
Effect of red and near-infrared wavelengths on low-level laser (light) therapy-induced healing of partial-thickness dermal abrasion in mice.

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Source
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Abstract

Low-level laser (light) therapy (LLLT) promotes wound healing, reduces pain and inflammation, and prevents tissue death. Studies have explored the effects of various radiant exposures on the effect of LLLT; however, studies of wavelength dependency in in vivo models are less common. In the present study, the healing effects of LLLT mediated by different wavelengths of light in the red and near-infrared (NIR) wavelength regions (635, 730, 810, and 980 nm) delivered at constant fluence (4 J/cm²) and fluence rate (10 mW/cm²) were evaluated in a mouse model of partial-thickness dermal abrasion. Wavelengths of 635 and 810 nm were found to be effective in promoting the healing of dermal abrasions. However, treatment using 730- and 980-nm wavelengths showed no sign of stimulated healing. Healing was maximally augmented in mice treated with an 810-nm wavelength, as evidenced by significant wound area reduction (p<0.05), enhanced collagen accumulation, and complete re-epithelialization as compared to other wavelengths and non-illuminated controls. Significant acceleration of re-epithelialization and cellular proliferation revealed by immunofluorescence staining for cytokeratin-14 and proliferating cell nuclear antigen (p<0.05) was evident in the 810-nm wavelength compared with other groups. Photobiomodulation mediated by red (635 nm) and NIR (810 nm) light suggests that the biological response of the wound tissue depends on the wavelength employed. The effectiveness of 810-nm wavelength agrees with previous publications and, together with the partial effectiveness of 635 nm and the ineffectiveness of 730 and 980 nm wavelengths, can be explained by the absorption spectrum of cytochrome c oxidase, the candidate mitochondrial chromophore in LLLT.

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Source
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Abstract
The aim of the present study was to assess the histopathological effects of low-level laser therapy (LLLT) on healing of the oral mucosa after soft tissue graft operations. The alterations at the end of healing in normal and LLLT-applied oral mucosa were studied in two healthy adult New Zealand white rabbits by taking specimens for light microscopic inspection. There was no adverse event reported in the study and no post-operative complications, such as swelling, bleeding, or edema, were observed in the rabbits. Complete wound healing was faster in the LLLT-applied rabbit. Compared to the normal rabbit oral mucosa, thickening of the stratum corneum (hyperkeratosis) was found in the epithelia of the rabbits. A significant increase in the epithelial thickness was found in the samples of rabbits, suggesting increased scar tissue following the wound repair. Additionally, many mitotic figures were present in the epithelia of the LLLT-applied rabbit, indicating epithelial cell hyperplasia. Long and irregular connective tissue protrusions projecting into the undersurface of the epithelium and mononuclear cell infiltrations were noted in the rabbits. The results suggest that LLLT used for soft tissue operations provides better and faster wound healing and that LLLT enhances epithelization.


**Laser and LED phototherapies on angiogenesis.**

de Sousa AP, Paraguassú GM, Silveira NT, de Souza J, Cangussú MC, Dos Santos JN, Pinheiro AL.

**Source**

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**Abstract**

Angiogenesis is a key process for wound healing. There are few reports of LED phototherapy on angiogenesis, mainly in vivo. The aim of the present investigation was to evaluate histologically the angiogenesis on dorsal cutaneous wounds treated with laser (660 and 790 nm) or LEDs (700, 530, and 460 nm) in a rodent model. Twenty-four young adult male Wistar rats weighting between 200 and 250 g were used on the present study. Under general anesthesia, one excisional wound was created on the dorsum of each animal that were then randomly distributed into six groups with four animals each: G0-control; G1-laser 660 nm (60 mW, 2 mm, 10 J/cm(2)); G2-laser 790 nm (50 mW, 2 mm, 10 J/cm(2)); G3-LED 700±20 nm (15 mW, 16 mm, 10 J/cm(2)); G4-LED 530±20 nm (8 mW, 16 mm, 10 J/cm(2)); G5-LED 460±20 nm (22 mW, 16 mm, 10 J/cm(2)). Irradiation started immediately after surgery and was repeated every other day for 7 days. Animal death occurred at the eighth day after surgery. The specimens were removed, routinely processed to wax, cut and stained with HE. Angiogenesis was scored by blood vessel counting in the wounded area. Quantitative results showed that green LED (530±20 nm), red LED (700±20 nm), 790 nm laser and 660 nm laser caused significant increased angiogenesis when compared to the control group. It is concluded that both laser and LED light are capable of stimulating angiogenesis in vivo on cutaneous wounds and that coherence was not decisive on the outcome of the treatment.

Effect of laser and LED phototherapies on the healing of cutaneous wound on healthy and iron-deficient Wistar rats and their impact on fibroblastic activity during wound healing.

Oliveira Sampaio SC, de C Monteiro JS, Cangussu MC, Pires Santos GM, Dos Santos MA, Dos Santos JN, Pinheiro AL.

Source

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Abstract

Iron deficiency impairs the formation of hemoglobin, red blood cells, as well as the transport of oxygen. The wound healing process involves numerous functions, many of which are dependent on the presence of oxygen. Laser has been shown to improve angiogenesis, increases blood supply, cell proliferation and function. We aimed to study the effect of 660 nm laser and 700 nm light-emitting diode (LED) on fibroblastic proliferation on cutaneous wounds on iron-deficient rodents. Induction of iron anemia was carried out by feeding 105 newborn rats with a special iron-free diet. A 1×1 cm wound was created on the dorsum of each animal that were randomly distributed into seven groups: I, control anemic; II, anemic no treatment; III, anemic+L; IV, anemic+LED; V, healthy no treatment; VI, healthy+laser; VII, healthy+LED (n=15 each). Phototherapy was carried out using either a diode laser (660 nm, 40 mW, 10 J/cm(2)) or a prototype LED device (700±20 nm, 15 mW, 10 J/cm(2)). Treatment started immediately after surgery and was repeated at 48-h interval during 7, 14, and 21 days. After animal death, specimens were taken, routinely processed, cut, stained with hematoxylin-eosin, and underwent histological analysis and fibroblast counting. Significant difference between healthy and anemic subjects on regards the number of fibroblast between treatments was seen (p<0.008, p<0.001). On healthy animals, significant higher count was seen when laser was used (p<0.008). Anemic subjects irradiated with LED showed significantly higher count (p<0.001). It is concluded that the use of LED light caused a significant positive biomodulation of fibroblastic proliferation on anemic animals and laser was more effective on increasing proliferation on non-anemics.


Closure of non-healing chronic ulcer in Klippel-Trenaunay syndrome using low-level laser therapy.

Dixit S, Maiya AG, Umakanth S, Shastry BA.

Source

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Abstract
A 69-year-old man diagnosed with Klippel-Trenaunay syndrome (KTS) reported to the physiotherapy outpatient clinic with the complaint of a non-healing ulcer over the right medial malleolus, for a 6-month duration, that was non-granulating and had moderate pus discharge with foul odour at initial assessment. There was a decrease in scores of the Pressure Ulcer Scale of Healing, a significant increase in granulation tissue, a decrease in the amount of discharge and foul odour along with complete closure of the chronic wound after irradiation with a light-emitting diode (LED). This is a novel case study analysing the possible effect of a helium-neon laser and LEDs on non-healing chronic ulcers associated with KTS, where the complete closure of the chronic ulcer that was initially not responsive to standard medical care was observed.


**Healing activity of laser InGaAlP (660nm) in rats.**

Tacon KC, Santos HC, Parente LM, Cunha LC, Lino-Júnior Rde S, Ribeiro-Rotta RF, Tacon FS, Amaral WN.

**Source**

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**Abstract**

**PURPOSE:**

To evaluate the effect the healing activity of diode laser Indium Gallium Aluminum Phosphorus (InGaAlP) ð660nm on healing of surgical wounds in rats.

**METHODS:**

Fifty-four female Wistar rats were used, divided into three groups (n=18) and subdivided into three subgroups (n=6) to be studied in 5, 10 and 15(th) days after surgical procedures. The wound was induced in the dorsal-cervical using punch. The lesions were irradiated on alternate days with InGaAlP laser, the energy densities of 3J/cm(2) (L3) or 6J/cm(2) (L6). The control group received no irradiation. At 5, 10 and 15(th) days after surgery the animals were euthanized and the repair area was removed and histological sections were stained with hematoxylin-eosin and picrossirius. We evaluated macroscopic and histological lesions in the times cited, as well as morphometric analysis of angiogenesis and collagen content.

**RESULTS:**

The wound healing activity InGaAlP laser was evidenced by increased angiogenesis group L3 and L6 in relation to control group (CG) at the 5(th) day (p=0.0001) and decreased polymorphonuclear infiltrate and hemorrhage (p=0.045 and p=0.07 respectively) in the groups L3 and L6 in relation to control group (GC). On the 10 and 15(th) days was also observed in groups treated with laser L3 and L6 stimulation was pronounced fibroplasia (p=0.0003 and p=0.034 respectively) when compared with the control group (CG).

**CONCLUSION:**
The InGaAlP laser acted positively on the healing of skin wounds in rats.


**Method of local treatment of trophic ulcers of venous etiology.**

[Article in Russian]
Kukol'nikova EL, Zhukov BN.

**Abstract**

The study is based on the results of local treatment of trophic ulcers of 150 patients with chronic venous insufficiency of the lower extremities. Local treatment is laser treatment and diagnostic unit with a wavelength $\lambda=0.65$ mkm and output power of 30 mW in pulsed mode for 10 minutes 1 times per day for 7-10 days. As an objective criterion for determining the speed and intensity of the healing of trophic ulcers and non-contact fixing their area of applied computer thermography. True healing of ulcers was achieved in all patients during the period from 14 to 28 days


**The comparative assessment of the wound-healing effects of the treatment with the use of Bioptron, Minitag, Orion+ apparatuses and hollow cathode lamps (experimental study).**

[Article in Russian]
[No authors listed]

**Abstract**

The objective of the present experimental study was the comparative assessment of the wound-healing effects of radiation emitted from Bioptron, Minitag, Orion+ apparatuses and hollow cathode lamps (HCL). The emitters of any type were shown to be equally efficacious in that they accelerated wound epithelization by 30% on the average compared with control. Based on the difference between spectral and power characteristics of different sources of radiation and dynamics of their wound-healing efficacy (including that of two types of HCL), the authors arrived at the conclusion that the further development of the proposed approach to wound healing is a promising line of research in the field of spectral phototherapy.


**Effect of incoherent LED radiation on third-degree burning wounds in rats.**

Abstract

The main physiological characteristics in a burn process are the increase of the capillary permeability and the occurrence of edema and exudation. Light-emitting diode (LED) has been proposed as treatment of burning. This study investigated the effects of LED on the repair process of rat skin submitted to a third-degree burning. The lesions were produced on the dorsal surface of male Wistar rats. Animals were divided into 4 groups (n=6) as follows: L1 and L2 groups as LED-treated burned rats, and received LED therapy along 7 and 15 days with 48 h intervals, respectively; C1 and C2 groups as control, non-treated burned rats. A red LED (640 nm – 30 mW) operating with a fluence of 4 J/cm(2) was used. The wound area was measured daily after irradiation. Animals were euthanized at the 8(th) and 16th days after burning, and the wound fragment was submitted to histology. The inflammatory cells as well as the damaged area at the 8th day after burns were significantly lower for the LED-treated group when compared to control. Furthermore, the LED phototherapy effect on cellular migration was even more pronounced at the 16th day. Our results indicated that the treatment with a LED system was clearly effective in reducing the number of inflammatory cells and improving the healing process in an experimental model of third-degree burnings.

Visible light-induced healing of diabetic or venous foot ulcers: a placebo-controlled double-blind study.

Landau Z, Migdal M, Lipovsky A, Lubart R.

Source

Department of Internal Medicine D, and the Diabetic Foot and Infectious Diseases Unit, Kaplan Medical Center, Rehovot, Israel.

Abstract

BACKGROUND AND OBJECTIVES:

Non-healing ulcers represent a significant dermatological problem. Recently, conventional therapy-resistant chronic ulcers have been treated with low energy lasers or light-emitting diodes in the visible and near IR region, but only a few placebo-controlled double-blind studies have been performed to support the efficacy of this approach. The aim of the present study was to evaluate the efficacy of a broadband (400-800? nm) visible light device in the treatment of leg or foot ulcers.

METHODS:

A placebo-controlled double-blind study using broadband light source (400-800? nm) was performed on patients with diabetic foot ulcers or patients with chronic leg ulcers. The treatment group was illuminated with 180 ?mW/cm(2) broadband light twice a day for 4? min/session, while patients in the placebo group received non-healing light fluency (10? mW/cm(2))) projections. The treatment group included 10 patients with a total of 19 ulcers, whereas in the placebo group, 6 patients had 6 ulcers. The follow-up period was 12 weeks.

RESULTS:
At the end of the follow up, all the wounds were closed in 9 out of 10 patients (90%) from the treatment group, whereas in the placebo group only 2 out of 6 patients exhibited closed wounds (33%). The reduction in wound size in the treatment group versus the placebo group was 89% and 54%, respectively.

**CONCLUSIONS:**

In this small scale placebo-controlled double-blind study, broadband (400-800 nm) visible light was an effective modality for the treatment of leg or foot ulcers.


**Influence of low-level laser therapy on wound healing in nicotine-treated animals.**

Garcia VG, Macarini VC, de Almeida JM, Bosco AF, Nagata MJ, Okamoto T, Longo M, Theodoro LH.

**Source**

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**Abstract**

Low-level laser therapy (LLLT) has been shown to have several biological effects that favor the healing process, and nicotine has been shown to delay the healing process. In this study we investigated the healing of open wounds created on the back of rats treated with nicotine with or without LLLT. Of 115 animals, 59 received subcutaneous injections of saline solution, and the others received subcutaneous injections of nicotine (3 mg/kg body weight), twice a day throughout the study period. After 30 days, skin wounds were created on the back of the animals. The animals receiving saline injections were divided into two groups: group 1 (G1, n=29), in which the wounds were left untreated, and group 2 (G2, n=30), in which the wounds were treated with LLLT (GaAlAs, 660 nm, 30 mW, 5.57 J/cm(2) per point, 0.39 J, 13 s per point, 0.42 W/cm(2)). The animals receiving nicotine injections were also divided into two groups: group 3 (G3, n=29), in which the wounds were left untreated, and group 4 (G4, n=27), in which the wounds were treated with LLLT. The animals were killed 3, 7 or 14 days after surgery. Wound healing was evaluated histologically both qualitatively and semiquantitatively. Wounds of G2 showed a delay in epithelial migration and connective tissue organization compared to those of G1. Wounds of G2 showed faster healing than those of G1; similarly, wounds of G4 showed more advanced healing than those of G3. LLLT acted as a biostimulatory coadjuvant agent balancing the undesirable effects of nicotine on wound tissue healing.


**Effect of low-level laser therapy on experimental wounds of hard palate mucosa in mice.**
Fahimipour F, Nouruzian M, Anvari M, Tafti MA, Yazdi M, Khosravi M, Dehghannayeri Z, Sabounchi SS, Bayat M.

Source
Shahid Beheshti University MC, Tehran, Iran.

Abstract
Under general anesthesia and sterile conditions, incision wound was induced in the hard palate mucosa of adult male mice. The wounds of groups 1 and 2 were irradiated daily with He-Ne laser at 3 and 7.5 J/cm² for 120 and 300 s, respectively, while the incision wound of group 3 not exposed served as controls. On day 3 of injury, the laser-treated wounds contained significantly lower neutrophils than the wounds in the control group. By day 7 after injury, the laser-treated wounds contained significantly more fibroblasts and at the same time contained significantly fewer macrophages. In conclusion, an acceleration of the wound healing process of experimental wounds in the hard palate mucosa of mice at low-level laser therapy with a He-Ne laser at energy densities of 3 and 7.5 J/cm² was observed.


Combined use of low level laser therapy and cyclooxygenase-2 selective inhibition on skin incisional wound reepithelialization in mice: a preclinical study.

[Article in English, Portuguese]
Santuzzi CH, Buss HF, Pedrosa DF, Freire MO, Nogueira BV, Gonçalves WL.

Source
Universidade Federal do Espírito Santo.

Abstract
BACKGROUND:
Low level laser therapy and cyclooxygenase-2 (ICOX2) selective inhibitors have been widely used to modulate inflammatory response; however, their effect on wound reepithelialization are not well understood.

OBJECTIVE:
To evaluate the isolated and combined effects of low level laser therapy and ICOX2 in the reepithelialization of skin incisional wounds in mice.

METHODS:
We induced a 1-cm wound on the back of each mouse, which were divided into four groups (N = 20): control, laser therapy, treated with celecoxib and combined therapy. The animals in the celecoxib and combined therapy groups were treated with celecoxib for 10 days before skin incision. The experimental wounds were irradiated with He-Ne low power laser (632nm, dose: 4J/cm²) in scanning for 12 seconds during three consecutive days in the laser therapy and combined therapy groups. The animals were sacrificed 3 days after surgery. Samples of the wounds were collected and stained (Masson's Trichrome) for histomorphometric analysis.

**RESULTS:**

Both the laser therapy group and the celecoxib group showed an increase in skin reepithelialization compared to the control group; however, the combined therapy group showed no differences. As for keratinization, the laser therapy and combined therapy groups showed a reduction in keratinocytes compared with the control group.

**CONCLUSION:**

The results show that the use of low level laser therapy and ICOX2 in isolation increases epithelial cells, but only low level laser therapy reduced skin keratinocytes. The combined treatment restores innate epithelialization and decreases keratinization in spite of accelerating wound contraction with improvement in the organization of the wound in the skin of mice.


**Pressure ulcers.**

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**Source**

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**Abstract**

**INTRODUCTION:**

Unrelied pressure or friction of the skin, particularly over bony prominences, can lead to pressure ulcers in up to one third of people in hospitals or community care, and one fifth of nursing home residents. Pressure ulcers are more likely in people with reduced mobility and poor skin condition, such as older people or those with vascular disease. METHODS AND OUTCOMES: We conducted a systematic review and aimed to answer the following clinical questions: What are the effects of preventive interventions in people at risk of developing pressure ulcers? What are the effects of treatments in people with pressure ulcers? We searched: Medline, Embase, The Cochrane Library, and other important databases up to June 2010 (Clinical Evidence reviews are updated periodically, please check our website for the most up-to-date version of this review). We included harms alerts from relevant organisations such as the US Food and Drug Administration (FDA) and the UK Medicines and Healthcare products Regulatory Agency (MHRA).
RESULTS:

We found 64 systematic reviews, RCTs, or observational studies that met our inclusion criteria. We performed a GRADE evaluation of the quality of evidence for interventions.

CONCLUSIONS:

In this systematic review we present information relating to the effectiveness and safety of the following interventions: air-filled vinyl boots, air-fluidised supports, alternating-pressure surfaces (including mattresses), alternative foam mattresses, constant low-pressure supports, debridement, electric profiling beds, electrotherapy, hydrocellular heel supports, low-air-loss beds (including hydrotherapy beds), low-level laser therapy, low-tech constant-low-pressure supports, medical sheepskin overlays, nutritional supplements, orthopaedic wool padding, pressure-relieving overlays on operating tables, pressure-relieving surfaces, repositioning (regular “turning”), seat cushions, standard beds, standard care, standard foam mattresses, standard tables, surgery, therapeutic ultrasound, topical lotions and dressings, topical negative pressure, and topical phenytoin.


Conservative Management of Achilles Tendon Wounds: Results of a Retrospective Study.

Kleinman Y, Cahn A.

Abstract

Achilles tendon wounds are therapeutically challenging. The tendon’s functional importance, the paucity of soft tissue surrounding the ankle, and common patient comorbidities often limit surgical reconstructive procedure options. Depending on wound depth and overall patient health, secondary intention healing of these wounds can take many months. At the authors’ wound care center, patients who are referred with recalcitrant, deep Achilles tendon wounds and who are able to visit the center two to three times per week are offered a protocol of topical hyperbaric oxygen (THBO) followed by low-level laser therapy (LLLT) and moisture-retentive dressings. A retrospective study was conducted to evaluate the outcomes of patients who received treatment for a deep Achilles tendon wound during the years 2004 through 2008. Patients who were seen but did not obtain care at the center were contacted via telephone. Of the 80 patients seen, 15 were referred for amputation, 52 obtained treatment elsewhere, and 13 received the THBO/LLLT protocol. Patient median age was 73 years (range 52-90 years) and most (85%) had diabetes mellitus. Average wound size was 90 cm2 (range 6.25-300 cm2) with an average duration of 11.7 months (range 2-60 months) before treatment. Complete re-epithelialization was achieved in 10 patients (77%) following a mean treatment time of 19 ± 10 weeks (range 5-42 weeks). Of those, seven remained ambulatory and ulcer-free at mean follow-up of 3.3 ± 1.8 years. Eight of the 52 patients (15%) who were not treated in the authors’ center reported their ulcer was healed and 15 (29%) underwent amputation. Considering the severity of these wounds, the observed treatment outcomes are encouraging and may present a reasonable alternative for some patients with Achilles tendon wounds. Research is needed to clarify the role of these modalities in the conservative treatment of patients with Achilles tendon ulceration.
Low-Level Laser Therapy (LLLT) at 830?nm Positively Modulates Healing of Tracheal Incisions in Rats: A Preliminary Histological Investigation.


1 Department of Medical Biophysics, Pavol Jozef Šafárik University, Košice, Slovak Republic.

Abstract

Abstract Objective: The aim of the present study was to evaluate whether LLLT at 830?nm is able to positively modulate trachea incisional wound healing in Sprague-Dawley rats.

Background data: Tracheotomy may be associated with numerous complications. Development of excess granulation tissue represents a late complication that may lead to airway occlusion. Low-level laser therapy (LLLT) has been shown to have stimulatory effects on wound healing of different tissues. Therefore, it may be suggested that LLLT could be able to positively modulate trachea wound healing as well.

Materials and methods: Using general anesthesia, a median incision was performed from the second to the fifth tracheal cartilage ring in 24 rats. Animals were then randomly divided into sham-irradiated control and laser-treated groups. LLLT (power density: 450?mW/cm(2); total daily dose: 60?J/cm(2); irradiated area ?1?cm(2)) treatment was performed daily during the first week after surgery. Samples for histological evaluation were removed 7 and 28 days after surgical procedure. Histological sections were stained with hematoxylin-eosin and van Gieson.

Results: Results from our investigation showed that LLLT was able to reduce granulation tissue formation and simultaneously increase new cartilage development at both evaluated time intervals.

Conclusions: From this point of view, LLLT at 830?nm may be a valuable tool in trachea wound healing modulation. Nevertheless, further detailed research is needed to find optimal therapeutic parameters and to test these findings on other animal models.

Acta Cir Bras. 2011 Apr;26(2):129-34.

Effect of low level laser on sutured wound healing in rats.

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Department of Experimental Surgical, Federal University of Sergipe, Aracaju, SE, Brazil.

Abstract

PURPOSE: To evaluate the effect of low-level laser therapy (LLLT) é904 nm on healing of surgical wounds in rats.
METHODS: Forty male Wistar rats were used, divided into four groups, underwent incision along the lines Alba covering skin, subcutaneous and muscle abdominal, sutured continuously for nylon 5-0. Eight and fifteen days after the surgery process, the repairing area was removed and histological sections were stained with hematoxylin-eosin to assess cellularity inflammatory, Masson’s Trichrome and Picrossirus to quantify the collagen fibers and immunohistochemical technique for counting newly formed vessels. The data were compared statistically using analysis of variance ANOVA, with a “post-hoc Tukey test, p <0.05.

RESULTS: Low-level laser therapy reduced the intensity of the inflammatory reaction and influenced the dynamic of the immunoinflammatory response by inducing switching of the leukocyte infiltration pattern (neutrophilic to lymphoplasmacytic infiltration). Also stimulate the deposition and enhance the organization of collagen fibers, featuring a delicate collagen type III. Furthermore, it appeared to a significant increase in the average number of newly formed vessels (p = 0.00 and p = 0.02, respectively).

CONCLUSION: Low-level laser therapy resulted in modulate of the inflammatory response, enhanced deposition of collagen fibers and increase in the average number of newly formed vessels.


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.

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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 wound healing 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(2) (two seg); skin injury treated with HeNe 3 J/cm(2) (six seg); skin injury treated with GaAs 1 J/cm(2) (three seg); skin injury treated with GaAs 3 J/cm(2) (nine seg). A single circular wound measuring 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(2) dose and GaAs 3 J/cm(2) 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.

Lasers Surg Med. 2010 Nov;42(9):656-64.

**Laser photobiostimulation of wound healing: defining a dose response for splinted wounds in diabetic mice.**

Chung TY, Peplow PV, Baxter GD.

Department of Anatomy & Structural Biology, University of Otago, Dunedin, New Zealand.

**Abstract**

BACKGROUND AND OBJECTIVES: We have used a 660 nm, 80 mW laser diode in genetic diabetic mice to stimulate the healing of wounds covered with a Tegaderm HP dressing that causes a retardation of contraction (splinted wounds). The purpose of our study was to examine the effects of irradiating the wounds for different time intervals in order to determine a dose response relationship.

MATERIALS AND METHODS: A circular excisional wound was made on the left flank of diabetic mice using a 5-mm skin punch, and covered with a Tegaderm HP dressing. Mice were allocated to four groups in which wounds were irradiated 660 nm, 80 mW for 0, 10, 20, or 40 seconds each day for 7 days. In total, 51 mice were used. Wounds were harvested on day 14 and the healing assessed from hematoxylin-eosin stained sections examined by light microscopy.

RESULTS: The wounds were splinted in 40 of the mice, and splinting caused a retardation of healing. The findings for the four treatments showed that irradiation for 20 second/day for 7 days brought about the greatest extent of healing. The wounds healed mainly by re-epithelization and granulation tissue formation. This duration of irradiation represents an energy dose of 1.6 J per irradiation and, for an estimated area of irradiation of 32-43 mm², corresponds to an energy density of 3.7-5.0 J/cm².

CONCLUSION: Irradiation with 660 nm, 80 mW at an energy density of 3.7-5.0 J/cm² each day for 7 days caused the maximal stimulation of healing in splinted wounds of diabetic mice.


**Healing of surgical wounds made with lambda970-nm diode laser associated or not with laser phototherapy (lambda655 nm) or polarized light (lambda400-2000 nm).**

Medeiros JL, Nicolau RA, Nicola EM, dos Santos JN, Pinheiro AL.

Center of Biophotonics, School of Dentistry, Federal University of Bahia, Salvador, Bahia, Brazil.
Abstract

OBJECTIVE: The aim of this study was to analyze the effect of two phototherapies, laser and polarized light, on diode laser (970\(\lambda\) nm) wounds.

BACKGROUND DATA: Lasers have been used in surgery, and some wavelengths may cause thermal damage to the tissue and affect healing. Several studies have shown that some wavelengths are effective in improving healing. Coherent and noncoherent light have been successfully used on the modulation of biological phenomena of several origins.

ANIMALS AND METHODS: Thirty-one Wistar rats were divided into 3 groups (GI to GIII). A 20-mm x 2-mm wound was created on the dorsum of each animal with a diode laser (Sirolaser, Sirona, Bensheim, Germany). Group GI acted as control. On GII, laser light (\(\lambda655\) nm, 30 mW, phi approximately 3 mm, 12 J/cm\(^2\)) was used and on GIII illumination with polarized light (\(\lambda400-2000\) nm, 40 mW, phi approximately 5.5 cm, 12 J/cm\(^2\)) was used, every other day (GII) or daily (GIII) for 7 days. The animals were killed at 0, 7, and 14 days after surgery. Specimens were taken, routinely processed, stained and immunomarked [HE (hematoxylin-eosin), sirius red, alpha-smooth muscle actin (SMA)], and underwent histological analysis.

RESULTS: GII showed better response at day 14 when re-epithelialization was in a more advanced stage. The number of myofibroblasts was significantly different over the healing time (7 to 14 days); this number was smaller than that observed on G1. On GIII at day 7, the number of myofibroblasts was significantly higher than for GII. At day 14, a more pronounced deposition of collagen matrix was also seen, and inflammation was discrete and more advanced for GIII.

CONCLUSION: The results of the present study showed that the effect of the use of laser light was more evident at early stages of healing and that the use of polarized light improved the resolution of the inflammatory reaction, increased the deposition of collagen, increased the number of myofibroblasts, and quickened re-epithelialization during the experimental time.


Clinic-epidemiological evaluation of ulcers in patients with leprosy sequelae and the effect of low level laser therapy on wound healing: a randomized clinical trial.

Barreto JG, Salgado CG.

ABSTRACT:

BACKGROUND: Mycobacterium leprae is the only pathogenic bacteria able to infect peripheral nerves. Neural impairment results in a set of sensitive, motor and autonomic disturbances, with ulcers originating primarily on the hands and feet. The study objectives were to analyze the clinic-epidemiological characteristics of patients attended at one specialized dressing service from a leprosy-endemic region of the Brazilian Amazon and to evaluate the effect of low level laser therapy (LLLT) on wound healing of these patients.
METHODS: Clinic-epidemiological evaluation of patients with leprosy sequelae was performed at the reference unit in sanitary dermatology of the state of Para in Brazil. We conducted anamnesis, identification of the regions affected by the lesions and measurement of ulcer depth and surface area. After that, we performed a randomized clinical trial. Fifty-one patients with ulcers related to leprosy were evaluated, twenty-five of them were randomly assigned to a low level laser therapy group or a control group. Patients were treated 3 times per week for 12 weeks. Outcome measures were ulcer surface area, ulcer depth and the pressure ulcer scale for healing score (PUSH).

RESULTS: Ninety-seven ulcers were identified, with a mean (SD) duration of 97.6 (111.7) months, surface area of 7.3 (11.5) cm², and depth of 6.0 (6.2) mm. Statistical analysis of the data determined that there were no significant differences in the variables analyzed before and after treatment with low level laser therapy.

CONCLUSIONS: Ulcers in patients with leprosy remain a major source of economic and social losses, even many years after they have been cured of M. leprae infection. Our results indicate that it is necessary to develop new and more effective therapeutic tools, as low level laser therapy did not demonstrate any additional benefits to ulcer healing with the parameters used in this study. Trial Registration: The trial was registered at ClinicalTrials.gov as NCT00860717.

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Development and Evaluation of Fiber Optic Probe-based Helium-Neon Low-Level Therapy System for Tissue Regeneration-An In Vivo Experimental Study.

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Abstract

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(-2) of the system with appropriate controls, and 2 J cm(-2) 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(-2) 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(-2) irradiation group compared with the controls and other treatment groups. In conclusion, the wounds treated with 2 J cm(-2) immediately after the wounding show better healing compared with the controls.

Role of endogenous porphyrins in laser therapy of experimental skin wounds.

[Article in Russian]

Machneva TV, Bulgakova NN, Vladimirov IuA, Osipov AN.

Abstract

The role of endogenous porphyrins in the effect of laser irradiation on the superoxide dismutase (SOD) activity of wound exudate and rat leukocyte activity has been studied on models of aective incised skin wounds. Wounds were irradiated by a He-Ne laser (632.8 nm, 1.5 J/cm2) on the 2nd, 3rd, and 4th days after the beginning of the experiment. Irradiation effects were evaluated by the SOD activity (NBT test) and the activity of leukocytes of wound exudate (as a chemiluminescent response to opsonized zymosan). It was found that in animals subjected to laser irradiation, the SOD activity sharply increased. This effect depended on endogenous porphyrin concentration and was retained throughout the experiment. The SOD activity in unirradiated animals decreased from the 2nd to the 5th day of experiment. The evaluation of the activity of wound exudate leukocytes did not reveal any distinct dependence of the effect on the concentration of endogenous porphyrins.


The effect of equal daily dose achieved by different power densities of low-level laser therapy at 635 and 670 nm on wound tensile strength in rats: a short report.

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Department of Medical Biophysics, Pavol Jozef Safárik University, Kosice, Slovak Republic.

Abstract

OBJECTIVE: The aim of our study was to compare the effects of different power densities of LLLT at 635 and 670 nm achieving a daily dose of 5 J/cm(2) on wound tensile strength (TS) in rats.

BACKGROUND DATA: Optimal parameters of low-level laser therapy (LLLT) are still unknown.

MATERIALS AND METHODS: Under general anesthesia, one full-thickness skin incision was performed on the back of each rat (n = 40) and immediately closed using an intradermal running suture. Rats were separated into five groups depending on treatment parameters: (1) sham irradiated control group (SIC); (2) 635 nm laser-treated group at 4 mW/cm(2) (L-635/4); (3) 635 nm laser-treated group at 15 mW/cm(2) (L-635/15); (4) 670 nm laser-treated group at 4 mW/cm(2) (L-670/4); and (5) 670 nm laser-treated group at 15 mW/cm(2) (L-670/15). The total daily dose was 5 J/cm(2). Seven days after surgery each wound was removed for wound TS measurement.
RESULTS: The lowest wound TS results were measured in the SIC rats (10.5 +/- 2.8 g/mm(2)). Higher wound TS results were measured in group L-670/15 (11.5 +/- 2.5 g/mm(2)) and group L-635/4 (11.7 +/- 4.3 g/mm(2)) rats, while significantly higher results were found in group L-670/4 (15.8 +/- 4.4 g/mm(2)) and group L-635/15 (15.9 +/- 4.8 g/mm(2)). The differences were significant between certain groups (p < 0.01: SIC vs. L-635/15, SIC vs. L-670/4; p < 0.05: L-635/4 vs. L-635/15, L-635/4 vs. L-670/4, L-635/15 vs. L-670/15, L-670/4 vs. L-670/15).

CONCLUSION: Both red lasers significantly increased wound TS at selected parameters. Whereas the 635 nm laser significantly improved wound healing by using the higher power density, the 670 nm laser improved healing using a lower power density.

Med Pregl. 2010 Mar-Apr;63(3-4):188-93.

**Stimulation of mucoperiostal slice epithelization by small power laser after the primary plastic of oroantral communication.**

[Article in Serbian]

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**Abstract**

**INTRODUCTION:** The oroantral communication is a pathologic communication between the oral cavity and maxillary sinus. It originates with extraction of the upper lateral teeth. Primary plastics communication, which is more extensive than 5 mm has been unsuccessful in 16%. Small power lasers have positive reaction on wounds healing. The aim of this work was to determine the lasers effects on slice epithelization after the plastics more extensive than 5 mm.

**MATERIAL AND METHODS:** The experimental research was done on dogs with extraction of the upper second premolars on both sides, and formed oroantral communication having diameter of 10 mm. After the plastics of sinus, the left side slices were exposed to radiation for 7 days, and the opposite slices healed spontaneously. Eight points (8x1J) were treated for 100s by GaAlAs laser, power 10 mW and wavelength 670 nm. Biopses of the slices connections were taken on the 14th day to be laboratory treated and examined microscopically. The study included 36 examinees with communication diameter of 10 mm and performed plastics of sinuses. In half of the examinees wounds were exposed to radiation for 7 days, and in other examinees they healed spontaneously. The results were analyzed on the fourteenth day according to the scale: (1) complete healing, without dehiscention; (2) incomplete healing, with minimal dehiscention; (3) communication did not heal, with partial dehiscention; (4) open communication, with significant dehiscention.

**RESULTS AND DISCUSSION:** The microscopic analysis shows that no wounds exposed to radiation were overcast with mucous membrane which had smooth sub epithelia chronic inflammation and inflammbale infiltrate, and strong fibroplasias and granulations. Wounds exposed to radiation had mucous membrane without any signals of inflammation. Laser
radiation causes anti-inflammatory reaction, i.e., it provokes reduction of exudation, alteration and proliferation, it blocks cyclo- and lipo-oxygenation by delaying the synthesis of prostaglandin, stimulates neutrophil, macrophage and lissome activity and it activates the function of immune complex T and B lymphocytes, so this difference could be primary referred to the action of laser. Our clinical study shows that complete healing of oroantral communication was recorded in 88.8% of the examinees who were exposed to radiation in relation to 50%, of those who did not receive radiation therapy which is statistically much higher percentage (chi2 test < 0.05). The surgery was repeated in 5.6% of those who had received radiation therapy and in 16.7% of those who had not been exposed to radiation. Laser radiation stimulates changing of ADP in ATP and it accelerates cells metabolism, it increases microcirculation and accelerates substance exchange of cells, it increases DNK and RNK synthesis and stimulates cells division, which cause quicker regeneration of epithelia, i.e., it accelerates the process of wound healing.

CONCLUSION: It can be concluded that small power laser can be used successfully as additional method of treatment, after closing of oroantral communication surgically.


Effects of laser photobiomodulation on cutaneous wounds treated with mitomycin C: a histomorphometric and histological study in study in a rodent model.

Santos NR, dos Santos JN, Sobrinho JB, Ramalho LM, Carvalho CM, Soares LG, Pinheiro AL.

Laser Center, School of Dentistry, Federal University of Bahia, Salvador, Brazil.

Abstract

AIM: The aim of the present study was to assess histologically the effect of Laser Photobiomodulation (LPBM) on skin wounds treated with Mitomycin C (MMC).

BACKGROUND DATA: Wound healing occurs because of a competitive mechanism between the synthesis and lyses of collagen. Therefore, any factor that increases the lyses or reduces the synthesis of collagen may result in changes in the healing process. MMC is an antineoplastic drug that inhibits fibroblast proliferation, collagen synthesis, and neoangiogenesis. LPBM has been shown to stimulate wound healing, increasing the production of collagen, fibroblastic proliferation, and angiogenesis.

MATERIALS AND METHODS: Forty-eight Wistar rats were randomly distributed into 4 main groups (n = 12): G1–control (G1a–7 d and G1b–14 d); G2–MMC (G2a–7 d and G2b–14 d); G3–MMC + lambda660 nm laser (G3a–7 d and G3b–14 d); and G4–MMC + lambda790 nm laser (G4a–7 d and G4b–14 d). Under general anesthesia, one excisional wound was created on the dorsum of each animal. Two ml of MMC solution was applied to the wound 4 h after surgery for 5 min. LPBM was performed on groups G3 (lambda690 nm; 20 J/cm(2); 30 mW; Phi = 2 mm) and G4 (lambda790 nm; 20 J/cm(2); 40 mW; Phi = 2 mm), starting immediately after the application of the MMC and repeated every other day during the experimental period. Laser light was applied transcutaneously at 4 equidistant points on the wound margin (4 x 5 J/cm(2), 20 J/cm(2)/session). The specimens were routinely cut and processed to wax. The slides were stained with HE and Sirius red. Computerized hystomorphometry was performed.
RESULTS: LPBM resulted in reduced inflammation and an increase in both fibroblast proliferation and collagen deposition.

CONCLUSION: The use of LPBM improves wound healing in subjects treated with MMC.


**Phenotype characterization of pericytes during tissue repair following low-level laser therapy.**

Medrado A, Costa T, Prado T, Reis S, Andrade Z.

Laboratory of Experimental Pathology, Oswaldo Cruz Foundation, Salvador, Brazil.

Abstract

Background/purpose: The action of low-level laser therapy (LLLT) on pericytes during wound healing is not well established. The objective of this study was to identify the effect of laser treatment on pericytes during tissue repair.

Methods: Punch biopsies were performed on 40 Wistar rats. Twenty animals had their wounds treated with a dose of 4 J/cm(2) using a 670 nm diode laser (9 mW output, 0.031 W/cm(2)) every other day, while the controls received sham irradiation. Animals were sacrificed 3, 7, 10 and 14 days after punch biopsy. Immunohistochemistry staining with anti-desmin, anti-smooth muscle alpha-actin and anti-NG2 antibodies was used to characterize and count pericytes around blood vessels and myofibroblasts dispersed in the extracellular matrix (ECM). The morphology of pericytes was confirmed by transmission electronic microscopy.

Results: The laser group exhibited significantly more smooth muscle alpha-actin-positive staining cells at day 7 and more desmin-positive staining cells at day 10 around blood vessels. Laser treatment was also associated with higher numbers of NG2-positive staining cells, especially on days 3 and 7 post-biopsy (P<0.05). Ultrastructural findings confirmed the presence of pericytes sharing the basal membrane with endothelial cells.

Conclusion: LLLT stimulated the proliferation and migration of pericytes to the ECM and their phenotypic modulation to myofibroblasts.


**Low-level laser therapy for the treatment of epidermolysis bullosa: A case report.**

Minicucci EM, Barraviera SR, Miot H, Almeida-Lopes L.

Department of Dermatology and Radiotherapy, Botucatu School of Medicine of São Paulo State University – UNESP, Brazil.

Abstract
Abstract Epidermolysis bullosa (EB) is a rare group of diseases characterized by skin fragility. There is no specific treatment, short of protection from trauma, currently available for these patients. Low-level laser therapy (LLLT) was effective as an analgesic and in accelerating cutaneous wound healing after six sessions of therapy in a child with dystrophic EB with cutaneous scarring and blisters on the limbs and trunk.


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

da Silva JP, da Silva MA, Almeida AP, Lombardi Junior I, Matos AP.

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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.


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

Rodrigo SM, Cunha A, Pozza DH, Blaya DS, Moraes JF, Weber JB, de Oliveira MG.

School of Dentistry, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil.

**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 cm²; CW; P=30 mW; D=20 J, time of irradiation=667 sec), infrared laser (gallium-aluminum-arsenide (GaAlAs); lambda=830 nm; phi=0.0314 cm²; CW; P=50 mW; D=20 J, time of irradiation=401 sec), and both lasers (infrared laser: GaAlAs; lambda=830 nm; phi=0.0314 cm²; CW; P=50 mW; D=10 J, time of irradiation=201 sec+red laser: AlGaInP; lambda=685 nm; phi=0.0314 cm²; 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 wound healing, 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.


Effects of 780-nm Low-level Laser Therapy with a Pulsed Gallium Arsenide Laser on the Healing of a Surgically Induced Open Skin Wound of Rat.

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Physical Therapy Research Group, Academic Center for Education, Culture, and Research, Iran Medical Science Branch University, Vanak, Tehran, Iran.

Abstract Objective: The aim of the present investigation is to evaluate the effects of a 780-nm low-level laser on open skin wound healing. Background Data: Optimal parameters of low-level laser therapy (LLLT) for wound healing are discussed.

Methods: One full-thickness skin wound was surgically induced in the dorsum skin of 30 rats. The rats were divided into two groups. Rats in the experimental group were daily treated with a gallium aluminum arsenide (GaAlAs) laser (2 J/cm², lambda = 780 nm, pulse frequency of 2336 Hz). Rats in the sham-exposed group received LLLT with switched off equipment. After 4, 7, and 15 days, wounds were checked by histological and biomechanical methods. Data were analyzed by the Mann-Whitney U-test.

Results: Fibroblasts, endothelium of blood vessels, blood vessel sections, and maximum stress were significantly increased, whereas macrophages were significantly decreased, compared with those of the sham-exposed group.
Conclusion: Pulsed LLLT with a 780-nm GaAlAs laser significantly accelerates the process of healing of surgically induced, full-thickness skin wounds in rat.


Effects of laser photobiomodulation on cutaneous wounds treated with mitomycin C: a histomorphometric and histological study in a rodent model.

Santos NR, dos Santos JN, Sobrinho JB, Ramalho LM, Carvalho CM, Soares LG, Pinheiro AL.

Laser Center, School of Dentistry, Federal University of Bahia, Salvador, Brazil.

Abstract

AIM: The aim of the present study was to assess histologically the effect of Laser Photobiomodulation (LPBM) on skin wounds treated with Mitomycin C (MMC).

BACKGROUND DATA: Wound healing occurs because of a competitive mechanism between the synthesis and lyses of collagen. Therefore, any factor that increases the lyses or reduces the synthesis of collagen may result in changes in the healing process. MMC is an antineoplastic drug that inhibits fibroblast proliferation, collagen synthesis, and neoangiogenesis. LPBM has been shown to stimulate wound healing, increasing the production of collagen, fibroblastic proliferation, and angiogenesis.

MATERIALS AND METHODS: Forty-eight Wistar rats were randomly distributed into 4 main groups (n = 12): G1–control (G1a–7 d and G1b–14 d); G2–MMC (G2a–7 d and G2b–14 d); G3–MMC + lambda660 nm laser (G3a–7 d and G3b–14 d); and G4–MMC + lambda790 nm laser (G4a–7 d and G4b–14 d). Under general anesthesia, one excisional wound was created on the dorsum of each animal. Two ml of MMC solution was applied to the wound 4 h after surgery for 5 min. LPBM was performed on groups G3 (lambda690 nm; 20 J/cm(2); 30 mW; Phi = 2 mm) and G4 (lambda790 nm; 20 J/cm(2); 40 mW; Phi = 2 mm), starting immediately after the application of the MMC and repeated every other day during the experimental period. Laser light was applied transcutaneously at 4 equidistant points on the wound margin (4 x 5 J/cm(2), 20 J/cm(2)/session). The specimens were routinely cut and processed to wax. The slides were stained with HE and Sirius red. Computerized hystomorphometry was performed.

RESULTS: LPBM resulted in reduced inflammation and an increase in both fibroblast proliferation and collagen deposition.

CONCLUSION: The use of LPBM improves wound healing in subjects treated with MMC.


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

Rodrigo SM, Cunha A, Pozza DH, Blaya DS, Moraes JF, Weber JB, de Oliveira MG.
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 cm²; CW; P=30 mW; D=20 J; time of irradiation=667 sec), infrared laser (gallium-aluminum-arsenide (GaAlAs): lambda=830 nm; phi=0.0314 cm²; CW; P=50 mW; D=20 J; time of irradiation=401 sec), and both lasers (infrared laser: GaAlAs; lambda=830 nm; phi=0.0314 cm²; CW; P=50 mW; D=10 J; time of irradiation=201 sec+red laser: AlGaInP; lambda=685 nm; phi=0.0314 cm²; 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 wound healing, 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.


Effect of equal daily doses achieved by different power densities of low-level laser therapy at 635 nm on open skin wound healing in normal and corticosteroid-treated rats.


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Optimal parameters of low-level laser therapy (LLLT) for wound healing are still discussed. Hence, our study was aimed to compare effects of different power densities of LLLT at 635 nm in rats. Four, round, full-thickness, skin wounds were made on the backs of 48 rats that were divided into two groups (non-steroid laser-treated and steroid laser-treated). Three wounds were stimulated daily with a diode laser (daily dose 5 J/cm²) each with different power density (1 mW/cm², 5 mW/cm², and 15 mW/cm²), whereas the fourth wound served as
a control. Two days, 6 days, and 14 days after surgery, eight animals from each group were killed and samples were removed for histological evaluation. In the non-steroid laser-treated rats, significant acceleration of epithelization and collagen synthesis 2 days and 6 days after surgery was observed in stimulated wounds. In steroid laser-treated rats, 2 days and 14 days after surgery, a decreased leucocyte/macrophage ratio and a reduction in the area of granulation tissue were recorded, respectively. In conclusion, LLLT, by the method we used, improved wound healing in the non-steroid laser-treated rats, but it was useless after corticosteroid treatment.

Photomed Laser Surg. 2009 Sep 15. [Epub ahead of print]

**The Effect of Low-Level Laser Therapy on Healing of Skin Incisions Made Using a Diode Laser in Diabetic Rats.**

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Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Ataturk University, Erzurum, Turkey.

Abstract Background and Objective: To investigate the effect of low-level laser therapy (LLLT) on healing of skin incisions made using a diode laser in diabetic rats.

Material and Methods: Eighteen diabetic Wistar rats were used for this study. One incision was performed on the left side of the dorsum using a diode laser, and the other two incisions were made with a scalpel and diode laser on the right side of each rat. The wound on the left side of each rat received laser stimulation (10 J/cm(2)). The rats were assigned to three experimental groups. Group 1, scalpel (n = 18); Group 2, diode (n = 18); Group 3, diode + biostimulation (n = 18).

Results: Reepithelialization was fastest in Group 2 than Group 1 at day 10. The difference between Groups 1 and 3 was also statistically significant in reepithelialization at day 10. There was a significant difference between Groups 1 and 2 and between Groups 2 and 3 in inflammation at day 10. There was no difference between any of the groups in inflammation and reepithelialization at day 20.

Conclusions: Scalpel incisions heal more slowly than diode and diode + biostimulation incisions in diabetic rats. We can suggest that diode + biostimulation may produce the least amount of tissue injury, with the fastest resolution of inflammatory response in diabetic rats. Diode laser incision (4 W) with 10-J/cm(2) LLLT seems to have a beneficial effect on skin incisions in diabetic rats.

Cell Tissue Bank, 2009 Jul 11. [Epub ahead of print]

**Effects of diode laser therapy on the acellular dermal matrix.**

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Acellular dermal matrix (ADM) was subcutaneously implanted into calvarian skin of male Wistar rats (n = 40). Low-level laser (lambda 685 nm, 4 J/cm²) was locally applied in experimental group (n = 20) above the skin flap. Grafts were harvested at 1, 3, 7 and 14 days after surgery and underwent histological analyses. In treated animals, the extent of edema and the number of inflammatory cells were reduced (P < 0.05). The amount of collagen in graft treated with low-level laser were significantly higher than those of controls (P < 0.05) and were statistically more prominent on the 14th day after surgery. The mean count of fibroblasts was significantly higher in the low-laser therapy group within the 3rd day, showing a marked influx of fibroblasts into area. In conclusion, wound healing of the ADM appear to be positively affected by laser therapy.


Low level laser therapy in acute dehiscence saphenectomy: therapeutic proposal.

[Article in English, Portuguese]

Pinto NC, Pereira MH, Stolf NA, Chavantes MC.

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Dehiscence is a feared complication after major surgeries. Patient who had undergone coronary artery bypass grafting developed saphenectomy’s dehiscence on lower limb with edema and pain on the 15th postoperative day. Conventional treatment had been initially performed without clinical improvement. On the 30th postoperative day only Low Level Laser Therapy (LLLT) was applied punctually around surgical wounds edge. The results revealed granulated tissue, reduction of inflammatory process and analgesic effect since the first application. In this pilot study, LLLT has shown a considerable role as a wound healing agent, through a new proposal for efficient, safe and noninvasive therapy.


Visible lasers were better than invisible lasers in accelerating burn healing on diabetic rats.

Al-Watban FA, Zhang XY, Andres BL, Al-Anize A.

Laser Research Section, Biological and Medical Research Department, King Faisal Specialist Hospital and Research Centre, Riyadh, Kingdom of Saudi Arabia. watban@kfshrc.edu.sa

OBJECTIVE: This study was designed to assess and compare the efficacy of accelerating burn healing in diabetic rats using low-power visible and invisible lasers. Background Data: Low-level laser therapy (LLLT) has been used in a number of diabetic animal and human studies, with both positive and no effects.

MATERIALS AND METHODS: Male Sprague-Dawley rats were used in the study. Streptozotocin (70 mg/kg) was given for diabetes induction. A burn wound was created on the shaved back of the animals using a metal rod heated to 600 degrees C. The study was performed using
532-, 633-, 670-, 810-, and 980-nm diode lasers. Incident doses of 5, 10, 20, and 30 J/cm² and a treatment schedule of three times per week were used in the experiments. The burned areas on all rats were measured and plotted on a chart, and the slope values (mm²/d) and the percentages of burn healing were compared.

RESULTS: The percentage of burn healing on diabetic rats after LLLT was 78.37% for the visible lasers and 50.68% for the invisible lasers. There was a significant difference (p < 0.005) between visible lasers and invisible lasers in the percentage of burn healing on diabetic rats after laser therapy.

CONCLUSION: LLLT at the appropriate treatment parameters can accelerate burn healing on diabetic rats using both visible and invisible lasers. The effects of visible lasers were better than those of invisible lasers in accelerating burn healing on diabetic rats in this study.


A study of the effect of low-intensity laser radiation of the blue, green, and red spectral regions on the healing of experimental skin wounds in rats.

[Article in Russian]

Machneva TV, Protopopov DM, Vladimirov IuA, Osipov AN.

Abstract

The effect of low-intensity laser radiation of the blue (441.2 nm), green (532 nm), and red (632.8 nm) spectral regions on the healing of experimental skin wounds in rats has been studied. The effect of the traditionally applied laser radiation in the red region has been compared with the effect of laser radiation in the other spectral regions, assuming that, upon irradiation of wounds by lasers emitting in the blue and green regions, a similar effect can be achieved at lower doses. The following parameters characterizing the healing of experimental wounds were used: the functional activity of phagocytes of wound exudates, which was determined by luminol-dependent chemiluminescence, and their number; the antioxidant activity of wound exudates; and the rate of healing, which was determined as a change in the wound area. It was shown that irradiation with laser accelerated the healing of wounds in all cases. The exposure to laser radiations in the red (1.5 J/cm), blue, and green (0.75 J/cm²) spectral regions shortened the time of wound healing from 22 to 17 and 19 days, respectively. The functional activity of leukocytes after the exposure increased on day 5 after the infliction of the wound, whereas in the control it decreased. The superoxide dismutase activity increased in all experimental groups by day 5 after the operation. A maximum increase in the superoxide dismutase activity occurred after the exposure to laser radiation in the red region at a dose of 1.5 J/cm and in the blue and green spectral regions at a dose of 0.75 J/cm².


Low level laser therapy for healing acute and chronic wounds – the extendicare experience.
The purpose of the study is to assess the effectiveness of low level laser therapy for wound healing when combined with the Extendicare Wound Prevention and Management Program. Sixteen residents at a Canadian Extendicare nursing home had a total of 27 sites treated consisting of 23 open wounds and 4 ‘at risk’ areas. Of the 23 open wounds, two wounds in between toes were not able to be ‘traced’ and deemed ‘immeasurable’ wounds, resulting in 21 open, measured wounds. The four ‘at risk’ (closed) areas were treated preventatively. Pressure, venous insufficiency and diabetic wounds were included. The majority (12/21) or 57.1%, of the wounds were chronic (≥3 months duration) and 42.9% were acute (<3 months duration). The primary outcome measures included the PUSH Tool score, EZ Graph tracings and photographs. Secondary outcome measures were employed to better understand potential barriers to successful integration into clinical practice. Feedback on the effectiveness of low level laser therapy, the education program and determinations of hands-on relevance was sought from staff. At the end of the 9-week trial, the majority (61.9%) of the 21 wounds achieved significant improvement (≥50% wound closure). Nine (42.8%) had 100% closure. Some improvement was seen in 14.3% and 23.8% of wounds demonstrated no change. Chronic and acute wounds had similar improvement. None of the wounds in this debilitated, frail population deteriorated during the study and no negative consequences of treatment were encountered. Without staff support, even if new technology has positive clinical outcomes, success would be limited. Staff rated low level laser, easy to learn and use, effective for the majority of their residents worth the additional time. Staff requested a continuation of low level laser even after study completion.

Effectiveness of laser photobiomodulation at 660 or 780 nanometers on the repair of third-degree burns in diabetic rats.

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OBJECTIVE: The aim of this investigation was to compare by light microscopy the effects of laser photobiomodulation (LPBM) at lambda = 660 nm and lambda = 780 nm on third-degree burns in diabetic Wistar rats. BACKGROUND DATA: Burns are severe injuries that result in fluid loss, tissue destruction, infection, and shock, that may result in death. Diabetes is a disease that reduces the body’s ability to heal properly. LPBM has been suggested as an effective method of improving wound healing.

MATERIALS AND METHODS: A third-degree burn measuring 1.5 x 1.5 cm was created in the dorsum of each of 55 animals, and they were divided into three groups that were or were not treated with LPBM (λ = 660 nm or λ = 780 nm, 35 mW, φ = 2 mm, 20 J/cm²). The treatments were started immediately post-burn at four points within the burned area (5 J/cm²) and were repeated at 24-hour intervals over 21 d. The animals were
humanely killed after 3, 5, 7, 14, and 21 d by an overdose of intraperitoneal general anesthetic. The specimens were routinely cut and stained and analyzed by light microscopy.

RESULTS: We found that healing in the animals receiving 660-nm laser energy was more apparent at early stages, with positive effects on inflammation, the amount and quality of granulation tissue, fibroblast proliferation, and on collagen deposition and organization. Epithelialization and local microcirculation were also positively affected by the treatment.

CONCLUSION: The use of 780-nm laser energy was not as effective as 660-nm energy, but it had positive effects at early stages on the onset and development of inflammation. At the end of the experimental period the primary effect seen was on the amount and quality of the granulation tissue. The 660-nm laser at 20 J/cm(2), when used on a daily basis, was more effective than the 780-nm laser for improving the healing of third-degree burns in the diabetic rats beginning at the early stages post-burn.
Light therapy and advanced wound care for a neuropathic plantar ulcer on a Charcot foot.

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Light therapy is a relatively novel modality in wound care. I used a light-emitting diode (LED) and superluminous diode (SLD) to deliver low-intensity laser light as an adjunctive treatment to a patient with a chronic diabetic foot ulcer. Standard treatment of conservative sharp debridement, off-loading, bioburden management, and advanced dressings was delivered in a WOC clinic setting. This combination of therapies resulted in closure of the neuropathic plantar ulcer within 8 weeks.


Effect of low-level laser therapy on skin fibroblasts of streptozotocin-diabetic rats.

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OBJECTIVE: This study explored the effects of low-level laser therapy (LLLT) on cellular changes in cell culture and organ culture of skin from streptozotocin-diabetic (STZ-D) rats.

BACKGROUND DATA: Growth of skin and its fibroblasts are impaired in diabetes. Therefore the healing of skin wounds is impaired in diabetic patients. The positive effects of LLLT on complications of diabetes in patients and animal models have been shown.

METHODS: Diabetes was induced in rats by streptozotocin 30 days after its injection. Two sets of skin samples were extracted from skin under sterile conditions. Fibroblasts that were extruded from the samples were proliferated in vitro, and another set of samples were cultured as organ culture. A 24-well culture medium containing Dulbecco’s modified minimum essential medium was supplemented by 12% fetal bovine serum. There were five laser-treated and five sham-exposed groups. A helium-neon laser was used, and 0.9-4 J/cm(2) energy densities were applied four times to each organ culture and cell culture. The organ cultures were analyzed by light microscopy and transmission electron microscopy examinations. Cell proliferation was evaluated by dimethylthiazol-diphenyltetrazolium bromide (MTT) assay.

RESULTS: Statistical analysis revealed that 4-J/cm(2) irradiation significantly increases the fibroblast numbers compared to the sham-exposed cultures (p = 0.046).

CONCLUSION: It is concluded that LLLT resulted in a significant increase of fibroblast proliferation of STZ-D rats in vitro.

The effect of low reactive-level laser therapy (LLLT) with helium-neon laser on operative wound healing in a rat model.

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Abstract

The effect of low reactive-level laser therapy (LLLT) with a He-Ne laser on operative wound healing was investigated in a rat model. 10-millimeter surgical wounds were created on the backs of Sprague Dawley rats, and animals were assigned to one of eleven groups (n=5). Ten groups received either 8.5 mW or 17.0 mW irradiation of 15 seconds LLLT a day with one of five different irradiation frequencies, i.e. daily (from the 1st to 6th day following surgery), every other day (the 1st, 3rd, and 5th day), on only the 1st day, on only the 3rd day, and on only the 5th day; the 1st day was the day following the surgery. The control group received no irradiation. A skin specimen was harvested from the dorsal thoracic region on the 7th day to measure the rupture strength. The control group had the lowest rupture strength (5.01 N), and the 17.0 mW every other day irradiation group had the highest rupture strength (13.01 N). Statistical differences were demonstrated in the 8.5 mW irradiation setting between the every other day irradiation group and the control group (p<0.05); and in 17.0 mW irradiation setting between the every day irradiation, the every other day, and the 1st day only groups vs. the control group (p<0.01). Histological examination demonstrated that wound healing in the 17.0 mW every other day irradiation group was promoted most significantly such as the prevention of excessive inflammation, increased formation of collagen fibers, and recovery in continuity of tissues. The control group showed poor wound healing and the other experimental groups showed intermediate healing. Thus LLLT with a He-Ne laser was found to promote the healing of operative wounds in the present rat model, in which the most favorable application of LLLT was the 17.0 mW setting of 15 seconds a day with a frequency of every other day.


The influence of laser irradiation with different power densities on incisional wound healing in healthy and diabetic rats

[Article in Slovak]


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INTRODUCTION: The optimal parameters of low level laser therapy (LLLT) are still under debate. It has been documented that a dose of 5 J/cm2 would be capable to accelerate the
wound healing process in patients. However, the optimal delivering form, i.e. power intensity, is unknown. Therefore, the aim of our study was to compare different power densities of LLLT.

MATERIALS AND METHODS: Sixteen male Sprague-Dawley rats were included in this experiment and randomized into two groups, normal healthy group and streptozotocine induced diabetic group. In general anesthesia four full thickness skin incisions were performed under standard aseptic conditions on the back of each rat and immediately closed using intradermal running suture. Three wounds were stimulated with diode laser (wavelength: 635 nm; daily dose 5 J/cm²; power densities: 1 mW/cm², 5 mW/cm² and 15 mW/cm²) each with different power density while the fourth wound served as control. Six days after surgery animals were sacrificed and samples removed for histological evaluation.

RESULTS: Our study demonstrated that LLLT positively influences wound healing. The most significant changes were observed in wounds stimulated at the highest power density 15 mW/cm². Since using the highest power density the shortest time is needed to achieve the optimal daily dose of 5 J/cm², it can be suggested that 15 mW/cm² might be optimal parameter for such a therapy in patients.


Low-level laser therapy enhances wound healing in diabetic rats: a comparison of different lasers.

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OBJECTIVE: The effects of wound healing acceleration on diabetic rats were determined and compared using different laser wavelengths and incident doses.

BACKGROUND DATA: Many studies have demonstrated that low-level laser therapy (LLLT) can promote the wound healing on non-diabetic animals.

METHODS: Male Sprague-Dawley rats were used. Streptozotocin (70 mg/kg) was applied for diabetes induction. An oval full-thickness skin wound was created aseptically with a scalpel in 51 diabetic rats and six non-diabetic rats on the shaved back of the animals. The study was performed using 532, 633, 810, and 980 nm diode lasers. Incident doses of 5, 10, 20, and 30 J/cm(2) and treatment schedule of 3 times/week were used in the experiments. The area of wound on all rats was measured and plotted on a slope chart. The slope values (mm²/day), the percentage of relative wound healing, and the percentage of wound healing acceleration were computed in the study.

RESULTS: Mean slope values were 6.0871 in non-diabetic control and 3.636 in diabetic control rats (p > 0.005). The percentages of wound healing acceleration were 15.23, 18.06, 19.54, and 20.39 with 532-nm laser, 33.53, 38.44, 32.05, and 16.45 with 633-nm laser, 15.72, 14.94, 9.62, and 7.76 with 810-nm laser, and 12.80, 16.32, 13.79, and 7.74 with 980-nm laser, using incident doses of 5, 10, 20, and 30 J/cm(2), respectively. There were significant differences (p > 0.001) in the mean slope value of wound healing on diabetic rats between control groups and treatment groups in 532, 633, 810, and 980 nm lasers.
CONCLUSION: The wound healing on control rats with diabetes was slower than on control rats without diabetes. LLLT at appropriate treatment parameters can enhance the wound healing on diabetic rats. The optimum wavelength was 633 nm, and the optimum incident dose was 10 J/cm² in our study.


Comparison between wound healing in induced diabetic and nondiabetic rats after low-level laser therapy.

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OBJECTIVE: The aim of this work was to compare the effect of low-level laser therapy (LLLT) on the wound healing process in nondiabetic and diabetic rats.

BACKGROUND DATA: Among the clinical symptoms caused by diabetes mellitus, a delay in wound healing is a potential risk for patients. It is suggested that LLLT can improve wound healing.

METHODS: The tissue used for this study was extracted from animals suffering from diabetes, which was induced by Streptozotocin, and from nondiabetic rats. Animals were assembled into two groups of 25 rats each (treated and control) and further subdivided into two groups: diabetic (n = 15) and nondiabetic (n = 10). A full-thickness skin wound was made on the dorsum area, with a round 8-mm holepunch. The treated group was irradiated by a HeNe laser at 632.8 nm, with the following parameters: 15 mW, exposition time of 17 sec, 0.025 cm² irradiated area, and energy density of 10 J/cm². Square full-thickness skin samples (18 mm each side, including both injured and noninjured tissues) were obtained at 4, 7, and 15 days after surgery and analyzed by qualitative and quantitative histological methods.

RESULTS: Quantitative histopathological analysis confirmed the results of the qualitative analysis through histological microscope slides. When comparing tissue components (inflammatory cells, vessels and fibroblast/area), we found that treated animals had a less intense inflammatory process than controls.

CONCLUSION: Results obtained by both qualitative and quantitative analyses suggested that irradiation of rats with HeNe (632.8 nm), at the tested dose, promoted efficient wound healing in both nondiabetic and diabetic rats as, compared to the control group.


Analysis of the influence of low-power HeNe laser on the healing of skin wounds in diabetic and non-diabetic rats.

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PURPOSE: To study the influence of HeNe laser irradiation on the collagen percentage in surgically-induced skin wounds in rats with and without alloxan-induced diabetes, by morphometric analysis of collagen fibers.

METHODS: 48 male Wistar rats were used, divided into groups: laser-treated diabetic (group 1); untreated diabetic (group 2); treated non-diabetic (group 3); and untreated non-diabetic (group 4). For groups 1 and 2, diabetes was induced by intravenous injection of alloxan (2,4,5,6-tetraoxypyrimidine; 5,6-dioxyuracil; Sigma), into the dorsal vein of the penis, at a rate of 0.1 ml of solution per 100 g of body weight. A wound was made on the back of all the animals. Groups 1 and 3 were treated with HeNe laser (4 J/cm2) for 60 s. One animal from each group was sacrificed on the 3rd, 7th and 14th days after wounding. Samples were taken, embedded in paraffin, stained with hematoxylin-eosin and Masson’s trichrome, and morphometrically analyzed using the Imagelab software. The percentages of collagen fibers were determined from the samples from the euthanasia animals. The data were treated statistically using analysis of variance (ANOVA) and the Student t and Kruskal-Wallis tests. The significance level was set at 0.05 or 5%.

RESULTS: The results obtained from the samples taken on the third, seventh and fourteenth days after wounding demonstrated that the laser-treated group presented a statistically significant (p<0.05) greater mean quantity of collagen fibers than in the non-treated group, both for diabetic rats (p = 0.0104) and for non-diabetic rats (p = 0.039).

CONCLUSION: The low-power laser (632.8 nm) was shown to be capable of influencing the collagen percentage in skin wounds by increasing the mean quantity of collagen fibers, both for the diabetic and for the non-diabetic group.


A comparison of the effects of laser and light-emitting diodes on superoxide dismutase activity and nitric oxide production in rat wound fluid

[Article in Russian]

Klebanov GI, Shuraeva NIu, Chichuk TV, Osipov AN, Vladimirov IuA.

Abstract

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.

A comparative study of the effects of laser and light-emitting diode irradiation on the wound healing and functional activity of wound exudate leukocytes

[Article in Russian]

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Abstract

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.


Polarized light (400-2000 nm) and non-ablative laser (685 nm): a description of the wound healing process using immunohistochemical analysis.

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Abstract

OBJECTIVE: This study aimed to describe, through morphologic and cytochemical analysis, the healing process of wounds submitted (or not) to laser therapy (lambda685 nm) or polarized light (lambda400-2000 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/cm2. 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/cm² 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/cm² 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/cm², 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/cm² resulted in increased collagen deposition and better organization on healing wounds, and the number of myofibroblast was increased when polarized light is used.


Effect of low intensity helium-neon (He-Ne) laser irradiation on diabetic wound healing dynamics.

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OBJECTIVE: The aim of this study was to determine the effect of low-energy He-Ne laser treatment on wound healing dynamics (histological and biochemical) in diabetic rats.

BACKGROUND DATA: Low-energy laser photostimulation at certain wavelengths can enhance tissue repair by releasing growth factors from fibroblasts and can facilitate the healing process of diabetic wounds.

MATERIALS AND METHODS: A circular 4 cm² excisional wound was created on the dorsum of the experimentally (Alloxan)-induced diabetic rats. In the study group (N = 24) the wound was treated with He-Ne laser (632.8 nm wavelength) at a dose of 4.8 J/cm² for 5 days a week until the wound healed completely. The control group (N = 24) was sham-irradiated. The results were statistically analyzed by an independent t test for biochemical analysis and the nonparametric Mann-Whitney U test for histopathological parameters.

RESULTS: The analysis of the biochemical parameters and histopathological parameters of the wounds showed that the laser-treated group healed faster and better as compared to the control group (p < 0.0001). The laser-treated group healed on average by the 18th day whereas, the control group healed on average by the 59th day.

CONCLUSION: Laser photostimulation promotes the tissue repair process of diabetic wounds.
Low level laser therapy (LLLT) as an effective therapeutic modality for delayed wound healing.

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Low level laser therapy (LLLT) is a form of phototherapy that involves the application of low power monochromatic and coherent light to injuries and lesions. It has been used successfully to induce wound healing in nonhealing defects. Other wounds treated with lasers include burns, amputation injuries, skin grafts, infected wounds, and trapping injuries. The unique properties of lasers create an enormous potential for specific therapy of skin diseases. As with any new device, the most efficacious and appropriate use requires an understanding of the mechanisms of light interaction with tissue as well as the properties of the laser itself.


Mitochondrial signal transduction in accelerated wound and retinal healing by near-infrared light therapy.


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Photobiomodulation by light in the red to near infrared range (630-1000 nm) using low energy lasers or light-emitting diode (LED) arrays has been shown to accelerate wound healing, improve recovery from ischemic injury in the heart and attenuate degeneration in the injured optic nerve. Recent evidence indicates that the therapeutic effects of red to near infrared light result, in part, from intracellular signaling mechanisms triggered by the interaction of NIR light with the mitochondrial photoacceptor molecule cytochrome c oxidase. We have demonstrated that NIR-LED photo-irradiation increases the production of cytochrome oxidase in cultured primary neurons and reverses the reduction of cytochrome oxidase activity produced by metabolic inhibitors. We have also shown that NIR-LED treatment prevents the development of oral mucositis in pediatric bone marrow transplant patients. Photobiomodulation improves wound healing in genetically diabetic mice by upregulating genes important in the promotion of wound healing. More recent studies have provided evidence for the therapeutic benefit of NIR-LED treatment in the survival and functional recovery of the retina and optic nerve in vivo after acute injury by the mitochondrial toxin, formic acid generated in the course of methanol intoxication. Gene discovery studies conducted using microarray technology documented a significant upregulation of gene expression in pathways involved in mitochondrial energy production and antioxidant cellular protection. These findings provide a link between the actions of red to near infrared light on mitochondrial oxidative metabolism in vitro and cell injury in vivo. Based on these findings and the strong evidence that mitochondrial dysfunction is involved in the pathogenesis of numerous diseases processes, we propose that NIR-LED photobiomodulation represents an innovative and non-invasive therapeutic approach for the treatment of tissue injury and disease processes in which mitochondrial dysfunction is
Postulated to play a role including diabetic retinopathy, age-related macular degeneration, Leber’s hereditary optic neuropathy and Parkinson’s disease.


**Photobiomodulation improves cutaneous wound healing in an animal model of type II diabetes.**


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**OBJECTIVE:** We investigated the effects of photobiomodulation (PBM) on cutaneous wound healing in an animal model of type II diabetes, Psammomys obesus (Sand Rats).

**BACKGROUND DATA:** 632-nm light has been established as the most effective wavelength for treatment of cutaneous wounds; however, the inconsistent efficacy of PBM may be due to inadequate treatment parameter selection.

**METHODS:** Using 632-nm light, an initial series of experiments were done to establish optimal treatment parameters for this model. Following creation of bilateral full-thickness skin wounds, non-diabetic Sand Rats were treated with PBM of differing dosages. Wound healing was assessed according to wound closure and histological characteristics of healing. Optimal treatment parameters were then used to treat type II diabetic Sand Rats while a diabetic control group received no irradiation. In order to elucidate the mechanism behind an improvement in wound healing, expression of basic fibroblast growth factor (bFGF) was assessed.

**RESULTS:** Significant improvement in wound healing histology and wound closure were found following treatment with 4 J/cm\(^2\) (16 mW, 250-sec treatments for 4 consecutive days; \(p < 0.05\)). The 4 J/cm\(^2\) dosage significantly improved histology and closure of wounds in the diabetic group in comparison to the non-irradiated diabetic group. Quantitative analysis of bFGF expression at 36 h post-injury revealed a threefold increase in the diabetic and non-diabetic Sand Rats after PBM.

**CONCLUSIONS:** The results demonstrate that PBM at an energy density of 4 J/cm\(^2\) is effective in improving the healing of cutaneous wounds in an animal model of type II diabetes, suggesting that PBM (632 nm, 4 J/cm\(^2\)) would be effective in treating chronic cutaneous wounds in diabetic patients.


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

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Abstract

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.


Polychromatic LED therapy in burn healing of non-diabetic and diabetic rats.

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OBJECTIVE: We determined the effect of polychromatic light-emitting diodes (LED) in burn healing of non-diabetic and streptozotocin-induced diabetic rats. BACKGROUND DATA: LEDs were used as the light source for phototherapy. MATERIALS AND METHODS: The polychromatic LED is a cluster of 25 diodes emitting photons at wavelengths of 510-543, 594-599, 626-639, 640-670, and 842-879 nm with 272-mW output power. Age-matched, male Sprague-Dawley rats (n = 30) were used. Streptozotocin (70 mg/kg) was used for diabetes induction. Rat weight, hyperglycemia, and glycosuria were monitored for the first 3 days and weekly thereafter. Rats were anesthetized and shaved after 1 week of diabetes. Burn areas of
1.5 +/- 0.03 cm² were created using a metal rod pre-heated up to 600 degrees C that was applied for 2 sec. Diabetic and non-diabetic rats were randomized into the following treatment groups: control, 5, 10, 20, and 30 J/cm². Light treatment commenced after burn infliction and was repeated three times per week. Burn areas were measured daily. RESULTS: Burn healing was impaired significantly during diabetes by -46.17%. Polychromatic LED treatment using 5, 10, 20, and 30 J/cm² incident doses influenced healing by 6.85%, 4.93%, -4.18%, and -5.42% in the non-diabetic rats; and 73.87%, 76.77%, 60.92%, and 48.77% in the diabetic rats, relative to their controls, respectively. CONCLUSION: The effect of polychromatic LED in non-diabetic rats was insignificant; however, it simulated the trend of stimulation and inhibition seen using low-level lasers. Significant stimulation observed in the diabetic rats demonstrated the usefulness of polychromatic LED in diabetic burn healing.


**Effect of NASA light-emitting diode irradiation on wound healing.**


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OBJECTIVE: The purpose of this study was to assess the effects of hyperbaric oxygen (HBO) and near-infrared light therapy on wound healing. BACKGROUND DATA: Light-emitting diodes (LED), originally developed for NASA plant growth experiments in space show promise for delivering light deep into tissues of the body to promote wound healing and human tissue growth. In this paper, we review and present our new data of LED treatment on cells grown in culture, on ischemic and diabetic wounds in rat models, and on acute and chronic wounds in humans.

MATERIALS AND METHODS: In vitro and in vivo (animal and human) studies utilized a variety of LED wavelength, power intensity, and energy density parameters to begin to identify conditions for each biological tissue that are optimal for biostimulation.

Results: LED produced in vitro increases of cell growth of 140-200% in mouse-derived fibroblasts, rat-derived osteoblasts, and rat-derived skeletal muscle cells, and increases in growth of 155-171% of normal human epithelial cells. Wound size decreased up to 36% in conjunction with HBO in ischemic rat models. LED produced improvement of greater than 40% in musculoskeletal training injuries in Navy SEAL team members, and decreased wound healing time in crew members aboard a U.S. Naval submarine. LED produced a 47% reduction in pain of children suffering from oral mucositis.

CONCLUSION: We believe that the use of NASA LED for light therapy alone, and in conjunction with hyperbaric oxygen, will greatly enhance the natural wound healing process, and more quickly return the patient to a preinjury/illness level of activity. This work is supported and managed through the NASA Marshall Space Flight Center-SBIR Program.


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Objective: This study aimed to establish the behavior of wounded human skin fibroblasts (HSF) after helium-neon (HeNe) (632.8 nm) laser irradiation using one, two, or three exposures of different doses, namely, 2.5, 5.0, or 16.0 J/cm(2) on each day for 2 consecutive days.

Background Data: Low-level laser therapy (LLLT) is a form of phototherapy used to promote wound healing in different clinical conditions. LLLT at than adequate wavelength, intensity, and dose can accelerate tissue repair. However, there is still conflicting information about the effect of multiple irradiations on the cellular responses of wounded cells. Methods: Cellular responses to HeNe laser irradiation were evaluated by measuring changes in cell morphology, cell viability, cell proliferation, and damage caused by multiple irradiations.

Results: A single dose of 5.0 J/cm(2), and two or three doses of 2.5 J/cm(2) had a stimulatory or positive effect on wounded fibroblasts with an increase in cell migration and cell proliferation while maintaining cell viability, but without causing additional stress or damage to the cells. Multiple exposures at higher doses (16 J/cm(2)) caused additional stress, which reduces cell migration, cell viability, and ATP activity, and inhibits cell proliferation.

Conclusion: The results show that the correct energy density or fluence (J/cm(2)) and number of exposures can stimulate cellular responses of wounded fibroblasts and promote cell migration and cell proliferation by stimulating mitochondrial activity and maintaining viability without causing additional stress or damage to the wounded cells. Results indicate that the cumulative effect of lower doses (2.5 or 5 J/cm(2)) determines the stimulatory effect, while multiple exposures at higher doses (16 J/cm(2)) result in an inhibitory effect with more damage.


Reversal of diabetic peripheral neuropathy and new wound incidence: the role of MIRE.

Powell MW, Carnegie DE, Burke TJ.

Northwest Orthopedic Center, Springdale, AR, USA.

OBJECTIVE: To determine if improved foot sensitivity to the Semmes-Weinstein 10-g (5.07) monofilament, originally impaired because of diabetic peripheral neuropathy, might be associated with a reduced incidence of new diabetic foot wounds.

DESIGN: Retrospective cohort study using a health status questionnaire.
SUBJECTS: Sixty-eight individuals over age 64 with diabetes, diabetic peripheral neuropathy, and loss of protective sensation who had clinically demonstrable increases in foot sensation to the Semmes-Weinstein monofilament after treatment with monochromatic near infrared photo energy.

MAIN RESULTS: After reversal of diabetic peripheral neuropathy following treatment with monochromatic near infrared photo energy, only 1 of 68 patients developed a new diabetic foot wound, for an incidence of 1.5%. Comparatively, the incidence previously reported in the Medicare-aged population with diabetes was 7.3%.

CONCLUSIONS: Improved foot sensitivity to the Semmes-Weinstein monofilament in patients previously suffering from loss of protective sensation due to diabetic neuropathy appears to be associated with a lower incidence of new diabetic foot ulcers when compared with the expected incidence in the Medicare-aged population with diabetes.

CLINICAL RELEVANCE: Therapeutic interventions that effectively improve foot sensitivity that has been previously diminished due to diabetic peripheral neuropathy may substantially reduce the incidence.

Improved sensitivity in patients with peripheral neuropathy: effects of monochromatic infrared photo energy.

DeLellis SL, Carnegie DH, Burke TJ.

Gulf Coast Foot, Ankle and Wound Center, Tarpon Springs, FL, USA.

The medical records of 1,047 patients (mean age, 73 years) with established peripheral neuropathy were examined to determine whether treatment with monochromatic infrared photo energy was associated with increased foot sensitivity to the 5.07 Semmes-Weinstein monofilament. The peripheral neuropathy in 790 of these patients (75%) was due to diabetes mellitus. Before treatment with monochromatic infrared photo energy, of the ten tested sites (five on each foot), a mean +/- SD of 7.9 +/- 2.4 sites were insensitive to the 5.07 Semmes-Weinstein monofilament, and 1,033 patients exhibited loss of protective sensation. After treatment, the mean +/- SD number of insensate sites on both feet was 2.3 +/- 2.4, an improvement of 71%. Only 453 of 1,033 patients (43.9%) continued to have loss of protective sensation after treatment. Therefore, monochromatic infrared photo energy treatment seems to be associated with significant clinical improvement in foot sensation in patients, primarily Medicare aged, with peripheral neuropathy. Because insensitivity to the 5.07 Semmes-Weinstein monofilament has been reported to be a major risk factor for diabetic foot wounds, the use of monochromatic infrared photo energy may be associated with a reduced incidence of diabetic foot wounds and amputations.

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

Herascu N, Velciu B, Calin M, Savastru D, Talianu C.
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.


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 postoperative 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.


The comparison of effects between pulsed and CW lasers on wound healing.

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OBJECTIVE: In order to evaluate the effects of pulsed continuous wave (CW) laser and detect the role of wound healing in rats using both pulsed and CW 635-nm low-level laser therapy (LLLT), a pilot study was undertaken.

Background Data: Some acceleration effects of wound healing on animals were found after treatment using various lasers with CW. There are other reports, however, using pulsed CW laser to evaluate the effects of wound healing in rats.

MATERIALS AND METHODS: An elliptic wound was created aseptically with a scalpel on the shaved back of the rats after anesthesia. The rats treated were restrained in a Plexiglas cage without anesthesia during the laser irradiation period. An Erchonia pulse laser (635 nm) was used in the experiment. The laser beam was delivered through an expander. The percentage of relative wound healing was calculated. RESULTS: The percentage of relative wound healing was 4.32 in 100 Hz, 3.21 in 200 Hz, 3.83 in 300 Hz, 2.22 in 400 Hz, 1.73 in 500 Hz and 4.81 in CW.

CONCLUSION: LLLT using pulsed, CW laser at the appropriate dosimetry and frequency can provide acceleration in wound healing in rats. The 100-Hz frequency had a better effect than other pulse frequencies used in the study. The effects of treatment using CW laser was higher than pulse frequency. The frequency of pulsed CW laser was not found to increase wound healing in rats compared with normal CW laser, as reported in our previous studies.


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

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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(2). Lesion "L(//)" was irradiated by He-Ne laser (lambda = 632.8 nm), D= 1.0 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.

LASER THERAPY IN WOUND MANAGEMENT

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The end product of wound management should be a healed wound. To appreciate how low intensity laser therapy (LILT) can assist in achieving this it is necessary first to be familiar with the normal structure of the tissues involved in the injury · the stages involved in the repair of these tissues.

Following a brief description of the above as they apply to skin, the effects of LILT on the cellular events which occur during the healing of acute wounds of skin will be examined. Used correctly these effects can lead to an acceleration of the healing process in wounds healing suboptimally. This acceleration is due, at least in part, to reduction in the duration of acute inflammation resulting in a more rapid entry into the proliferative stage of repair when granulation tissue is produced. Methods of converting chronic wounds into acute wounds in which healing can be accelerated will be suggested. The cellular mechanisms that cause this acceleration will be described. Reversible membrane permeability changes, for example to calcium ions, occur. These stimulate cell activity leading to a range of events including enhanced · growth factor release by macrophages· keratinocyte proliferation· mast cell recruitment and degranulation· angiogenesis.

The urgent need for controlled, double blind clinical studies of wound healing in volunteers and patients using calibrated LILT devices whose output is known and fully reported will be emphasised. Ideally wound healing should be monitored objectively and noninvasively throughout the healing process to provide the data needed for evidence based clinical LILT practice. The potential role of high resolution (20 MHz) digitised ultrasound B-scans of wounds in providing this data will be described.
OPEN WOUND HEALING (BED SORES, ULCUS CRURUS, BURNS) WITH SYSTEMIC EFFECTS OF LLLT

Adam Mester

Semmelweiss University, Budapest, Hungary

I. The wound healing phases and laser effects: 1) subcellular, 2) cellular effects: leukocytes and mediators, fibroblast proliferation, lymphocyte activation and mediators, endothelial capillaries regeneration/ revascularisation, epithelial cell regeneration, mucosal regeneration.

II. Anti-inflammatory laser effects in wound healing: Prostaglandin synthesis, Immunological reactions, Helper and suppressor T-cell effects. B-cell effects. IgM/IgG/complement, skin transplantation.

III. Pain relief effect of laser irradiation: direct neurone effects, neurotransmitter effects, indirect effects. Prostaglandin synthesis related chemical effects. Oedema reduction and vascular effects. Perfusion and endothel reactions.


V. Side effects of laser irradiation: Carcinogenesis, co-carcinogenesis, de novo tumour provocation. Effects on growth of already existing tumours.


VII. Role of laser and other photostimulative therapies in the complex wound management. Acknowledgement: The Central Research Institute of the Hungarian Academy of Sciences and LASOTRONIC AG (Switzerland) was helping the research.


Augustation of wound healing using monochromatic infrared energy. Exploration of a new technology for wound management.

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The results presented in this paper document healing of different types of extremity wounds with 890 nanometer (nm) monochromatic infrared energy. Recalcitrant dermal lesions, including venous ulcers, diabetic ulcers, and a wound related to scleroderma, were treated
with a Food and Drug Administration-cleared infrared device. The infrared protocol was instituted after conventional management protocols were shown to be ineffective. The rate and quality of healing of these previously refractory wounds, following use of monochromatic infrared energy, may be related to local increases in nitric oxide concentration. Increases in nitric oxide previously have been demonstrated to correlate with vasodilatory and anabolic responses. Further research is needed to confirm the results found in these patients.


**Effects of photostimulation on wound healing in diabetic mice.**

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**BACKGROUND AND OBJECTIVE:** Low-level laser irradiation at certain fluences and wavelengths can enhance the release of growth factors from fibroblasts and stimulate cell proliferation in vitro. We evaluated whether low-level laser irradiation can improve wound healing in diabetes mellitus.

**STUDY DESIGN/MATERIALS AND METHODS:** Genetically diabetic mice (C57BL/Ksj/db/db) were used as the animal model for this wound healing study. The experimental animals were divided among four groups: negative control, positive control (topical basic fibroblast growth factor [bFGF] on wound), laser therapy group; and a combination group of laser therapy and topical bFGF. An argon dye laser (Lexel Aurora Model 600) at a wavelength of 630 nm and an output of 20 mW/cm² was used as the light source. The speed of wound closure and histological evaluation were used to analyze the experimental results.

**RESULTS:** Laser irradiation enhanced the percentage of wound closure over time as compared to the negative control group (58.4 +/- 2.6 vs. 40.8 +/- 3.4 at day 10 and 95.7 +/- 2 vs. 82.3 +/- 3.6 at day 20, P < .01). Histological evaluation showed that laser irradiation improved wound epithelialization, cellular content, granulation tissue formation, and collagen deposition in laser-treated wounds as compared to the negative control group (6.4 +/- 0.16 vs. 3.8 +/- 0.13 at day 10 and 12 +/- 0.21 vs. 8.2 +/- 0.31, P < .01).

**CONCLUSION:** This study of laser biostimulation on wound healing in diabetic mice suggests that such therapy may be of great benefit in the treatment of chronic wounds that occur as a complication of diabetes mellitus.

**NO-SURGICAL LASER TREATMENT IN PHLEBOLOGY**

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Many Lasers have been used in the treatment of phlebologic diseases, with wavelengths of 488- 511- 532- 577 – 585 – 595 – 600 – 632 – 810 – 950 – 1064 – 1320 nm. To summarize, Laser therapy could be the elective treatment for the wound healing, while edema, haematoma, ulcers are treatable with lasers only after an accurate diagnosis. The purpose of our study is to review the different types of laser beams used in these pathologies, underlining their respective advantages and drawbacks. We can offer some options on the choice of no-
surgical lasers in phlebology, based our 25 years of personal experience and the data reported in the literature. The treatment procedure is always important, and we must remember that laser beams can be used also synergistically in association with other treatments. In conclusion, laser therapy has a positive and specific role in the treatment of various phlebologic diseases, but it must be used after an exact diagnosis and according to an appropriate procedure.

WOUND HEALING PROCESS: INFLUENCE OF LLLT ON THE PROLIFERATION OF FIBROBLASTS AND ON THE LYMPHATIC REGENERATION

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In order to fully understand the positive influence of LLLT on wound healing, we investigated the influence that laser has on proliferation of fibroblasts, one of the basic elements in the wound healing process, and on the regeneration of the lymphatic system, which is important for the evacuation of fluids and waste products out of the wound area.

Material and Method: 1) To do so we cultivated cells coming from 2 different mice (type NMRI) and divided 4 groups per mouse. Two were irradiated, two not using a IR (904nm, 3,7mW) laser. Then we did a BrdU labeling with 4 flasks (2 were irradiated, 2 control) 2) To investigate the regeneration of the lymphatic system, we made a standardized incision on the ventrolateral side of 600 mice. In the control group (n=500) as well as the experimental group the evolution of 4 parameters was studied (adhesion, local oedema, regeneration of the vein and regeneration of the lymph vessel) by means of transillumination microscopy. The wounds in the test group were irradiated twice a day with a combined HeNe (632nm, 5mW)-IR (904nm 68,8mW) laser.

Results: 1) The results show a significant increase (p<0.05) of fibroblast proliferation. The BrdU labeling showed an increased DNA activity. There is also a perfect match between number of fibroblasts and DNA activity. 2) The adhesion of the scar with the underlaying tissues disappeared after 10 days in the control group and after 4 days in the experimental group. The local oedema dissapeared in the test group after 8 days, while in the control group it lasted untill 10 days. A considerable acceleration of the regeneration of both vein and lymph vessel was seen in the test group.


Effect of helium-neon laser on wound healing.

Bisht D, Mehrotra R, Singh P A et al.

Two linear skin wounds were produced on either side of dorsal midline in rats and immediately sutured. Wounds on the left side were irradiated daily with helium neon laser at 4 J/cm2 for 5 min., while those on right side were not exposed and served as controls. The mean time required for complete closure in control group was 7 days while irradiated test wounds took only 5 days to heal. The mean breaking strength, as measured by the ability of the wound to resist rupture against force, was found to be significantly increased in the test group. Early epithelization, increased fibroblastic reaction, leucocytic infiltration and neovascularization were seen in the laser irradiated wounds.
Wound healing on animal and human body with use of low level laser therapy – treatment of operated sport and traffic accident injuries: a randomized clinical study on 74 patients with control group.

Simunovic Z, Ivankovich A D, Depolo A.

A wound healing study on rabbits suggested that 4 J/cm² was the optimal dose. A clinical study was performed on 74 patients suffering from injuries of soft tissue upon traffic accidents and sport activities. Two types of lasers were used: 830 nm for Trigger point treatment and a combined 633/904 for scanning, both applied in monotherapy. Clinical parameters studied were redness, heat, pain, swelling, itching and loss of function. Wound healing was accelerated 25-35% in the laser group compared to the control group. Pain relief and functional recovery was significantly improved in the laser group as well.

Notes from a presentation at The 2nd Congress of The world Assoc. for Laser Therapy, Kansas, MO, USA, Sept. 2.5 1998

Wound healing: US Food & Drug Administration: results from a preliminary wound healing trial.

Waynant R.,

A pilot study used six Sprague-Dawley rats – three controls with no treatment and three that were irradiated for 250 seconds with 630 nm. All rats were wounded on both hips – an 8 mm circular full thickness hole. The irradiated rats received the 630nm 5 J/cm² dose on only the left hip. The animals were irradiated one hour after the wounds were given and then one dose per day for four days. The results are: ten days after wounding the closure on the control rats averaged 26%, but irradiated rats averaged a closure of 65% on both left (irradiated) and right hips – a systemic effect on the right, as it received no irradiation.

Schindl treated a chronic radiation ulcer with HeNe laser, 30 J/cm².

A video measuring system was used to determine the number of dermal vessels in the ulcer before and after the laser treatment. After 7 irradiations the ulcer had healed completely. Light microscopy in combination with the video measuring system showed a significant increase in the number of capillaries after laser treatment. Schindl A et al. Increased dermal neovascularization after low dose laser therapy of chronic radiation ulcer determined by a video measuring system. Proc. 2nd

Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 34


Laser therapy in ambulatory patients with venous stasis ulcers
55 patients with long lasting chronic venous ulcers, suffering for more than 6 months without improvement, were treated with LLLT by Lichtenstein. 42 patients were treated with HeNe, 13 with 780 nm GaAlAs. The follow-up ranged from 6 months to 6 years. Wound closure was achieved after 7 to 40 treatments in most of the patients. Complete healing was achieved in 47 patients and moderate improvement in 4 patients. LLLT was used in parallel Lichtenstein therapy.

In a study extended over 6 years Soriano treated 231 patients with venous leg ulcers.

The exclusion criteria were diabetes, arterial disease, vasculitis, congestive heart failure and loss of follow up at 6 months. 122 of 154 patients in the laser group fulfilled the study. In the control group (traditional treatment only) 46 of 77 patients fulfilled. Wounds were all of Size Rate 4 or larger (diameter major + diameter minor). A 40 mW GaAs laser at 10.000 Hz was used. The laser was applied in the point technique with a dose of 3 J/cm² per point around the border and onto the bed of the ulcer in non contact. Three sessions a week were performed for 4 months, or until the ulcer was completely healed. The results were evaluated as complete healing, partial healing (more than 50%) or non healing (less than 50%). In the laser group there was a 70% healing rate and a 14% rate of partial healing. In the control group 26% of the patients had a complete healing and 22% a partial healing. In the laser group, only 19% of the ulcers of great size (>16) healed completely and if the wound was more than one year old, the percentage of complete healing was 40%. Wounds with an oedema failed to heal with the parameters used. Soriano F. GaAs laser treatment of venous ulcers. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 128-130.

Physical and Occupational Therapy in Geriatrics.


The effect of low intensity laser therapy (LILT) biostimulation on wound healing in a largely psychogeriatric population was assessed over a period of 6 years (1991-1996). In total, 84 psychiatric patients were referred for the treatment of open wounds of varying severity and etiology. The wound status, nutritional status, walking status, and psychiatric condition of each patient were assessed prior to the administration of laser therapy treatment. Traditional wound care management was also used in addition to laser therapy. According to laser therapy treatment protocol for open wounds, a single diode laser probe was used for biostimulation of the wound bed and the wound periphery. Pre- and post-treatment measurements of wound size were obtained periodically for a total of 188 open wounds. 84% of these wounds completely healed, 11.2% partially healed, 2.1% did not change, and 2.7% got worse. The number of treatments for the 158 completely healed wounds ranged from 3 to 133 (mean 18.5) and the treatment period ranged from 5 to 383 days (mean 47.7). Wound healing was found to be related to nutritional status but neither walking status nor wound size. Results indicate that LILT is effective in the treatment of open wounds when it is used as a component of a total wound management program. Implications and directions for future research are discussed.

Effect of NASA light-emitting diode irradiation on molecular changes for wound healing in diabetic mice.


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OBJECTIVE: The purpose of this study was to assess the changes in gene expression of near-infrared light therapy in a model of impaired wound healing. Background Data: Light-Emitting Diodes (LED), originally developed for NASA plant growth experiments in space, show promise for delivering light deep into tissues of the body to promote wound healing and human tissue growth. In this paper we present the effects of LED treatment on wounds in a genetically diabetic mouse model.

MATERIALS AND METHODS: Polyvinyl acetal (PVA) sponges were subcutaneously implanted in the dorsum of BKS.Cg-m +/+ Lepr(db) mice. LED treatments were given once daily, and at the sacrifice day, the sponges, incision line and skin over the sponges were harvested and used for RNA extraction. The RNA was subsequently analyzed by cDNA array.

RESULTS: Our studies have revealed certain tissue regenerating genes that were significantly upregulated upon LED treatment when compared to the untreated sample. Integrins, laminin, gap junction proteins, and kinesin superfamily motor proteins are some of the genes involved during regeneration process. These are some of the genes that were identified upon gene array experiments with RNA isolated from sponges from the wound site in mouse with LED treatment.

CONCLUSION: We believe that the use of NASA light-emitting diodes (LED) for light therapy will greatly enhance the natural wound healing process, and more quickly return the patient to a preinjury/illness level of activity. This work is supported and managed through the Defense Advanced Research Projects Agency (DARPA) and NASA Marshall Space Flight Center-SBIR Program.


Effects of 630-, 660-, 810-, and 905-nm laser irradiation delivering radiant exposure of 1-50 J/cm2 on three species of bacteria in vitro.

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OBJECTIVE: To examine the effects of low-intensity laser therapy (LILT) on bacterial growth in vitro.
BACKGROUND DATA: LILT is undergoing investigation as a treatment for accelerating healing of open wounds. The potential of coincident effects on wound bacteria has received little attention. Increased bacterial proliferation could further delay recovery; conversely inhibition could be beneficial. MATERIALS AND METHODS: Pseudomonas aeruginosa, Escherichia coli, and Staphylococcus aureus were plated on agar and then irradiated with wavelengths of 630, 660, 810, and 905 nm (0.015 W/cm(2)) and radiant exposures of 1-50 J/cm(2). In addition, E. coli was irradiated with 810 nm at an irradiance of 0.03 W/cm(2) (1-50 J/cm(2)). Cells were counted after 20 h of incubation post LILT. Repeated measures ANOVA and Tukey adjusted post hoc tests were used for analysis.

RESULTS: There were interactions between wavelength and species (p = 0.0001) and between wavelength and radiant exposure (p = 0.007) in the overall effects on bacterial growth; therefore, individual wavelengths were analyzed. Over all types of bacteria, there were overall growth effects using 810- and 630-nm lasers, with species differences at 630 nm. Effects occurred at low radiant exposures (1-20 J/cm(2)). Overall effects were marginal using 660 nm and negative at 905 nm. Inhibition of P. aeruginosa followed irradiation using 810 nm at 5 J/cm(2) (-23%; p = 0.02). Irradiation using 630 nm at 1 J/cm(2) inhibited P. aeruginosa and E. coli (-27%). Irradiation using 810 nm (0.015 W/cm(2)) increased E. coli growth, but with increased irradiance (0.03 W/cm(2)) the growth was significant (p = 0.04), reaching 30% at 20 J/cm(2) (p = 0.01). S. aureus growth increased 27% following 905-nm irradiation at 50 J/cm(2).

CONCLUSION: LILT applied to wounds, delivering commonly used wavelengths and radiant exposures in the range of 1-20 J/cm(2), could produce changes in bacterial growth of considerable importance for wound healing. A wavelength of 630 nm appeared to be most commonly associated with bacterial inhibition. The findings of this study might be useful as a basis for selecting LILT for infected wounds.


Low-level laser therapy for wound healing: feasibility of wound dressing transillumination.

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OBJECTIVE: The purpose of this study was to assess the feasibility of exposing wounds during low-level laser therapy (LLLT) by transillumination of the wound dressings.

BACKGROUND DATA: LLLT has been associated with accelerated wound healing in chronic ulcers. The usual approach is to remove wound dressings prior to exposure and to treat three to five times weekly. Frequent change of wound dressings is time consuming and costly; it disrupts the healing process, increases the risk of wound infection, and may be traumatic for the patient.

METHODS: A double integrating sphere setup was employed to quantify the diffuse transmittance and reflectance of various wound dressings. Differences in transmittance for large area sources and point sources were demonstrated through the use of a diode laser and an incoherent light source.
RESULTS: There were a number of gels and membrane style wound dressings with diffuse transmittance of more than 50%. Hence, for these dressings the prescribed radiant exposure to the wound surface could be achieved by increasing the exposure duration, while maintaining reasonable overall treatment times.

CONCLUSIONS: Although LLLT by transillumination of wound dressings is feasible for a variety of wound dressings without significant commitments in additional treatment time, the specific transmission of products not included in this study needs to be determined at the intended treatment wavelength. A transillumination approach may facilitate a faster rate of wound healing than LLLT applied to exposed wounds by reducing trauma and the risk of infection.


Prevention of inflammatory complications of mandibular osteosynthesis by a combination of low-frequency ultrasound and laser exposure.

[Article in Russian]

Tarasenko SV, Agapov VS, Trukhina GM, Techiev SK, Artsibushev VI.

Clinical and laboratory study of the efficiency of separate and combined use of low-frequency ultrasound and laser exposure of the operative wound for prevention of pyoinflammatory complications during mandibular osteosynthesis was carried out. Clinical parameters of wound reparation in the course of healing and microbiological and cytological findings in various methods of treatment are presented. The results evidence a high efficiency of these physical methods, particularly of their combination.


Induction of complete wound healing in recalcitrant ulcers by low-intensity laser irradiation depends on ulcer cause and size.

Schindl M, Kerschan K, Schindl A, Schön H, Heinzl H, Schindl L.

Institute for Laser Medicine, Vienna, Austria.

Chronic skin ulcers still represent a therapeutic challenge in dermatology. Among the various non-invasive treatment modalities used for the improvement of impaired wound healing, low-intensity laser irradiations are gaining an increasing body of interest. We used low-intensity laser irradiations delivered by a 30 mW helium-neon laser at an energy density of 30 J/cm² three times weekly for the induction of wound healing in ulcers of diverse causes. Twenty patients with the same number of ulcers, which had previously been treated by conventional wound care for a median period of 34 weeks (range: 3-120 weeks) without any significant evidence of healing, were included in the study. Concerning the underlying disorders, patients were divided into four groups: diabetes, arterial insufficiency, radio damage and autoimmune vasculitis. In all ulcers, complete epithelization could be induced by laser therapy. No amputation or any other surgical intervention was necessary and no adverse effects of any
kind were noted during low-intensity laser treatment. Regarding the different diagnoses, a statistically significant difference was noted (P = 0.008): ulcers due to radio damage healed significantly faster than those caused by diabetes (6 weeks [range: 3-10 weeks] vs. 16 weeks [range: 9-45 weeks], P = 0.005). Wound healing in autoimmune vasculitis (24 weeks [range: 20-35 weeks]) required longer than in radiodermitis, although the difference was not significant. In addition to the diagnosis, wound size was found to be an important factor influencing the duration of wound closure (P = 0.028), whereas duration of previous conventional treatment (P = 0.24) and depth (P = 0.14) showed no effect. Our results indicate that low-intensity laser irradiation could be a valuable non-invasive tool for the induction of wound healing in recalcitrant ulcers, and that healing time is correlated with the ulcer cause and size.


Evaluation of low level laser therapy on primary healing of experimentally induced full thickness teat wounds in dairy cattle.

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OBJECTIVE: The purpose of this study was to evaluate the effect of low-level laser therapy (LLLT) on sutured wounds of the teat in dairy cattle.

STUDY DESIGN: By using the Latin square design, the effect of LLLT was evaluated by radiography, measurement of microcirculation flow, histopathology, tensiometry, and hydroxyproline analysis.

ANIMALS OR SAMPLE POPULATION: Sixteen teats of four dairy cattle.

METHODS: Full thickness wounds were made on the cranial surface of the teats. Teats were distributed into four groups; group A and B wounds were closed with a Gambee pattern, group C and D wounds were closed with three-layers of continuous suture pattern. Group B and D wounds were treated with 3.64 J/cm² of LLLT using a helium-neon system continuous wave (632.8 nm) output of 8.5 nW.

RESULTS: The teat wall in non-LLLT groups was significantly thicker than in LLLT groups on day 7, 14 and 21. The mean blood flow differences between control and sutured sites in LLLT groups were significantly lower than those in non-LLLT groups. The morphology of the epidermis in LLLT groups more closely resembled the normal epidermis than that of non-LLLT groups. Collagen fibers in LLLT groups were denser, thicker, better arranged and more continuous with existing collagen fibers than those in non-LLLT groups. The mean tensile strength was significantly greater in LLLT groups than in non-LLLT groups.

CONCLUSION: The LLLT affects various aspects of the healing process, including minimizing inflammation, formation of edema, improvement of skin regeneration and enhancement of collagen synthesis. CLINICAL RELEVANCE: The LLLT could accelerate healing of sutured wounds of the teat in dairy cattle.
Evaluation of wound healing of the teat with and without low level laser therapy in dairy cattle by laser Doppler flowmetry in comparison with histopathology, tensiometry and hydroxyproline analysis.

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Perforated teat wounds in eight lactating Holstein-Friesian cows were closed by four suture patterns with or without low level laser therapy (LLLT). Wound healing was evaluated by laser Doppler flowmetry (LDF), tensiometry and hydroxyproline analysis, and compared with histopathological examination. The three-layer pattern provided the best healing of the entire teat. Mucosal hyperplasia was observed in Gambee and continuous two-layer pattern while eversion of the skin, presence of suture tracts and a greater amount of granulation tissue were observed with the continuous and interrupted two-layer patterns. The epidermis in LLLT groups more closely resembled the normal epidermis, and collagen fibres were denser, thicker and better arranged in LLLT than in non-LLLT groups. LDF, tensiometry and hydroxyproline analysis correlated well with histopathological examination. The results suggest that LDF, a more rapid, less invasive and painless procedure, can replace tensile strength measurement or hydroxyproline analysis to assess the progress of teat wound healing.

Histopathological effect of low-level laser therapy on sutured wounds of the teat in dairy cattle.

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Perforating wounds were made on the cranial surface of 32 teats in eight dairy cattle. The teats were distributed into eight groups with four kinds of suture patterns. The used suture patterns were Gambee in Groups A and E, continuous 2-layer (Cushing for submucosal layer, continuous horizontal mattress for intermediate layer and skin) in Groups B and F, separated 2-layer (simple continuous for mucosal layer, vertical mattress for intermediate layer and skin) in Groups C and G, and 3-layer (simple continuous for mucosal and intermediate layers, simple interrupted for skin) in Groups D and H. The wounds of Groups E, F, G and H were subjected to 3.64 J/cm² dose of low-level laser, using a helium-neon system with an output of 8.5 mW, continuous wave at 632.8 nm. Histopathologically, healing was different between various suture patterns and between low level laser therapy (LLLT) and non-LLLT-groups. The results suggest that the 3-layer pattern was the best and LLLT could accelerate healing of perforating wounds of the teat in dairy cattle.
Effect of laser pulse repetition rate pulse duration on mast cell number and degranulation.

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BACKGROUND AND OBJECTIVE: Mast cell activation by low-level laser therapy (LLLT), leading to degranulation and the release of mediators, may be one of the mechanisms by which LLLT can accelerate tissue repair in mammals. The objective of this work, part of an investigation to determine the optimum parameters for increasing mast cell number and degranulation in injured skin, was to determine the effect of different pulsing frequencies of LLLT.

STUDY DESIGN/MATERIALS AND METHODS: Partial-thickness wounds in anaesthetized adult male Wistar rats were irradiated immediately after injury with monochromatic coherent light (wavelength 820 nm) pulsed at either 2.5, 20, 292, or 20,000 Hz at an average power density of 800 mW/cm² for 27 seconds; the energy density was 21.6 J/cm². The effects on mast cell number and degranulation were assessed 2 hours post-treatment by counting the numbers of intact and degranulated mast cells in Carnoy-fixed, toluidine blue-stained, sections of irradiated and sham-irradiated wounds.

RESULTS: The total number of mast cells was increased significantly (P < 0.05) by all the frequencies when compared to the sham-irradiated group, but there was no significant difference between frequencies (P > 0.05). However, although the number of degranulated mast cells was higher in all laser-treated wounds, in comparison with the sham-irradiated group, only the 20 Hz (pulse duration 45 ms) and 292 Hz (pulse duration 3 ms) frequencies were significantly effective (P < 0.05).

CONCLUSION: Increase in mast cell number is not pulsing frequency dependent, whereas degranulation is.


Low-level laser irradiation and its effect on repair processes in the skin.

[Article in Croatian]

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INTRODUCTION: Application of laser beams for therapeutic purposes is of relatively recent date, but today there is no field of medicine where lasers cannot be used.

PHYSICAL CHARACTERISTICS OF LASER RADIATION: Laser radiation is a type of electromagnetic radiation with some specific characteristics such as coherence, monochromaticity and parallelity.
TYPES OF LASER DEVICES: Nowadays, there are many laser devices on the market used in medicine and dentistry. According to the type of their active medium, lasers can be classified as solid, gas, semiconductor and liquid.

EFFECTS OF LOW LEVEL LASER THERAPY ON BIOLOGICAL SYSTEMS: The exact mechanism of action of low level laser therapy is still not completely understood. Its basic feature is to modulate cell behaviour, without causing significant temperature increase. During irradiation of a tissue with a laser beam, an interaction between cells and photons takes place—photochemical reaction. After a cell absorbs the photon, the photon stops existing, and its energy is incorporated into the molecule which has absorbed it. Once this energy is transferred to different biomolecules, it can be transferred to other molecules as well. The energy transferred to the molecule can increase its kinetic energy, and activate or deactivate enzymes or alter physical or chemical properties of main macromolecules.

EFFECTS OF LOW LEVEL LASER THERAPY ON WOUND HEALING: Effects of low level laser therapy on wound healing process is one of the most fully studied aspects of this type of therapy. It affects all phases of this very complex process. This paper offers a more detailed analysis of these aspects.


Effect of NASA light-emitting diode irradiation on wound healing.


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OBJECTIVE: The purpose of this study was to assess the effects of hyperbaric oxygen (HBO) and near-infrared light therapy on wound healing.

BACKGROUND DATA: Light-emitting diodes (LED), originally developed for NASA plant growth experiments in space show promise for delivering light deep into tissues of the body to promote wound healing and human tissue growth. In this paper, we review and present our new data of LED treatment on cells grown in culture, on ischemic and diabetic wounds in rat models, and on acute and chronic wounds in humans.

MATERIALS AND METHODS: In vitro and in vivo (animal and human) studies utilized a variety of LED wavelength, power intensity, and energy density parameters to begin to identify conditions for each biological tissue that are optimal for biostimulation.

Results: LED produced in vitro increases of cell growth of 140-200% in mouse-derived fibroblasts, rat-derived osteoblasts, and rat-derived skeletal muscle cells, and increases in growth of 155-171% of normal human epithelial cells. Wound size decreased up to 36% in conjunction with HBO in ischemic rat models. LED produced improvement of greater than 40% in musculoskeletal training injuries in Navy SEAL team members, and decreased wound healing time in crew members aboard a U.S. Naval submarine. LED produced a 47% reduction in pain of children suffering from oral mucositis.
CONCLUSION: We believe that the use of NASA LED for light therapy alone, and in conjunction with hyperbaric oxygen, will greatly enhance the natural wound healing process, and more quickly return the patient to a preinjury/illness level of activity. This work is supported and managed through the NASA Marshall Space Flight Center-SBIR Program.


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

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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.

Low-level laser irradiation attenuates production of oxygen species by human neutrophils.

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OBJECTIVE: The aim of this study was to examine the effects of low-level laser therapy (LLLT) on production of reactive oxygen (ROS) species by human neutrophils.

BACKGROUND DATA: LLLT is an effective therapeutic modality for inflammatory conditions.

MATERIALS AND METHODS: The laser device used was the infrared diode laser (GaAlAs), 830-nm continuous wave (150 mW/cm²). After irradiation, ROS production by neutrophils was measured using luminol-dependent chemiluminescence (LmCL) and expression of CD11b and CD16 on neutrophil surface was measured by flow cytometry.

RESULTS: The LmCL response of neutrophils was reduced by laser irradiation at 60 min prior to the stimulation with opsonized zymosan and calcium ionophore. The attenuating effect of LLLT was larger in neutrophils of smokers than non-smokers, while the amount of produced ROS was larger in neutrophils of smokers. Expression of CD11b and CD16 on neutrophil surface was not affected by LLLT.

CONCLUSION: Attenuation of ROS production by neutrophils may play a role in the effects of LLLT in the treatment of inflammatory tissues. There is a possible usage of LLLT to improve wound healing in smokers.