KNOWN BIOLOGICAL EFFECTS OF LASER THERAPY- (LT)

Clinical studies and trials of laser therapy technology indicate the following beneficial effects of laser light therapy on tissues and cells:

1. **Accelerated Tissue Repair And Cell Growth**. Photons of light from lasers penetrate deeply into tissue and accelerate cellular reproduction and growth. The laser light increases the energy available to the cell so that the cell can take on nutrients faster and get rid of waste products. As a result of exposure to laser light, the cells of tendons, ligaments and muscles are repaired faster.
2. **Faster Wound Healing.** Laser light stimulates fibroblast development (fibroblasts are the building blocks of collagen, which is predominant in wound healing) in damaged tissue. Collagen is the essential protein required to replace old tissue or to repair tissue injuries. As a result, LT is effective on open wounds and burns.
3. **Reduced Fibrous Tissue Formation**. LT reduces the formation of scar tissue following tissue damage from cuts, scratches, burns or surgery.
4. **Anti-Inflammation**. Laser light therapy has an anti-edemic effect as it causes vasodilation, but also because it activates the lymphatic drainage system (drains swollen areas). As a result, there is a reduction in swelling caused by bruising or inflammation.
5. **Anti-Pain (Analgesic).** Laser therapy has a high beneficial effect on nerve cells which block pain transmitted by these cells to the brain and which decreases nerve sensitivity. Also, due to less inflammation, there is less edema and less pain. Another pain blocking mechanism involves the production of high levels of pain killing chemicals such as endorphins and enkephlins from the brain and adrenal gland.
6. **Improved Vascular Activity**. Laser light will significantly increase the formation of new capillaries in damaged tissue that speeds up the healing process, closes wounds quickly and reduces scar tissue. Additional benefits include acceleration of angiogenesis, which causes temporary vasodilatation, an increase in the diameter of blood vessels.
7. **Increased Metabolic Activity**. Laser therapy creates higher outputs of specific enzymes, greater oxygen and food particle loads for blood cells.
8. **Improved Nerve Function**. Slow recovery of nerve functions in damaged tissue can result in numbness and impaired limbs. Laser light will speed up the process of nerve cell reconnection and increase the amplitude of action potentials to optimize muscle action.
9. **Immunoregulation.** Laser light has a direct effect on immunity status by stimulation of immunoglobines and lymphocytes. LT is absorbed by chromophones (molecule enzymes) that react to laser light. The enzyme flavomono-nucleotide is activated and starts the production of ATP (adenosine-tri-phosphate), which is the major carrier of cell energy and the energy source for all chemical reactions in the cells.
10. **Trigger Points and Acupuncture Points**. Laser therapy stimulates muscle trigger points and acupuncture points on a non-invasive basis providing musculoskeletal pain relief.

ARTHRITIS-OSTEOARTHRITIS

The clinical efficacy of low-power laser therapy on pain and function in cervical osteoarthritis. Clinical Rheumatology. 2001; 20(3): 181-184.
Oezdemir F, Birtane M, Kokino S

Pain is a major symptom in cervical osteoarthritis (COA). Low-powerlaser (LPL) therapy has been claimed to reduce pain inmusculoskeletal pathologies, but there have been concerns about thispoint. The aim of this study was to evaluate the analgesic efficacy of LPL therapy and related functional changes in COA. Sixty patients between 20 and 65 years of age with clinically and radiologically diagnosed COA were included in the study. They were randomised into two equal groups according to the therapies applied, either with LPL or placebo laser. Patients in each group were investigated blindly in terms of pain and pain-related physical findings, such as increased paravertebral muscle spasm, loss of lordosis and range of neck motion restrictio n before and after therapy. Functional improvements were also evaluated. Pain, paravertebral muscle spasm, lordosis angle, the range of neck motion and function were observed to improve significantly in the LPL group, but no improvement was found in the placebo group. LPL seems to be successful in relieving pain and improving function in osteoarthritic diseases.

Laser therapy is effective for degenerative osteoarthritis
Stelian J, Gil I, Habot B et al. Improvement of pain and disability in elderly patients with degenerative osteoarthritis of the knee treated with narrow-band light therapy. J Am Geriatr Soc. 1992; 40: 23-26.

In an Israeli study the effect of laser therapy in degenerative osteoarthritis (DOA) of the knee was investigated in a double blind study among 50 patients. One group received infrared (GaAlAs) and one red (HeNe) laser. Only the first group could be blinded, while the latter was open. Patients were treated twice daily, 15 minutes each time, for 10 days. The patients treated themselves after instruction. Total dose for each session was 10.3 J for red and 11.1 for infrared. Continuous mode was used for 7.5 minutes, pulsed for 7.5 minutes, rationale not stated. There was a significant pain reduction in the laser groups as compared to the placebo groups. There was no significant difference between the red and the infrared group. The Disability Index Questionnaire also revealed an improvement in the laser groups. All patients in the placebo group required analgesics within two months after laser therapy while the patients in the laser group were pain free ranging from 2 months to 1 year.

THE EFFECT OF LOW POWER LASER THERAPY ON OSTEOARTHRITIS OF THE KNEE. Basirnia A., Sadeghipoor G., Esmaeeli Djavid G. et al.
Treatment was performed on 20 patients, aging from 42 to 60 years. All patients had received conservative treatment with poor results. Laser device used for this treatment was pulsed IR diode laser; 810 nm wavelength once per day for 5 consecutive days, followed by a 2-day interval .The total number of applications was 12 sessions. Irradiation was performed on 5 periarticular tender points, each for 2 min. The treatment outcome (pain relief and functional ability) was observed and measured according to the following methods: 1) Numerical rating scales (NRS), 2) Self assessment by the patient, 3) Index of severity for osteoarthritis of the knee (ISK), 4) Analgesic requirements. We achieved significant improvement in pain relief and quality of life in 70% of patients, comparing to their previous status ($p<0.05$). There was no significant change in range of motion of the Knee.

BONE EFFECTS

Effect of Low-level Laser on Calvarial Bone Defect, **M. KHADRA**[1], N. KASEM[2], H.R. HAANÆS[1], and S.P. LYNGSTADAAS[1], [1] Oslo University, Norway, [2] Karolinska Institute, Stockholm, Sweden

Objective: The purpose of the present study was to evaluate by animal means the effect of low level laser therapy (LLLT) with GaAlAs diode laser device on bone healing and growth in rat calvarial bone defects.

Methods: The study was performed as an animal trial of 4 weeks duration with blinded, placebo-controlled design. 20 rats had a standardised round osseous defect 2,7 mm in diameter made in each parietal bone (2 defects). The animals were then randomly divided into two equal groups. A GaAlAs diode laser (wavelength 830 nm, output power 75 mw and energy density 23 J/cm2) was used immediately after surgery and carried out daily for 7 consecutive days. The rats were thereafter sacrificed at day 14 and 28 after surgery. Levels of calcium, phosphorous and protein were determined in 20 bone defects, while the histological analyses were performed in the other 20 defects. Statistical analyses between the test and control were performed using Student's t-test.

Results: The results indicate that calcium, phosphorous and protein contents were significantly higher in the laser-irradiated healing tissues than in the sham group on both time-points. The histological analyses showed that proliferation of fibroblasts, osteoid tissue and bone were more prominent in the irradiated group.

Conclusion: The findings suggest that LLLT may promote metabolism and/or mineralisation in bone forming tissues during the healing of bone defects.

Bone repair of the periapical lesions treated or not with low intensity laser (wavelenght=904 nm). Laser Surg Med. Abstract Issue 2002. abstract 303.
Sousa G R, Ribeiro M S, Groth E B.

.The effect of bone repair in periapical lesions has been studied by Sousa []. 15 patients with a total of 18 periapical lesions were divided into two groups. One group received endodontic treatment and/or periapical surgery. The patients in the other group were submitted to the same procedure and in addition the lesions were irradiated by GaAs laser, 11 mW, 9 J/cm2. This therapy was performed during 10 sessions with an interval of 72 hours. Bone regeneration was evaluated through X-ray examination. The results showed a significant difference between the laser and the control group in favour of the laser group.

CARTILAGE EFFECTS

THE INFLUENCE OF LOW LEVEL INFRA RED LASER THERAPY ON THE REGENERATION OF CARTILAGE TISSUE. P.Lievens , Ph.van der Veen
This study concerns the influence of Laser treatment on the regeneration process of cartilage tissue. There is no need saying that the regeneration of cartilage tissue is a very big problem in rheumatic diseases for example. The lack of blood supply is one of the most important factors involved. Lots of previous publications give us proof of the regeneration capacities of Laser therapy (in wound healing, bone repair etc.)
In this study we have chosen to experiment on cartilage tissue of the ear of mice. We are aware of

the fact that the elastic cartilage tissue of the ear is not totally comparable with the hyaline cartilage of articulations. For technical reasons however and because of the fact that the chondrocytes are comparable, we decided to use mice ears in our experiment. A 0,4 mm hole was drilled in both ears on 30 mice. The right ears remain untreated, while the left ears were treated daily with IR-Laser (904 nm) for 3 minutes. Macroscopical as well as histological evaluations were performed on the cartilage regeneration of both ears.
Our results show that after one day postsurgery no differences were found between the irradiated and the non-irradiated group. After the second day, only in the irradiated group there is a clear activation of the perichondrium. After four days, there is a significant ingrowth of the perichondrium into the drill hole in the experimental group and there is only an active perichondrium zone in our control group.

Low-power diode laser stimulation of surgical osteochondral defects:results after 24 weeks. Artificial cells, blood substitutes, amd immobilization biotechnology. 2001.29 (3): 235-44.
Guzzardella G A, Tigani D, Torricelli P, Fini M, Martini L, Morrone G, Giardino R.

The purpose of this study was to evaluate osteochondral lesions of the knee, treated intraoperatively with low-power laser stimulation, and assess results at 24 weeks. Surgery was performed under general anesthesia on six rabbits; a bilateral osteochondral lesion was created in the femoral medial condyles with a drill. All of the left lesions underwent immediate stimulation using the diode Ga-Al-As laser (780nm), whereas the right knees were left untreated as control group. After 24 weeks, the explants from the femoral condyles, either treated employing laser energy or left untreated, were examined histomorphometrically. Results obtained on the lased condyles showed good cell morphology and a regular aspect of the repaired osteocartilaginous tissue

Assessment of low-power laser biostimulation on chondral lesions: an "in vivo" experimental study. Artificial cells, blood substitutes, amd immobilization biotechnology. 2000;28 (5): 441-449.
Guzzardella-G-A, Morrone-G, Torricelli-P et al.

The purpose of this study was to evaluate whether intraoperative laser biostimulation can enhance healing of cartilaginous lesions of the knee. Surgery was performed on eighteen rabbits: a bilateral chondral lesion of 1.25 +/- 0.2 mm in length and 0.8 +/- 0.2 mm in width was created in the femoral medial condyle with a scalpel. The lesion in the left knee of each animal was treated intraoperatively using the diode Ga-Al-As 780nm. laser (300 Joules/cm2, 1 Watt, 300 Hertz, 10 minutes), while the right knee was left untreated, as control group. The animals were divided into three groups, A, B and C, according to the survival time after surgery, two, six and twelve weeks, respectively. The explants from the femoral condyles, both treated employing laser energy and left untreated, were examined histologically. Results showed a progressive filling with fibrous tissue of the cartilaginous lesion treated with laser irradiation, while no changes in the original lesion of the untreated group were observed at the end of the study.

COSMETIC SURGERY

The effects of adding low energy laser irradiation after skin resurfacing in lowering complication. Laser Surg Med. Abstract issue, 2002, abstract 242. Fereydson E, Samieh M.

Laser therapy is a valuable supportive therapy after skin resurfacing with CO2 laser. In a study by Fereydson. twenty patients had full face skin resurfacing with superpulse CO2 laser, 500 mJ/cm2. Ten patients had additional 780 nm laser therapy. This additional therapy lowered complications such as pain, erythema, infection rate and itching.

EPICONDYLITIS

TREATMENT OF MEDIAL AND LATERAL EPICONDYLITIS - TENNIS AND GOLFER¨S ELBOW - WITH LOW LEVEL LASER THERAPY: A MILTICENTER, DOUBLE - BLIND, PLACEBO - CONTROLLED CLINICAL STUDY ON 324 PATIENTS.

Zlatko Simunovic, M.D. F.M.H. (1), Tatjana Trobonjaca, M.D. (2), Zlatko Trobonjaca, M.D. (3).
(1) Pain Clinic, Laser Center, Locarno, Switzerland;
(2) Laser Center, Opatija, Croatia;
(3) Department of Physiology and Immunology, Faculty of Medicine, University of Rijeka, Croatia.

Among the other treatment modalities of medial and lateral epicondylitis, Low Level Laser Therapy (LLLT) has been promoted as highly successful method. The aim of this clinical study was to determine the efficacy of LLLT on medial and lateral epicondylitis using Trigger Points (TPs) and scanning application technique under placebo - controlled conditions in two independent Laser Centers located at Locarno, Switzerland and Opatija, Croatia. Unilateral cases of either type of epicondylitis (n=283) were randomly allocated to one of three treatment groups according to the LLLT technique applied: (1) TPs; (2) scanning; (3) combination of TPs and scanning. Bilateral cases of either type of epicondylitis (n=41) were subject to crossover, placebo-controlled conditions. Laser devices used in all groups of patients were infrared diode laser (GaAlAs) 830 nm continuous wave for treatment of TPs and HeNe 632,8 nm combined with infrared diode laser 904 nm. Puled wave for scanning technique. Treatment outcom was observed and measured according to the following methods: (1) short form McGill's Pain Questionnaire; (2) Visual Analogue Scales; (3) Verbal Rating Scales; (4) Patient's pain diary; and (5) hand dynamometer. The result have demonstrated that total relief of pain with consequently improved functional ability was achieved in 82% of chronic cases all of which were treated by combination of TPs and scanning technique. The current clinical study provides further evidence of the efficacy of LLLT in the management of lateral and medial epicondylitis

HEART DISEASE

Evaluation of quantum therapy for the treatment of stable angina
[Otsinka efektyvnosti vplyvu kvantovoi terapii na perebig stabil'noi stenokardii].
Likars'ka sprava. 2001; (5-6): 111-114.

A total of 68 patients were examined. Of these, 21 had functional class (FC) I stabile angina, 23 presented with FC II angina, 24 had FC III angina. Instituted in the control group patients (n = 30) was standard antianginal therapy (SAT). Laser therapy against the background of SAT employed has been found to improve the functional state of the myocardium, enhance tolerance to physical loads, improve indices for intracardiac hemodynamics. HeNe laser irradiation has an analgecizing effect. Patients with FC I-III exertional angina can derive benefit from laser therapy due to its cardioprotective effect. Positive hemodynamic shifts were accompanied by improvement in general health of patients manifested by lower frequency of angina attacks and episodes of pain-free ischemia of the myocardium. Laser therapy had an effect on relation between painful and painless ischemia of the myocardium as evidenced by a predominant decrease in pain-free episodes of myocardial ischemia, this being regarded as a prognostically favourable fact.

LIGAMENTS

Therapeutic low energy laser improves the mechanical strength of repairing medial collateral ligament.
Fung DT, Ng GY, Leung MC, Tay DK. Lasers Surg Med. 2002; 31:91-96. Twenty-four rats received surgical transection to their right MCL and eight received sham operation. After surgery, 16 received a single dose of gallium aluminum arsenide laser to their transected MCL for 7.5 minutes (n = 8) or 15 minutes (n = 8) and eight served as control with placebo laser, while the sham group didn't receive any treatment. The MCLs were biomechanically tested at either 3 or 6 weeks post-operation. The normalized ultimate tensile strength (UTS) and stiffness of laser and sham groups were larger than control ($P < 0.001$). The UTS of laser and sham groups were comparable. Laser and sham groups had improved in stiffness from 3 to 6 weeks ($P < 0.001$). A single dose of low energy laser therapy improves the UTS and stiffness of repairing MCL at 3 and 6 weeks after injury.

LIPOSUCTION

Fat liquefaction: effect of low-level laser energy on adipose tissue.
Neira R, Arroyave J, Ramirez H, Ortiz et al. Plast Reconstr Surg 2002 Sep 110:912-922.
Low-level laser energy has been increasingly used in the treatment of a broad range of conditions and has improved wound healing, reduced edema, and relieved pain of various etiologies. This study examined whether 635-nm low-level lasers had an effect on adipose tissue in vivo and the procedural implementation of lipoplasty/liposuction techniques. The experiment investigated the effect of 635-nm, 10-mW diode laser radiation with exclusive energy dispersing optics. Total energy values of 1.2 J/cm(2), 2.4 J/cm(2), and 3.6 J/cm(2) were applied on human adipose tissue taken from lipectomy samples of 12 healthy women. The tissue samples were irradiated for 0, 2, 4, and 6 minutes with and without tumescent solution and were studied using the protocols of transmission electron microscopy and scanning electron microscopy. Nonirradiated tissue samples were taken for reference. More than 180 images were recorded and professionally

evaluated. All microscopic results showed that without laser exposure the normal adipose tissue appeared as a grape-shaped node. After 4 minutes of laser exposure, 80 percent of the fat was released from the adipose cells; at 6 minutes of laser exposure, 99 percent of the fat was released from the adipocyte. The released fat was collected in the interstitial space. Transmission electron microscopic images of the adipose tissue taken at x60,000 showed a transitory pore and complete deflation of the adipocytes. The low-level laser energy affected the adipose cell by causing a transitory pore in the cell membrane to open, which permitted the fat content to go from inside to outside the cell. The cells in the interstitial space and the capillaries remained intact. Low-level laser-assisted lipoplasty has a significant impact on the procedural implementation of lipoplasty techniques.

LIVER

Laser enhancement in hepatic regeneration for partially hepatectomized rats.. Lasers in Surgery and Medicine. 2001; 29(1): 73-77.
De Castro e Silva O Jr, Zucoloto S, Menegazzo L A G, Granato R G et al.

The bio-stimulation effect of laser has been observed in many areas of Medicine. However, there are a few works which investigate its use for liver regeneration. Most of their results were inconclusive due to the use of high power lasers. This work was carried out to investigate the bio-stimulation effect of laser in liver regeneration using low power lasers. We used Wistar male rats, which were irradiated with laser light (wavelength 590 nm and intensity of 50 mW/cm2 for 5 minutes after 70% hepatectomy. The respiratory mitochondrial activity, the serum level of aminotransferase and the PCNA were measured. Results: Our results show a dramatic increase in the mitochondrialactivity for the laser treated group at 24 hours after the hepatectomy. Conclusion: We conclude that the laser promotes a bio-stimulation effect on the early stages of liver regeneration without any detectable damage of the cells.

PAIN MANAGEMENT AND NEURO-CONDITIONS

A systematic review of low level laser therapy with location-specific doses for pain from chronic joint disorders.
Australian J Physiother. 2003; 49: 107-116. Bjordal J M, Couppè, C, Chow R, Tunér J, Ljunggren A E.
The authors investigated if low level laser therapy of the joint capsule can reduce pain in chronic joint disorders (CJD). A literature search identified 88 randomised-controlled trials, of which 20 trials included patients with CJD. Six trials had to be excluded for not irradiating the joint capsule. Three trials used doses lower than a denominated a priori dose range for reducing inflammation in the joint capsule. These trials found no significant difference between active and placebo treatments. The remaining 11 trials, including 565 patients, were of acceptable methodological quality with an average PEDro score of 6.9 (range 5-9). In these trials, LLLT within the suggested dose-range was administered to the knee, temporomandibular and zygapophyseal joints. The results showed a mean weighted difference in change of pain on VAS by 45.6 % (95 % CI 35.0 to 56.2) in favour of LLLT. Global status was improved for 33.4 % (95% CI 20.9 to 45.9) more patients in the LLLT group. LLLT with the suggested dose range significantly reduces pain in CJD, but the heterogeneity in patient samples, treatment procedures and trial design calls for cautious interpretation of the results.

Laser irradiation abates neuronal responses to nociceptive stimulation of rat-paw skin. Brain Res Bull. 1994; 34 (4): 369-374. Tsuchiya K; Kawatani M; Takeshige C; Matsumoto I

The effects of diode laser irradiation on peripheral nerves was examined by monitoring neuronal discharges elicited by application of various stimuli to the hind-paw skin of rats. Neuronal discharges elicited by brush, pinch, cold, and/or heat stimulation, as well as chemical stimulation by injection of turpentine (0.1 ml, SC) were recorded from L5 dorsal roots in urethane-anaesthetised rats. Diode laser irradiation (830 nm, 40 mW, 3 min, continuous wave) of the saphenous nerve exposed from the muscle of the lower leg significantly inhibited neuronal discharges elicited by pinch (68.4 +/- 6.5%), cold (45.4 +/- 9.2%), and heat stimulation (49.2 +/- 11.3%). Neuronal discharges induced by brush stimulation (104.3 +/- 4.7%) were not affected by laser irradiation. Injection of turpentine, a chemical irritant, into the hind-paw skin (0.1 ml, SC) elicited neuronal discharges in the ipsilateral dorsal root, and these discharges were significantly inhibited or abolished by laser irradiation. In 6- to 7-week-old rats treated neonatally with capsaicin (10 mg/kg, SC), injection of turpentine into the hind-paw skin did not elicit neuronal discharges and laser irradiation did not affect the background discharges. These data suggest that laser irradiation may selectively inhibit nociceptive neuronal activities.

Cranial irradiation with GaAlAs laser leads to naloxone reversible analgesia in rats. Psychol Rep. 1996; 78 (3): 727-731. Wedlock P M; Shephard R A.

Laser irradiation of the rat cranium can produce analgesia. The present experiment investigated the mechanism of such action. 27 rats received all possible combinations of laser (0, 6.4, and 12J/cm2) and naloxone (0, 5, and 10 mg/kg) prior to a hot plate test. Laser (820 nm, 1000 Hz pulsing, was applied to the rats' skulls and hind paw lick latencies (in seconds) were recorded immediately, 30 min., and 24 hr. after the administration of treatment. When animals were tested immediately following laser irradiation at 12J/cm2 significant analgesia resulted. Treatment with naloxone at either dose antagonised this effect, but naloxone produced no significant hyperalgesia when given alone. This suggests that opioid peptide mechanisms mediate the analgesic action of low-intensity laser irradiation of the cranium.

SOFT TISSUE

LOW LEVEL LASER THERAPY OF SOFT TISSUE INJURIES UPON SPORT ACTIVITIES AND TRAFFIC ACCIDENTS: A MULTICENTER, DOUBLE-BLIND, PLACEBO-CONTROLLED CLINICAL STUDY ON 132 PATIENTS. Zlatko Simunovic, M.D., F.M.H. (1), Tatjana Trobonjaca, M.D. (2) (1) Pain Clinic-Laser Center, Locarno, Switzerland; (2) 2 Laser Center, Opatija, Croatia. (3)

The aim of current multicenter clinical study was to assess to efficacy of Low Level Laser Therapy (LLLT) in the treatment of sport- and traffic-related soft tissue injuries compared to the placebo and classical physiotherapeutic procedures. This study was conduct in two centers located in Locarno, Switzerland (n=94) and Opatija, Croatia (n=38). Two types of irradiation techniques were used: (1) direct, skin contact technique for treatment of Trigger Points (TPs)

where infrared diode laser (GaAIAs) 830 nm continuous wave was applied; and (2) scanning technique for irradiation of larger surface area with use of Helium Neon (HeNe) laser 632.8 nm combined with infrared diode laser 904 nm pulsed wave. Control group of patients was treated with classical physiotherapeutic procedures. Results were evaluated according to the clinical parameters like: hematoma, edema, heat, pain and loss of function. All findings were scored and statistically analyzed according to the chi-square test. The results have demonstrated that the recovery process was accelerated (35-50%) in 85% of patients treated with LLLT compared to the control group of patients, what is specially important by professional athletes. The advantages of LLLT observed in this study appear to be efficient withdrawal of all clinical symptoms, functional recovery, no risks or side effects, painlessness, good toleration by any age and sex, cost benefit, etc. The results and advantages obtained proved once again the efficacy of LLLT as new as successful way in the treatment of soft tissue injuries.

SPINAL CORD

Cellular invasion following spinal cord lesion and low power laser irradiation. Laser Med Surg Abstract issue, 2002: 11.
Byrnes K R, Waynant R W, Ilev I K et al.
In a rat experiment by Byrnes the spinal cord was hemisected at vertebral level T9. 810 nm laser was applied immediately after hemisection and daily for 14 days, 1589 J/cm2. Control rats received identical treatment, but without laser. The results indicate that laser therapy initially blocks cell invasion and activation of the injured spinal cord. Once laser therapy ceases at 14 days post-injury (the time point at which lesioned axons are reported to begin to sprout) there is a rebound increase in non-inflammatory cell invasion and activation that is visible 16 days post-injury. These alterations in the spinal cord environment may contribute to the ability of lesioned axons to regenerate following injury.

Transplantation of embryonal spinal cord nerve cells cultured in biodegradable microcarriers followed by low power laser irradiation for the treatment of traumatic paraplegia in rats. Neur Res. 2002; 24.
Rochkind S, Shahar A, Alon M, Nevo Z.

In the study by Rochkind embryonal spinal cord nerve cells dissociated from rat fetuses, cultured in biodegradable microcarriers and embedded in hyaluronic acid, were implanted in the completely transsected spinal cords in 24 adult rats. 15 rats underwent 14 days of consecutive laser irradiation (780 nm, 250 mW, 30 minutes daily). 7 rats received the same treatment but without laser. Eleven of the 15 laser treated rats showed different degrees of active leg movements and gait performance compared to 4 of the 9 rats with implantation alone. In a control group of 7 rats with no therapy after the transsection of the spinal cord, six remained completely paralysed. Intensive axonal sprouting occurred in the laser group. In the control group the transsected area contained proliferating fibroblasts and blood capillaries only.

Double-blind randomized study evaluating regeneration of the rat transected sciatic nerve after suturing and postoperative low-power laser treatment. Journal of reconstructive microsurgery. 2001; 17 (2): 133-137.
Shamir M H, Rochkind S, Sandbank J, Alon M.

This double-blind randomized study evaluated the therapeutic effect of low-power laser irradiation (LPLI) on peripheral nerve regeneration, after complete transection and direct anastomosis of the rat sciatic nerve. After this procedure, 13 of 24 rats received postoperative LPLI, with a wavelength of 780 nm laser, applied transcutaneously, 30 min daily for 21

consecutive days, to corresponding segments of the spinal cord and to the injured sciatic nerve. Positive somatosensory evoked responses were found in 69.2 percent of the irradiated rats compared to 18.2 percent of the non-irradiated rats. Immunohistochemical staining in the laser-treated group showed an increased total number of axons and better quality of the regeneration process, due to an increased number of large-diameter axons compared to the non-irradiated control group. The study suggests that postoperative LPLI enhances the regenerative processes of peripheral nerves after complete transection and anastomosis.

Effects of laser irradiation on the spinal cord for the regeneration of crushed peripheral nerve in rats. Lasers in Surgery and Medicine 2001, 28 (3): 216-219
Rochkind-S, Nissan-M, Alon-M et al.
The purpose of the study was to examine the recovery of the crushed sciatic nerve of rats after low- power laser irradiation applied to the corresponding segments of the spinal cord. After a crush injury to the sciatic nerve in rats, low-power laser irradiation was applied transcutaneously to corresponding segments of the spinal cord immediately after closing the wound by using 16 mW, 632 nm He-Ne laser. The laser treatment was repeated 30 minutes daily for 21 consecutive days. The electrophysiologic activity of the injured nerves (compound muscle action potentials--CMAPs) was found to be approximately 90% of the normal precrush value and remained so for up to a long period of time. In the control nonirradiated group, electrophysiologic activity dropped to 20% of the normal precrush value at day 21 and showed the first signs of slow recovery 30 day after surgery. The two groups were found to be significantly different during follow-up period (P 0.001). This study suggests that low-power laser irradiation applied directly to the spinal cord can improve recovery of the corresponding injured peripheral nerve.

TENDONS

Gallium-Arsenide Laser Photostimulation Augments the Strength of Healing Rabbit Calcaneal Tendons. Chukuka S. Enwemeka and Ivette Rodriguez, Research Service, Veterans Affairs Medical Center & Department Of Orthopedics & Rehabilitation, Division of Physical Therapy, University of Miami School of Medicine, Miami, Florida.

Laser photostimulation has been purported to promote fibroplasia and collagen synthesis in skin wounds. To test the hypothesis that GaAs laser promotes collagen synthesis and hence augments the strength of healing tendons, the right calcaneal tendons of 2l rabbits were tenotomized, repaired and immobilized in plaster casts. Then, beginning one day after surgery, the repaired tendons of 14 rabbits were exposed to 904nm GaAs laser of 1 J cm^{-2} (N=7 tendons) or 1.5 J cm^{-2} (N=7 tendons) daily. The remaining 7 tendons served as nontreated controls. On the 14 post-operative days, the tendons were excised, and tested on an Instron device for differences in tensile strength and tensile stress. Analysis of variance showed that the mean tensile strength of photostimulated tendons, 94.7±12.25N_and 89.7±10.83n for I Jcm $^{-2}$ and *1.5* J cm^{-2} respectively, were significantly different from the control values, 56.4±4.05 N. Subsequently, Student-Neuman-Keul post-hoc test revealed that stimulation at 1 J cm^{-2} significantly increased the tensile strength of the tendons over controls. Correspondingly, the mean tensile stress of stimulated tendons, 251. 6±34.35 N cm^{-2} dose and 221.60± 30.94 N cm^{-2} for the *1.5* J cm^{-2} dose, were significantly higher than mean control value, 153.56±11.64 N cm^{-2}. No differences were found in the mean tensile strength and mean tensile stress of tendons stimulated at the two doses. These findings indicate that 1 or 1.5 J cm^{-2} Ga-As laser augments the healing strength of experimentally tenotomized rabbit calcaneal tendons and that doses greater than 1 Jcm^{-2} may not promote healing better than a dose of 1 Jcm^{-2}

Paper presented at the American Society for Laser Medicine and Surgery, April 29, 1991, San Diego, Ca. U.S.A

TMJ DISEASE

Effectiveness of low-level laser therapy in temporomandibular disorder.
Scand J Rheumatol. 2003; 32 (2):114-118. Kulekcioglu S, Sivrioglu K, Ozcan O, Parlak M.
Thirty-five patients were evaluated by magnetic resonance imaging and randomly allocated to active treatment (n=20) and placebo treatment (n= 15) groups. In addition to a daily exercise program, all patients were treated with fifteen sessions of low-level laser therapy. Pain, joint motion, number of joint sounds and tender points were assessed. Significant reduction in pain was observed in both active and placebo treatment groups. Active and passive maximum mouth opening, lateral motion, number of tender points were significantly improved only in the active treatment group. Treatment effects in myogenic and arthrogenic cases were similar.

WOUND HEALING

A histopathological study of the effects of low-power laser irradiation on wound healing of exposed dental pulp tissues in dogs, with special reference to lectins and collagens.
J Endod. 1998; (3):187-193. Utsunomiya T
This study investigated the effects of low-power laser irradiation on exposed pulp tissue in dogs. GaAlAs laser (300 mW) irradiation was applied to the exposed surface of the pulp, and histopathological changes were observed at 1, 3, and 7 wk after the operation. In addition, the lectin, binding pattern and distribution of collagens (type I, III, and V) were examined to determine the histochemical and immunohistochemical nature of wound healing. The fibrous matrix formation and the continuing changes in the dentin bridge formation of the irradiation group were observed earlier (1 wk after the operation) than in the nonirradiation control group. Lectin histochemistry and collagen immunohistochemistry showed that concanavalin A, peanut agglutinin, wheat germ agglutinin, and collagens (types I, III, and V) were distributed in the fibrous matrix and dentin bridge. The expression of these lectins and collagens occurred earlier in the laser irradiation group than in the control group. These results suggest that laser irradiation accelerates wound healing of the pulp and the expression of the lectins and collagens. Furthermore, D-glucose-, D-mannose-, N-acetyl-D-galactosamine-, and N-acetyl-neuraminic acid-binding sugars and type I, III, and V collagens play an important role in the healing of pulp wounds.

Laser photostimulation accelerates wound healing in diabetic rats. Wound Repair and Regeneration. 2001; 9 (3): 248-255. Reddy G K, Stehno-Bittel L, Enwemeka C S.

In this study the hypothesis that laser photostimulation can facilitate healing of impaired wounds in experimental diabetes using a rat model was studied. Diabetes was induced in male rats by streptozotocin injection and two 6 mm diameter circular wounds were created on either side of the spine. The left wound of each animal was treated with a 632.8 nm He:Ne laser at a dose of 1.0 J/cm2 for five days a week until the wounds closed (three weeks). Measurements of the biomechanical properties of the laser-treated wounds indicated there was a marginal increase in maximum load (16%), stress (16%), strain (27%), energy absorption (47%) and toughness (84%) compared to control wounds of diabetic rats. Biochemical assays revealed that the amount of total collagen was significantly increased in laser treated wounds (274 +/- 8.7 microg) over the control

wounds
(230 +/- 8.4 microg). Sequential extractions of collagen from healing wounds showed that laser treated wounds had significantly greater concentrations of neutral salt soluble (15%) and insoluble collagen (16%) than control wounds, suggesting accelerated collagen production in laser treated wounds. There was an appreciable decrease in pepsin soluble collagen (19%) in laser treated wounds over control wounds, indicating higher resistance to proteolytic digestion. In conclusion, the biomechanical and biochemical results collectively suggest that laser photostimulation promotes the tissue repair process by accelerating collagen production and promoting overall connective tissue stability in healing wounds of diabetic rats.