in  $\log(e)$  improvement scores between groups could be demonstrated (unpaired t-test:  $p=0.59$ ). During the treatment period 11% of the patients in the control group and 8% of the patients in the LLLT group developed a stage IV decubitus ulcer (Fisher's exact test:  $p=0.72$ ). The patients' Norton scores did not change during the treatment period. In this trial we found no evidence that justifies using low-level laser therapy as an adjuvant to the consensus decubitus ulcer treatment.

PMID: 12928815 [PubMed - indexed for MEDLINE]



### **Efficiency of laser therapy applied in labial traumatism of patients with spastic cerebral palsy.**

[Moreira LA](#), [Santos MT](#), [Campos VF](#), [Genovese WJ](#). [Braz Dent J](#). 2004;15 Spec No:SI29-33.

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The aim of this study was to report the effectiveness of laser therapy applied to traumatic labial injury of patients with spastic cerebral palsy. We report two cases of patients with internal mucosa and lower lip traumatism caused by oral reflex automatism with spastic tonic bite and lower lip interposition. One patient presented extensive lower lip ulceration, loss of tissue, crusty and hemorrhagic areas, with increasing pain and spasticity. The other patient presented local congestion signs, extremely enlarged tissue growth and increased labial volume. Laser therapy was applied to all injured areas, with a low-potency diode InGaAlP laser [685 nm Quasar (Dentoflex), 190 J/cm<sup>2</sup>, with a 24-h interval between the first and second administration, and a 7-day interval between the two subsequent ones. At first re-evaluation, 24 h later, there was a striking reduction in inflammation, a decrease in vascular congestion, and a reduction of the ulcerated area with spasticity and pain reduction. At the 14-day re-evaluation, significant clinical differences in the advanced healing process were seen. Low-intensity laser showed to be effective in traumatic soft tissue treatment in cerebral palsy patients by accelerating the healing process, reducing secondary contamination, promoting analgesia; thus, it can be an important tool in the treatment of these patients.

Publication Types: [Case Reports](#) PMID: 15690768 [PubMed - indexed for MEDLINE]

### **Burn healing with a diode laser: 670 nm at different doses as compared to a placebo group.**

[Al-Watban FA](#), [Delgado GD](#). [Photomed Laser Surg](#). 2005 Jun;23(3):245-50.

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OBJECTIVE: A study on burn healing in rats was initiated using a diode laser at varied doses for determination of optimum dosimetry and treatment schedule. MATERIALS AND METHODS: A number of male Sprague-Dawley rats were randomly assigned to several groups. Anesthesia (a mixture of ketamine HCl and Xylocaine) was administered intraperitoneally. Burn on both flanks was created using a preheated metal probe and measured daily using a caliper. The right side of the treated rats was irradiated five times and three times per week. Slopes from the actual burn areas were obtained and compared against the control with the healing rate calculated and expressed in percent. RESULTS: In reference to the control group, no significant difference in healing was observed. In comparing both treatment schedules, there was likewise no significant difference at any day in both



age-groups. Notably in younger rats, accelerated healing was observed with the highest rate in the lower range of doses (1 and 5 J/cm<sup>2</sup>), 12.4% and 11.6%, respectively. CONCLUSION: This experiment affirms that the beneficial effect on burn healing in rats is indeed affected by an interplay of several factors.

PMID: 15954810 [PubMed - indexed for MEDLINE]

### **In vitro effect of nitrogen and He-Ne laser on the apoptosis of human polymorphonuclear cells from burn cases and healthy volunteers.**

[omed Laser Surg.](#) 2005 Oct;23(5):476-9.

[Hemvani N](#), [Chitnis DS](#), [George M](#), [Chammania S](#).

Department of Microbiology and Immunology, Choithram Hospital & Research Centre, Indore, India.

OBJECTIVE: The aim of this study was to examine the effect of He-Ne and nitrogen lasers on the apoptosis of PMN in normal versus burn patients. BACKGROUND DATA: Nitrogen and He-Ne laser exposure increases the apoptotic death rate for human macrophages. Inflammation is a major consequence of thermal injury, and polymorphonuclear cell (PMN) infiltration exacerbates inflammatory process through the release of proinflammatory cytokines. The apoptotic death instead of necrotic death of PMN under the situation may help to resolve inflammation. METHODS: Ten healthy volunteers and 10 burn cases (30-50% burn surface) were included in the study. The PMN was separated by dextran sedimentation and density gradient centrifugation before suspending in RPMI-1640 medium supplemented with autologous serum. The cell suspension aliquoted in microwells was exposed to nitrogen (wavelength of 337 nm with power output of 3 mW) and He-Ne (LGN model no. 111, Russia, wavelength of 632.8 nm with power output of 3 mW) lasers for 10 and 5 min. The wells not exposed to laser were used as controls. After 24-36 h of incubation, the apoptotic rates were measured as percentage by morphological studies on acridine orange-ethidium bromide stained preparation using fluorescent microscope. RESULTS: Percentage of apoptotic death increases from 32.9% (SD +/- 4.14) in control PMN to 41.97% (SD +/- 14) in PMN exposed to nitrogen laser for 5 min and further increased to 62.7% (SD +/- 15.11) with nitrogen laser exposure for 10 min. He-Ne laser exposure for 10 min increased apoptotic cell percentage to 41.9%. Increased apoptosis in PMN exposed to nitrogen laser was statistically significant ( $p < 0.03$ ) both for PMN from healthy subjects and burn cases. It was significantly elevated ( $p = 0.005$ ) only for PMN from healthy volunteers exposed to He-Ne laser for 10 min but not among He-Ne exposed PMN from burn cases. CONCLUSIONS: These observations support the therapeutic application of nitrogen laser to reduce inflammation and improve wound healing for burn cases.

PMID: 16262577 [PubMed - indexed for MEDLINE]





### **Identification of chondrocyte proliferation following laser irradiation, thermal injury, and mechanical trauma.**

[Wong BJ](#), [Pandhoh N](#), [Truong MT](#), [Diaz S](#), [Chao K](#), [Hou S](#), [Gardiner D](#) *Lasers Surg Med.* 2005 Jul;37(1):89-96..

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**BACKGROUND AND OBJECTIVE:** Cartilage has a limited regenerative capacity, and there are a lack of reliable techniques and methods to stimulate growth of new tissue to treat degenerative diseases and trauma. This study focused on identifying chondrocyte cell proliferation in ex vivo cartilage tissue following heating Nd:YAG laser using whole-mount analysis and flow cytometry, and compared findings with results produced by contact, and water bath heating methods, mechanical injury, and the addition of transforming growth factor-beta (TGF-beta). **STUDY DESIGN/MATERIALS AND METHODS:** Ex vivo rabbit nasal septal cartilages were either irradiated with an Nd:YAG laser ( $\lambda = 1.32$  microm, 2-16 seconds, 6 W/cm<sup>2</sup>), heated by immersion in a warm saline bath, heated by direct contact with a metal rod, or mechanically damaged by scoring with a scalpel or crushing. After treatment, specimens were incubated for 7 or 14 days in growth media containing 10 microM bromodeoxyuridine (BrdU). Additional specimens were cultured with both BrdU and TGF-beta. Both whole-mount BrdU-double-antibody detection techniques and flow cytometry were used to determine the presence of DNA replication as a marker of proliferation. **RESULT:** An annular region of regenerating chondrocytes was identified surrounding the laser irradiation zone in whole-mount tissue specimens, and the diameter of this region increased with irradiation time. Using whole-mount analysis, no evidence of chondrocyte DNA replication was observed in tissues heated using non-laser methods, grown in TGF-beta, or mechanically traumatized. In contrast, flow cytometry identified the presence of BrdU-positive cells in the S-phase of the cell cycle (synthesis of DNA) for all protocols, indicating chondrocyte proliferation. The percentage of cells that are in S-phase increased with irradiation time. **CONCLUSION:** These data provide evidence that laser irradiation, along with other thermal and mechanical treatments, causes a proliferative response in chondrocytes, and this is observed ex vivo in the absence of cellular and humoral repair mechanisms. The advantage of using optical methods to generate heat in cartilage is that microspot injuries could be created in tissue and scanned across surfaces in clinical applications. (c) 2005 Wiley-Liss, Inc. PMID: 15900561 [PubMed - indexed for MEDLINE]

### **Influence of low level laser therapy on wound healing and its biological action upon myofibroblasts.**

[Medrado AR](#), [Pugliese LS](#), [Reis SR](#), [Andrade ZA](#). *Lasers Surg Med.* 2003;32(3):239-44.

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**BACKGROUND AND OBJECTIVE:** In re-evaluating the effects of laser therapy in wound healing, the role of extracellular matrix elements and myofibroblasts, was analyzed. **STUDY DESIGN/MATERIALS AND METHODS:** Cutaneous wounds were inflicted on the back of 72 Wistar rats. Low level laser was locally applied with different energy densities. Lesions were analyzed after 24, 48, 72 hours and 5, 7, and 14 days. Tissues were studied by histology, immunohistochemistry, and electron microscopy. **RESULTS:** In treated animals, the extent of edema and the number of inflammatory cells were reduced ( $P < 0.05$ ), but the amount of collagen and elastic fibers appeared slightly increased. Desmin/smooth muscle alpha-actin-phenotype myofibroblasts were statistically more prominent on the 3rd day after surgery ( $P < 0.05$ ) in treated wounds than in controls. Treatment with a dosage of 4 J/cm<sup>2</sup> was superior to that with 8 J/cm<sup>2</sup>. **CONCLUSIONS:** Laser therapy reduced the inflammatory reaction, induced increased collagen deposition and a greater proliferation of myofibroblasts in experimental cutaneous wounds. Copyright 2003 Wiley-Liss, Inc.

PMID: 12605432 [PubMed - indexed for MEDLINE]

**Polarized light (400-2000 nm) and non-ablative laser (685 nm): a description of the wound healing process using immunohistochemical analysis.** [Photomed Laser Surg.](#) 2005 Oct;23(5):485-92

[Pinheiro AL](#), [Pozza DH](#), [Oliveira MG](#), [Weissmann R](#), [Ramalho LM](#).

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**OBJECTIVE:** This study aimed to describe, through morphologic and cytochemical analysis, the healing process of wounds submitted (or not) to laser therapy ( $\lambda 685$  nm) or polarized light ( $\lambda 400-2000$  nm). **BACKGROUND DATA:** There are many reports on different effects of several types of phototherapies on the treatment of distinct conditions, amongst them, on wound healing. Laser therapy and the use of polarized light are still controversial despite successive reports on their positive effects on several biological processes. **METHODS:** Thirty male Wistar rats, approximately 4 months old, were used, and standardized excisional wounds were created on their dorsum. The wounds were irradiated in four equidistant points with laser light or illuminated with polarized light, both with doses of 20 or 40 J/cm<sup>2</sup>. Group 1 acted as untreated controls. Animals were irradiated every 48 h during 7 days, starting immediately after surgery, and were humanely killed on the 8th post-operative day. Specimens were taken and routinely processed and stained with H&E, and for descriptive analysis of myofibroblasts and collagen fibers, the specimens were immunomarked by smooth muscle alpha-actin and picrosirius stain. **RESULTS:** Control specimens showed the presence of ulceration, hyperemia, discrete edema, intense, and diffuse inflammation, collagen deposition was irregular, and myofibroblasts were seen parallel to the wound margins. Wounds treated by laser therapy with a dose of 20 J/cm<sup>2</sup> showed mild hyperemia, inflammation varied from moderate to intense, the number of fibroblasts was large, and the distribution of collagen fibers was more regular. Increasing the dose to 40 J/cm<sup>2</sup> evidenced exuberant neovascularization, severe hyperemia, moderate to severe inflammation, large collagen deposition, and fewer myofibroblasts. On subjects illuminated



with polarized light with a dose of 20 J/cm<sup>2</sup>, mild to moderate hyperemia was detectable, and collagen matrix was expressive and unevenly distributed; a larger number of myofibroblasts was present and no re-epithelialization was seen. Increasing the dose resulted in mild to moderate hyperemia, no re-epithelialization was seen, edema was discrete, and inflammation was moderate. CONCLUSION: The use of 685-nm laser light or polarized light with a dose of 20 J/cm<sup>2</sup> resulted in increased collagen deposition and better organization on healing wounds, and the number of myofibroblast was increased when polarized light is used.

PMID: 16262579 [PubMed - indexed for MEDLINE]

**[A comparative study of the effects of laser and light-emitting diode irradiation on the wound healing and functional activity of wound exudate leukocytes]** [Biofizika](#). 2005 Nov-Dec;50(6):1137-44

[Article in Russian] [Klebanov GI](#), [Shuraeva Nlu](#), [Chichuk TV](#), [Osipov AN](#), [Rudenko TG](#), [Shekhter AB](#), [Vladimirov IuA](#).

The effects of coherent He-Ne laser and non-coherent light-emitting diode radiation on rat skin wound healing and functional activity of wound exudate leukocytes were compared. A comparative pathomorphological analysis showed that the He-Ne laser and light-emitting diode irradiation stimulated the transition of the inflammatory phase of the wound healing into the reparative (proliferative) and scarring phases sequentially. It was also detected that the functional activity of leucocytes changed in a dose-dependent manner. The leukocyte activity was found to be similar in the groups with laser and light-emitting diode irradiation. Thus, we can conclude that coherent laser and non-coherent light-emitting diode radiation have very close effects on wound healing and activity of wound exudate leukocytes, and coherence is not required for this activity.

PMID: 16358796 [PubMed - indexed for MEDLINE]

**[A comparison of the effects of laser and light-emitting diodes on superoxide dismutase activity and nitric oxide production in rat wound fluid]** [Biofizika](#). 2006 Jan-Feb;51(1):116-22.[Article in Russian]

[Klebanov GI](#), [Shuraeva Nlu](#), [Chichuk TV](#), [Osipov AN](#), [Vladimirov IuA](#).

The action of laser and light-emitting diode radiation in the visible region on the content of reactive nitrogen species and activity of superoxide dismutase in rat wound fluid was studied, and efficiency of action of coherent laser and incoherent light emitting diode radiations in the red region of the spectrum on the parameters under study was compared. A model of incised aseptic wounds in rats proposed by L.I. Slutskiy was used. A He-Ne laser (632 nm) and a Y-332B light emitting diode served as radiation sources. It was shown that (1) exposure of wounds to the visible light of both laser and light-emitting diodes causes dose-dependent changes in superoxide dismutase activity and production of nitrites and (2) the radiation coherence does not play any significant role in the changes of superoxide dismutase activity or nitrogen oxide formation by wound fluid phagocytes.

PMID: 16521561 [PubMed - indexed for MEDLINE]



**Laser application effects on the bite strength of the masseter muscle, as an orofacial pain treatment.**

[de Medeiros JS](#), [Vieira GF](#), [Nishimura PY](#). [Photomed Laser Surg.](#) 2005 Aug;23(4):373-6.

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**OBJECTIVE:** The present research studies the effects of AsGaAl (low-intensity laser) on the bite strength of the masseter muscle in order to evaluate the contribution of laser therapy in patients with orofacial pain.

**BACKGROUND DATA:** Studies on laser therapy suggest its usefulness in the treatment of temporomandibular disorders. This paper presents the effects of low-intensity laser in the contraction of the masseter muscle in patients with neuromuscular discomfort. **METHODS:** Fifteen patients of both genders, ages 19-29, suffering from pain in the masseter muscle, were exposed to laser application (AsGaAl) applied from a 2-mm distance. **RESULTS:** All patients showed improvement in muscle contraction strength of about 2.51-3.01 kgf on the right and left masseter muscle. **CONCLUSIONS:** These results suggest that low-level laser application is an effective tool for the treatment of patients with orofacial pain.

PMID: 16144479 [PubMed - indexed for MEDLINE]

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

[Khadra M](#), [Kasem N](#), [Lyngstadaas SP](#), [Haanaes HR](#), [Mustafa K](#). Department of Oral Surgery and Oral Medicine, Faculty of Dentistry, University of Oslo, Oslo, Norway. [Clin Oral Implants Res.](#) 2005 Apr;16(2):168-75. [Links](#)

The aim of the study was to investigate the effect of low-level laser therapy (LLLT) on attachment and proliferation of human gingival fibroblasts (HGF) cultured on titanium implant material. HGF were exposed to gallium-aluminum-arsenide diode laser at dosages of 1.5 or 3 J/cm<sup>2</sup> and then cultured on commercially pure titanium discs. Cell profile areas were measured after 1, 3 and 24 h, using scanning electron microscopy and an automatic image analyzer. The results were expressed as percentage of attachment. In order to investigate the effect of LLLT on cellular growth after 8 and 10 days, HGF were cultured on titanium discs for 24 h and then exposed to laser irradiation on 3 consecutive days. Colony-forming efficiency (CFE) and clonal growth rates (CGR) were measured. Cell viability was determined by Hoechst and prodidium iodide staining. Non-lased cultures served as controls. Morphologically, the cells spread well on all titanium surfaces, indicating good attachment by both irradiated and non-irradiated cells. Fibroblasts exposed to laser irradiation had significantly higher percentages of cell attachment than the non-exposed cells (P<0.05). CFE and CGR were also enhanced for the irradiated cells (P<0.05). Cell viability was high (>90%) in the irradiated and control groups, without significant differences. It is concluded that in vitro LLLT enhances the attachment and proliferation of HGF on titanium implant material. PMID: 15777326 [PubMed - indexed for MEDLINE]



### **Low-level laser therapy (LLLT) efficacy in post-operative wounds.**

[Herescu N](#), [Velciu B](#), [Calin M](#), [Savastru D](#), [Talianu C](#). [Photomed Laser Surg](#). 2005 Feb;23(1):70-3.

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**OBJECTIVE:** The aim of this paper was to investigate the efficacy of low-level laser radiation (LLLR) with wavelength of 904 nm on the stimulation of the healing process of postoperative aseptic wounds (early scar). **BACKGROUND DATA:** Low-level laser therapy (LLLT) has been increasingly used to treat many disorders, including wounds. However, despite such increased clinical usage, there is still controversy regarding the efficacy of this wound treatment in current clinical practice. **METHODS:** LLLT has been used to treat cutting plague in the right instep and on the left foot. Both resulted from sutured wounds. The clinical evaluation by semiquantitative methods is presented. **RESULTS:** Clinical evaluation showed that the healing process of these postoperatively treated wounds has occurred and that the functional recovery of the patients (i.e., return to their ordinary life) was faster than without treatment. **CONCLUSION:** LLLR with wavelength of 904 nm to stimulate postoperative aseptic wounds (early scar) is efficient in both cases of cutting plague.

PMID: 15782037 [PubMed - indexed for MEDLINE]

### **Low-level laser therapy for wound healing: mechanism and efficacy.**

[Posten W](#), [Wrone DA](#), [Dover JS](#), [Arndt KA](#), [Silapunt S](#), [Alam M](#). [Dermatol Surg](#). 2005 Mar;31(3):334-40.

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**BACKGROUND:** Given the recent interest in light-emitting diode (LED) photomodulation and minimally invasive nonablative laser therapies, it is timely to investigate reports that low-level laser therapy (LLLT) may have utility in wound healing. **OBJECTIVES:** To critically evaluate reported in vitro models and in vivo animal and human studies and to assess the qualitative and quantitative sufficiency of evidence for the efficacy of LLLT in promoting wound healing. **METHOD:** Literature review, 1965 to 2003. **RESULTS:** In examining the effects of LLLT on cell cultures in vitro, some articles report an increase in cell proliferation and collagen production using specific and somewhat arbitrary laser settings with the helium neon (HeNe) and gallium arsenide lasers, but none of the available studies address the mechanism, whether photothermal, photochemical, or photomechanical, whereby LLLT may be exerting its effect. Some studies, especially those using HeNe lasers, report improvements in surgical wound healing in a rodent model; however, these results have not been duplicated in animals such as pigs, which have skin that more closely resembles that of humans. In humans, beneficial effects on superficial wound healing found in small case series have not been replicated in larger studies. **CONCLUSION:** To better understand the utility of



LLLT in cutaneous wound healing, good clinical studies that correlate cellular effects and biologic processes are needed. Future studies should be well-controlled investigations with rational selection of lasers and treatment parameters. In the absence of such studies, the literature does not appear to support widespread use of LLLT in wound healing at this time. Although applications of high-energy (10-100 W) lasers are well established with significant supportive literature and widespread use, conflicting studies in the literature have limited low-level laser therapy (LLLT) use in the United States to investigational use only. Yet LLLT is used clinically in many other areas, including Canada, Europe, and Asia, for the treatment of various neurologic, chiropractic, dental, and dermatologic disorders. To understand this discrepancy, it is useful to review the studies on LLLT that have, to date, precluded Food and Drug Administration approval of many such technologies in the United States. The fundamental question is whether there is sufficient evidence to support the use of LLLT.

Publication Types: [Review](#) PMID: 15841638 [PubMed - indexed for MEDLINE]

#### **Low-level laser therapy improves early healing of medial collateral ligament injuries in rats.**

[Bayat M](#), [Delbari A](#), [Almaseyeh MA](#), [Sadeghi Y](#), [Bayat M](#), [Reziae F](#). [Photomed Laser Surg](#). 2005 Dec;23(6):556-60.

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**OBJECTIVE:** This study sought to investigate whether or not low-level laser therapy (LLLT) with a helium-neon laser increased biomechanical parameters of transected medial collateral ligament (MCL) in rats. **BACKGROUND DATA:** It has been reported that LLLT can enhance tendon healing. **METHODS:** Thirty rats received surgical transection to their right MCL, and five were assigned as the control group. After surgery, the rats were divided into three groups: group 1 (n = 10) received LLLT with 0.01 J/cm<sup>2</sup> energy density per day, group 2 (n = 10) received LLLT with 1.2 J/cm<sup>2</sup> energy density per day, and group 3 (sham = exposed group; n = 10) received daily placebo laser with shut-down laser equipment, while the control group received neither surgery nor LLLT. Biomechanical tests were performed at 12 and 21 days after surgery. The data were analyzed by one-way analysis of variance. **RESULTS:** The ultimate tensile strength (UTS) of group 2 on day 12 was significantly higher than that of groups 1 and 3. Furthermore, the UTS and energy absorption of the control (uninjured) group were significantly higher than those of the other groups. **CONCLUSIONS:** LLLT with a helium-neon laser is effective for the early improvement of the ultimate tensile strength of medial collateral ligament injuries.

PMID: 16356146 [PubMed - indexed for MEDLINE]





### **Low intensity laser therapy (830nm) in the management of minor postsurgical wounds: a controlled clinical study.**

[Lagan KM](#), [Clements BA](#), [McDonough S](#), [Baxter GD](#). Rehabilitation Sciences Research Group, School of Health Sciences, University of Ulster, Northern Ireland. [km.lagan@ulst.ac.uk](mailto:km.lagan@ulst.ac.uk) [Lasers Surg Med](#). 2001;28(1):27-32

**BACKGROUND AND OBJECTIVE:** The stimulatory effects of low intensity laser therapy (LILT) have been widely published for the treatment of chronic ulceration. In contrast to this previous work, the current study investigated its potential efficacy (by using a dosage of 9 J/cm<sup>2</sup>) in the management of acute wounds. For this purpose, uncomplicated postoperative wounds after minor podiatric surgery were examined. **STUDY DESIGN/MATERIALS AND METHODS:** The study was designed as a controlled group study. Ethical approval was granted by the University of Ulster's Research Ethics Committee. Patients (n = 9) presenting with a total of 12 wounds after minor surgical procedures (partial/total nail avulsions/electrosurgery) were recruited from the Podiatry Teaching Clinic, Northern Ireland. Patients attended the clinic once per week for assessment and treatment. Weekly irradiation was performed by using a CBM Master 3 (CB Medico, Copenhagen, Denmark) diode laser (GaAlAs). The physical parameters of the output of this unit were as follows: wavelength, 830 nm; average power output, 30 mW; spot size, 0.1 cm<sup>2</sup>; irradiance, 300 mW/cm<sup>2</sup>; continuous wave output. Wound assessment and recording of pain levels were conducted weekly. Wound measurement was completed by using planimetry and digitising methods. **RESULTS:** Current findings indicated no statistically significant differences between Laser and Control groups for wound closure (P = 0.28 digitising; P = 0.49 planimetry) nor for pain levels reported (P = 0.88). **CONCLUSION:** It would seem that LILT provides no advantages in the management of minor postoperative wounds over current practice. Despite no apparent benefit of infrared laser at this dosage in the management of acute stage wounds, further research is required to determine its potential efficacy in the management of other wound types.

PMID: 11430439 [PubMed - indexed for MEDLINE]

### **Low-Level Laser Therapy Facilitates Superficial Wound Healing in Humans: A Triple-Blind, Sham-Controlled Study.**

[Hopkins JT](#), [McLoda TA](#), [Seegmiller JG](#), [David Baxter G](#). Brigham Young University, Provo, UT. : [J Athl Train](#). 2004 Sep;39(3):223-229.

**OBJECTIVE:** Low-level laser therapy (LLLT) has been promoted for its beneficial effects on tissue healing and pain relief. However, according to the results of in vivo studies, the effectiveness of this modality varies. Our purpose was to assess the putative effects of LLLT on healing using an experimental wound model. **DESIGN AND SETTING:** We used a randomized, triple-blind, placebo-controlled design with 2 within-subjects factors (wound and time) and 1 between-subjects factor (group). Data were collected in the laboratory setting. **SUBJECTS:** Twenty-two healthy subjects (age = 21 +/- 1 years, height = 175.6 +/- 9.8 cm, mass = 76.2 +/- 14.2 kg). **MEASUREMENTS:** Two standardized 1.27-cm<sup>2</sup> abrasions were induced on the anterior forearm. After wound cleaning, standardized digital photos were recorded. Each subject then received LLLT (8 J/cm<sup>2</sup>); treatment time = 2 minutes, 5 seconds; pulse rate = 700 Hz) to 1 of the 2 randomly chosen wounds from either a laser or a sham 46-diode cluster head.



Subjects reported back to the laboratory on days 2 to 10 to be photographed and receive LLLT and on day 20 to be photographed. Data were analyzed for wound contraction (area), color changes (chromatic red), and luminance. RESULTS: A group x wound x time interaction was detected for area measurements. At days 6, 8, and 10, follow-up testing revealed that the laser group had smaller wounds than the sham group for both the treated and the untreated wounds ( $P < .05$ ). No group x wound x time differences were detected for chromatic red or luminance. CONCLUSIONS: The LLLT resulted in enhanced healing as measured by wound contraction. The untreated wounds in subjects treated with LLLT contracted more than the wounds in the sham group, so LLLT may produce an indirect healing effect on surrounding tissues. These data indicate that LLLT is an effective modality to facilitate wound contraction of partial-thickness wounds.

PMID: 15496990 [PubMed - as supplied by publisher]

**Polarized light (400-2000 nm) and non-ablative laser (685 nm): a description of the wound healing process using immunohistochemical analysis.** [Photomed Laser Surg.](#) 2005 Oct;23(5):485-92

[Pinheiro AL](#), [Pozza DH](#), [Oliveira MG](#), [Weissmann R](#), [Ramalho LM](#).

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OBJECTIVE: This study aimed to describe, through morphologic and cytochemical analysis, the healing process of wounds submitted (or not) to laser therapy ( $\lambda 685$  nm) or polarized light ( $\lambda 400-2000$  nm). BACKGROUND DATA: There are many reports on different effects of several types of phototherapies on the treatment of distinct conditions, amongst them, on wound healing. Laser therapy and the use of polarized light are still controversial despite successive reports on their positive effects on several biological processes. METHODS: Thirty male Wistar rats, approximately 4 months old, were used, and standardized excisional wounds were created on their dorsum. The wounds were irradiated in four equidistant points with laser light or illuminated with polarized light, both with doses of 20 or 40 J/cm<sup>2</sup>. Group 1 acted as untreated controls. Animals were irradiated every 48 h during 7 days, starting immediately after surgery, and were humanely killed on the 8th post-operative day. Specimens were taken and routinely processed and stained with H&E, and for descriptive analysis of myofibroblasts and collagen fibers, the specimens were immunomarked by smooth muscle alpha-actin and picrosirius stain. RESULTS: Control specimens showed the presence of ulceration, hyperemia, discrete edema, intense, and diffuse inflammation, collagen deposition was irregular, and myofibroblasts were seen parallel to the wound margins. Wounds treated by laser therapy with a dose of 20 J/cm<sup>2</sup> showed mild hyperemia, inflammation varied from moderate to intense, the number of fibroblasts was large, and the distribution of collagen fibers was more regular. Increasing the dose to 40 J/cm<sup>2</sup> evidenced exuberant neovascularization, severe hyperemia, moderate to severe inflammation, large collagen deposition, and fewer myofibroblasts. On subjects illuminated with polarized light with a dose of 20 J/cm<sup>2</sup>, mild to moderate hyperemia was detectable, and collagen matrix was expressive and unevenly distributed; a larger number of myofibroblasts was present and no re-epithelialization was seen. Increasing the dose resulted in mild to moderate hyperemia, no re-epithelialization was seen, edema was discrete, and inflammation was moderate. CONCLUSION: The use of 685-nm laser light or polarized light with



a dose of 20 J/cm<sup>2</sup> resulted in increased collagen deposition and better organization on healing wounds, and the number of myofibroblast was increased when polarized light is used.

PMID: 16262579 [PubMed - indexed for MEDLINE]

### **Histomorphometric study of the healing of human oral mucosa after gingivoplasty and low-level laser therapy.**

[Damante CA](#), [Gregghi SL](#), [Sant'Ana AC](#), [Passanezi E](#), [Taga R](#). *Lasers Surg Med.* 2004;35(5):377-84.

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**BACKGROUND AND OBJECTIVES:** The aim of the present study was to analyze the effects of diode laser irradiation on the healing of human oral mucosa. **MATERIALS AND METHODS:** After gingivoplasty, the right hemi-arch (test group) of 16 patients was irradiated with a diode laser. The left side (control group) was not irradiated. Incisional biopsies were performed on both sides at 7, 14, 21, and 60 days after surgery and morphometrically analyzed by light microscopy. **RESULTS:** Epithelium width ranged from 260.6 to 393.5 microm. Volume densities of basal (20.2%), prickle cell (55.6%), and cornified (24.2%) layers remained stable. The peak number of neutrophils were 6 cells/mm<sup>2</sup> and the mononuclear cells were 44 cells/mm<sup>2</sup>. Collagen fibers (80%) and fibroblasts (14%) occupied the main volume of connective tissue. The one-way ANOVA and the paired Student's t-test were used for statistical analysis ( $P < 0.05$ ). **CONCLUSION:** Low-level laser therapy did not accelerate the healing of oral mucosa after gingivoplasty. (c) 2004 Wiley-Liss, Inc.

PMID: 15611961 [PubMed - indexed for MEDLINE]

### **Evaluation of photochemical tissue bonding for closure of skin incisions and excisions.**

[Kamegaya Y](#), [Farinelli WA](#), [Vila Echague AV](#), [Akita H](#), [Gallagher J](#), [Flotte TJ](#), [Anderson RR](#), [Redmond RW](#), [Kochevar IE](#). *Lasers Surg Med.* 2005 Oct;37(4):264-70.

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**BACKGROUND AND OBJECTIVES:** Photochemical tissue bonding (PTB) is a new non-thermal technique for tissue repair involving application of a photochemically active dye and irradiation with visible light. The objective was to compare PTB with standard sutures and the tissue adhesive, octyl cyanoacrylate, for closure of skin incisions and excisions. **STUDY DESIGN/MATERIALS AND METHODS:** Incisions and excisions made on the flanks of a Hanford mini-pig were secured with subcutaneous sutures. Superficial closure methods were 3-0 monofilament sutures, PTB (Rose Bengal and green light), tissue adhesive and the combination of tissue adhesive then PTB. Wounds were



evaluated 2, 4, and 6 weeks postoperatively for cosmetic outcomes and histology. RESULTS: Cosmetic outcomes and histological scar width of incisions and excisions did not differ among the treatment groups at 2, 4, and 6 weeks. CONCLUSION: PTB is as effective as standard sutures for wound closure in porcine skin in terms of cosmetic outcomes and safety. PMID: 16196042 [PubMed - indexed for MEDLINE]

**Wound healing of animal and human body sport and traffic accident injuries using low-level laser therapy treatment: a randomized clinical study of seventy-four patients with control group.**

[Simunovic Z](#), [Ivankovich AD](#), [Depolo A](#). [J Clin Laser Med Surg](#). 2000 Apr;18(2):67-73.

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BACKGROUND AND OBJECTIVE: The main objective of current animal and clinical studies was to assess the efficacy of low level laser therapy (LLLT) on wound healing in rabbits and humans. STUDY DESIGN/MATERIALS AND METHODS: In the initial part of our research we conducted a randomized controlled animal study, where we evaluated the effects of laser irradiation on the healing of surgical wounds on rabbits. The manner of the application of LLLT on the human body are analogous to those of similar physiologic structure in animal tissue, therefore, this study was continued on humans. Clinical study was performed on 74 patients with injuries to the following anatomic locations: ankle and knee, bilaterally, Achilles tendon; epicondylus; shoulder; wrist; interphalangeal joints of hands, unilaterally. All patients had had surgical procedure prior to LLLT. Two types of laser devices were used: infrared diode laser (GaAlAs) 830 nm continuous wave for treatment of trigger points (TPs) and HeNe 632.8 nm combined with diode laser 904-nm pulsed wave for scanning procedure. Both were applied as monotherapy during current clinical study. The results were observed and measured according to the following clinical parameters: redness, heat, pain, swelling and loss of function, and finally postponed to statistical analysis via chi2 test. RESULTS: After comparing the healing process between two groups of patients, we obtained the following results: wound healing was significantly accelerated (25%-35%) in the group of patients treated with LLLT. Pain relief and functional recovery of patients treated with LLLT were significantly improved comparing to untreated patients. CONCLUSION: In addition to accelerated wound healing, the main advantages of LLLT for postoperative sport- and traffic-related injuries include prevention of side effects of drugs, significantly accelerated functional recovery, earlier return to work, training and sport competition compared to the control group of patients, and cost benefit.

Publication Types: [Clinical Trial](#) [Randomized Controlled Trial](#) PMID: 11800105 [PubMed - indexed for MEDLINE]



[Stimulation of the healing of aseptic wounds using laser irradiation] : [Khirurgiia \(Mosk\)](#). 1991 Jul;(7):36-40

[Article in Russian][Tolstykh PI](#), [Gertsen AV](#), [Eliseenko VI](#), [Sarasek IuK](#).

On the basis of experimental studies conducted on 535 albino Wistar rats and clinical observations over 125 patients, and from complex appraisal of morphological, biochemical, and tensiometric data the conclusion is drawn that optimal operative cutting of tissues is achieved by means of far infrared carbon dioxide laser beam with a wavelength of 10.6 microns. Comparison of these characteristics showed the strength of the postoperative scar to be much less in intraoperative tissue cutting with a steel scalpel or high-energy beam of an AIG laser with a wavelength of 1.06 microns. Low-intensity laser radiation increased the strength of the postoperative scar in the early periods in all groups. Tissue cutting with a high-energy carbon dioxide laser beam with a wavelength of 10.6 microns in combination with pre- and postoperative exposure of the zone of the incision to low-intensity 0.89 micron wavelength laser beam considerably increases the strength of the postoperative scar and is the method of choice in the treatment of aseptic wounds. PMID: 1921196 [PubMed - indexed for MEDLINE]

**A preliminary report on the effect of laser therapy on the healing of cutaneous surgical wounds as a consequence of an inversely proportional relationship between wavelength and intensity: histological study in rats.**

[do Nascimento PM](#), [Pinheiro AL](#), [Salgado MA](#), [Ramalho LM](#). [Photomed Laser Surg](#). 2004 Dec;22(6):513-8. IPD, Univap, Sao Jose dos Campos, Sao Paulo, Brazil.

**OBJECTIVE:** The objective of the present investigation was to assess the histological effects of different wavelengths and intensities on the healing process of cutaneous wounds. **BACKGROUND DATA:** Tissue repair is a dynamic interactive process which involves mediators, cells and extra-cellular matrix. Several reports on the use of laser therapy have shown that the healing process is positively affected when the correct parameters are used. **METHODS:** Eighteen standardized wounds were surgically created on the dorsum of male and female Wistar rats, which were subsequently divided into two experimental groups according to wavelength used ( $\lambda$ .670 or  $\lambda$ .685 nm) for lasertherapy (LLLT). Each group was divided into three subgroups of three animals according to the intensity of the applied irradiation (2, 15, or 25 mW). Twelve animals were used as untreated controls and were not irradiated. The irradiation was carried out during seven consecutive days. The animals were sacrificed eight days after surgery. The specimens were removed, kept in 4% formaldehyde for 24 h, routinely prepared to wax, stained with H&E, and analyzed under light microscopy. **RESULTS:** For both groups, light microscopy showed a substitution repair process; however, when LLLT was used, a positive biomodulatory effect was detectable, chiefly associated with shorter wavelength and low intensity. **CONCLUSIONS:** The results of the present study indicate that LLLT improved cutaneous wound repair and that the effect is a result of an inversely proportional relationship between wavelength and intensity, with treatment more effective when combining higher intensity with short wavelength or lower intensity with higher wavelength.

PMID: 15684753 [PubMed - indexed for MEDLINE]



## The effect of low level laser irradiation on implant-tissue interaction. In vivo and in vitro studies.

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Low-level laser therapy (LLLT) is increasingly used in medicine and dentistry. It has been suggested that LLLT may be beneficial in the management of many different medical conditions, including pain, wound healing and nerve injury. The present thesis is based on a series of in vivo and in vitro experimental studies investigating whether LLLT has the potential to enhance titanium-implant interaction. Information about LLLT effect on bone healing is fundamental to understand whether LLLT may improve implant-tissue interaction. Thus in the initial study (I), the effect of LLLT on bone healing and growth in rat calvarial bone defects was investigated. It was found that LLLT may accelerate metabolism and/or mineralization during early bone healing. Based on these findings, study II explored the hypothesis that LLLT can enhance implant integration in the rabbit tibial bone. It was shown that LLLT stimulated the mechanical strength of the interface between the implant and bone after a healing period of 8 weeks. Histomorphometrical and mineral analyses showed that the irradiated implants had greater bone-to-implant contact than the controls. In the in vitro experiments, cellular responses to LLLT were studied in two cell types: primary cultures of human gingival fibroblasts and human osteoblast-like cells, with special reference to attachment, proliferation, differentiation and production of transforming growth factor beta1 (TGF-beta1). The objectives of studies III & IV were to develop a standardized, reproducible in vitro model for testing a GaAlAs diode laser device and to document the influence of single or multiple doses of LLLT, as a guide to defining the optimal laser dose for enhancing cell activity. A further objective was to investigate the effect of LLLT on initial attachment and subsequent behaviour of human gingival fibroblasts cultured on titanium. While both multiple doses (1.5 and 3 J/cm<sup>2</sup>) and a single dose (3 J/cm<sup>2</sup>) enhanced cellular attachment, proliferation increased only after multiple doses (1.5 and 3 J/cm<sup>2</sup>). Study V concerned the response to LLLT of osteoblast-like cells, derived from human alveolar bone cultured on titanium implant material. In this study LLLT significantly enhanced cellular attachment. Greater cell proliferation in the irradiated groups was observed first after 96 h indicating that the cellular response is dose dependent. Osteocalcin synthesis and TGF-beta1 production were significantly stimulated on the samples exposed to 3 J/cm<sup>2</sup>. 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/cm<sup>2</sup> may modulate the activity of cells interacting with an implant, thereby enhancing tissue healing and ultimate implant success.

PMID: 15906852 [PubMed - indexed for MEDLINE]