

## A SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY STUDY OF THE THERAPY OF INTRAVASCULAR LOW INTENSITY LASER IRRADIATION ON BLOOD FOR BRAIN INFARCTION

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We used single photon emission computed tomography (SPECT) in brain perfusion imaging to study the changes of regional cerebral blood flow (rCBF) and cerebral function in brain infarction patients treated with intravascular low intensity laser irradiation of blood (ILIB). Seventeen of 35 patients with brain infarction were admitted to be treated by ILIB on the base of standard drug therapy, and SPECT brain perfusion imaging was performed before and after ILIB therapy with self-comparison. The results were analyzed using the brain blood flow function change rate (BFGR%) model. The effect of ILIB during the therapy process in the other 18 patients was also observed. In the 18 patients, SPECT indicated an improvement of rCBF (both in focus and in total brain) and cerebral function after a 30 min-ILIB therapy. And the 17 patients showed an enhancement of total brain rCBF and cerebral function after ILIB therapy in comparison with that before, especially for the focus side of the brain. The enhancement for the focal area itself was extremely obvious with a higher significant difference ( $P < 0.0001$ ). The mirror regions had no significant change ( $P > 0.05$ ). BFGR% of foci was prominently higher than that of mirror regions ( $P < 0.0001$ ). In conclusion, the ILIB therapy can improve rCBF and cerebral function and activate brain cells of patients with brain infarction. The results denote new evidence of ILIB therapy for those patients with cerebral ischemia.

## ATTENUATION AND PENETRATION of VISIBLE 632.8nm and INVISIBLE INFRA-RED 904nm Light In Soft Tissues

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We studied the depth of penetration and the magnitude of attenuation of 632.8nm and 904nm light in skin, muscle, tendon, and cartilagenous tissues of live anaesthetized rabbits. Tissue specimens were dissected, prepared, and their thicknesses measured. Then, each wavelength of light was applied. Simultaneously, a power meter was used to detect and measure the amount of light transmitted through each tissue. All measurements were made in the dark to minimize interference from extraneous light sources. To determine the influence of pulse rate on beam attenuation, the 632.8nm light was used at two predetermined settings of the machine; continuous mode and 100 pulses per second (pps), at an on:off ratio of 1:1. Similarly, the 904nm infra-red light was applied using two predetermined machine settings: 292 pps and 2,336 pps. Multiple regression analysis of the data obtained showed significant positive correlations between tissue thickness and light attenuation ( $p < .001$ ). Student's t-tests revealed that beam attenuation was significantly affected by wavelength. Collectively, our findings warrant the conclusions that (1) The calf muscles of the New Zealand white rabbit attenuates light in direct proportion to its thickness. In this tissue, light attenuation is not significantly affected by the overlying skin, a finding which may be applicable to other muscles. (2) The depth of penetration of a 632.8nm and 904nm light is not related to the average power of the light source. The depth of penetration is the same notwithstanding the average power of the light source. (3) Compared to the 904nm wavelength, 632.8nm light is attenuated more by muscle tissue, suggesting that it is absorbed more readily than the 904nm wavelength or conversely that the 904nm wavelength penetrates more. Thus, wavelength plays a critical role in the depth of penetration of light.

## ADVANCES IN LASER THERAPY FOR BONE REPAIR

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During the last decade, it was discovered that low-power laser irradiation has stimulatory effects on bone cell proliferation and gene expression. The purposes of this review are to analyze the effects of low- power laser irradiation on bone cells and bone fracture repair, to examine what has been done so far, and to explore the additional works needed in this area. The studies reviewed show how laser therapy can be used to enhance bone repair at cell and tissue levels. As noted by researchers, laser properties, the combinations of wavelength and energy dose need to be carefully chosen so as to yield bone stimulation. With better study designs, the results will be more credible, allowing for greater recognition of advances in bone repair using laser therapy. Many studies on the effects of laser therapy on bone healing and fracture repair have used biochemical and histological methods. However, in order to establish the effects

of laser treatment on bone, additional studies need to be performed using biomechanical tests, the ultimate evidence of bone repair. Finally, future studies are needed to demonstrate that the same bone stimulation effects occurring in animals may also be seen in humans.

### **BIOMODULATORY EFFECTS OF LLLT ON BONE REGENERATION**

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Tissue healing is a complex process that involves local and systemic responses. The use of Low Level Laser Therapy (LLL) for wound healing has been shown to be effective in modulating both local and systemic response. Usually the healing process of bone is slower than that of soft tissues. The effects of LLLT on bone are still controversial as previous reports show different results. This paper reports recent observations on the effect of LLLT on bone healing. The amount of newly formed bone after 830nm laser irradiation of surgical wounds created in the femur of rats was evaluated morphometrically. Forty Wistar rats were divided into four groups: group A (12 sessions, 4.8J/cm<sup>2</sup> per session, 28 days); group C (three sessions, 4.8J/cm<sup>2</sup> per session, seven days). Groups B and D acted as non-irradiated controls. Forty eight hours after the surgery, the defects of the laser groups were irradiated transcutaneously with a CW 40mW 830nm diode laser, (f~1mm) with a total dose of 4.8J/cm<sup>2</sup>. Irradiation was performed three times a week. Computerized morphometry showed a statistically significant difference between the areas of mineralized bone in groups C and D (p=0.017). There was no significant difference between groups A and B (28 days) (p=0.383). In a second investigation, we determined the effects of LLLT on bone healing after the insertion of implants. It is known that dental implants need four and six months period for fixation on the maxillae and on the mandible before receiving loading. Ten male and female dogs were divided into two groups of five animals that received the implant. Two animals of each group acted as controls. The animals were sacrificed 45 and 60 days after surgery. The animals were irradiated three times a week for two weeks in a contact mode with a CW 40mW 830nm diode laser, (f ~1mm) with a total dose per session of 4.8J/cm<sup>2</sup> and a dose per point of 1.2J/cm<sup>2</sup>. The results of the SEM study showed better bone healing after irradiation with the 830nm diode laser. **These findings suggest that, under the experimental conditions of the investigation, the use of LLLT at 830nm significantly improves bone healing at early stages. It is concluded that LLLT may increase bone repair at early stages of healing.**

### **SOMATOSENSORY TRIGEMINAL EVOKED POTENTIAL AMPLITUDES FOLLOWING LOW LEVEL LASER AND SHAM IRRADIATION OVER TIME**

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The effect on somatosensory trigeminal evoked potentials (STEP) and latencies by intraoral low level laser irradiation of the maxillary nerve was evaluated. After electrical input at the left infraorbital foramen on 24 experimentally blinded pain-free subjects, He-Ne laser irradiation (1.7mW, 632.5nm, 50Hz) was performed for two minutes on 12 of these subjects, and sham irradiation on the other 12, at the left maxillary third molar apical area. Far-field STEP latencies and amplitudes were recorded: at base-line, immediately after intervention, and ten and twenty minutes after intervention. In the irradiated group, an immediate (average) STEP amplitude decrease from base-line of 60 per cent occurred, with further reduction to 65 and 72 per cent, at the ten and twenty minute intervals (p > .0001). No significant change occurred in the sham irradiation group (p > .05), and no change in latencies occurred in either group (p > .997). **Low level laser treatment is commonly used in musculoskeletal and neurologic conditions, with mixed results. This experiment demonstrates that intraoral laser application to the maxillary nerve, where covered only by mucous membrane, results in significantly reduced STEP amplitudes. This finding suggests that intraoral laser therapy may be an effective pain control treatment.**

### **Photobiostimulation As a Function of Different Wavelengths**

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In the current study we compare the effect of different light sources in the visible and near infra-red (IR) range on cell stimulation. It is obvious that in order to interact with the living cell, light has to be absorbed by intracellular chromophores. In a search for chromophores responsible for photobiostimulation, endogenous porphyrins, mitochondrial and membranal cytochromes were found to be suitable candidates, as they possess absorption bands in the visible and near I.R. ranges. The above-mentioned chromophores are photosensitizers that generate reactive oxygen species (ROS) following irradiation. In our opinion the first step in photobiostimulation

might be ROS formation. To confirm ROS formation by various light sources, we used the electron paramagnetic resonance (EPR) associated with spin trapping techniques. All wavelengths used (360, 630, 660, 830nm), including a broad band in the visible range (400-800nm), stimulated hydroxyl radical formation in sperm cells. Measuring the amount of OH radicals as a function of the irradiating wavelength shows that shorter wavelengths might be more effective on the cell than longer ones.

### **Thermographic study of Low Level Laser Therapy for Acute-Phase Injury**

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Acute-phase injury is generally treated by localized cooling of the region, and rarely by the active use of low level laser therapy (LLLT) in Japan. Thermographic studies of acute-phase injury revealed that circulatory disturbances at the site of trauma occurred due to swelling and edema on the day following the injury, and that skin temperature was high at the site of the trauma and low at the periphery. Following LLLT, circulatory disturbances rapidly improved, while temperature in the high temperature zone around the site of trauma fell by 3 degrees on the average, but at the periphery the low temperature rose by 3 degrees on the average to nearly normal skin temperature. Clinically, swelling and edema improved. LLLT was also useful in treating necrosis of the skin in the wound area and in accelerating healing of surgical wounds of paralytic feet, which are prone to delayed, wound healing and also wounds due to spoke injury. **LLLT is useful in treating swelling and edema in acute-phase injury and in accelerating healing of surgical wounds.**

### **The Biological Effects of Laser Therapy and Other physical Modalities on Connective Tissue Repair Processes**

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Connective tissue injuries, such as tendon rupture and ligamentous strains, are common. Unlike most soft tissues that require 7-10 days to heal, primary healing of tendons and other dense connective tissues take as much as 6 - 8 weeks during which they are inevitably protected in immobilization casts to avoid re-injury. Such long periods of immobilization impair functional rehabilitation and predispose a multitude of complications that could be minimized if healing is quickened and the duration of cast immobilization reduced. In separate studies, we tested the hypothesis that early function, ultrasound, 632.8 nm He-Ne laser, and 904 nm Ga-As laser, when used singly or in combination, promote healing of experimentally severed and repaired rabbit Achilles tendons as evidenced by biochemical, biomechanical, and morphological indices of healing. Our results demonstrate that: (1) appropriate doses of each modality, i.e., early functional activities, ultrasound, He-Ne and Ga-As laser therapy augment collagen synthesis, modulate maturation of newly synthesized collagen, and overall, enhance the biomechanical characteristics of the repaired tendons. (2) Combinations of either of the two lasers with early function and either ultrasound or electrical stimulation further promote collagen synthesis when compared to functional activities alone. However, the biomechanical effects measured in tendons receiving the multi-therapy were similar, i.e., not better than the earlier single modality trials. Although tissue repair processes in humans may differ from that of rabbits, **these findings suggest that human cases of connective tissue injuries, e.g., Achilles tendon rupture, may benefit from appropriate doses of He-Ne laser, Ga-As laser, and other therapeutic modalities,** when used singly or in combination. Our recent meta-analysis of the laser therapy literature further corroborate these findings.

### **LASER THERAPY IN THE TREATMENT OF DENTAL HYPERSENSITIVITY**

~A Histologic Study And Clinical Application

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Dentinal hypersensitivity has been studied for several years. It is reported as a strikingly painful condition that originates from the exposure of dentinal tubuli when the thickness of the enamel or cement is significantly reduced. Usually the exposed area is subjected to several kinds of stimuli, resulting in sharp acute pain. The aim of this study was to evaluate the efficacy of low level laser therapy (LLLT) in the treatment of patients with dentinal hypersensitivity. A total of 1102 teeth of 388 patients were treated with LLLT between 1995-2000. Ninety-eight males and 290 females aged 30 to 45 years old were treated. For LLLT, a 780nm continuous wave diode laser was used at an output of 40mW, elliptical area of the beam, 2mm<sup>2</sup>, and exposure time per point of 25s. This corresponds to an equivalent dose of 50 J/cm<sup>2</sup> at each point (considering the area of the spot). If a 1 cm<sup>2</sup> area is considered, the total dose per tooth was 4J/cm<sup>2</sup>. With the 830nm CW 50mW diode laser, the elliptical area of the beam was 2mm<sup>2</sup>, and exposure time per point was 20s. This corresponds to an equivalent dose of 50J/cm<sup>2</sup> at each point (considering the area of the spot). If a 1cm<sup>2</sup> area is considered, the total dose per tooth was 4J/cm<sup>2</sup>. The results showed 403 (36.57%) out of 1102 teeth required a single session for complete remission

of the symptom, 255 (23.14%) needed two sessions; 182 (16.51 %) three sessions; 107 (9.7%) four sessions; and 59 (5.35%) five sessions. Ninety-six (8.71%) did not respond to LLLT and the patients were re-assessed and treatment changed. The more affected tooth was the lower premolar (301 - 27.4%), followed by lower molars (163 - 14.8%), upper premolar (149 - 13.5%), lower incisor (148 - 13.4%), upper canine (119 - 10.7%), upper incisor (108 - 9.9%), lower canine (62 - 5.6%), and upper molars (52 - 4.7%). The result of the present investigation demonstrates that LLLT, when used with the correct irradiation parameters, is effective in treating dentinal hypersensitivity, as it quickly reduces pain and maintains a prolonged pain-free status in 91.27% of the cases. Previous studies carried out by the authors examined the histological reaction of the dentinal pulp in rats after application of LLLT. The LLLT was shown to be effective in stimulating odontoblasts, producing repaired dentine and closing dentine tubuli.

## **THERMOGRAPHIC EFFECTS OF LASER THERAPY IN PATIENTS WITH CEREBRAL PALSY**

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We investigated the characteristics of low-reactive-level laser therapy (LLL) and analyzed the effects thermographically in patients with cerebral palsy. We determined transmissivity in exposed bone specimens and in the human body using a camera with a wavelength-specific charge-coupled device. The effects of LLL were dispersed throughout the entire body, and transmitted through bone tissue as well. At an output level of 100 mW, the laser reached a depth of about 2 cm. To study the effects on the autonomic nervous system, we treated 50 patients with cerebral palsy using the gohkoku acupuncture point (between the bases of the first and second metacarpal bones) of the left hand, and measured changes in the skin temperature of both hands. A GaAlAs-diode continuous-wave laser beam with a wavelength of 810 nm and power output of 100mW was applied for 60 seconds and the skin temperature was measured with a Thermotracer TH1106 apparatus (NEC San-ei). The results were classified into 3 categories: temperature decrease, no change, and temperature increase. For evaluation of the autonomic nervous system, the laser was applied over muscles with increased muscle tone all over the body in 12 patients with cerebral palsy. Color Doppler showed an increase in blood flow in the common carotid artery in eight of the 12 patients. High speed Fourier analysis of the R-R interval in the Holter electrocardiogram showed increases in the high-frequency components originating from the parasympathetic nerves after irradiation in the same eight patients, suggesting the involvement of the autonomic nervous system in producing this change.

## **Changes in absorbance of monolayer of living cells induced by laser radiation at 633, 670 and 820 nm. IEEE J Selected Topics in Quantum Electronics. 2001; 7 (6): 982-988.**

Karu T, Afanaseyeva N, Kolyakov S et al.

Abstract-Redox absorbance changes in living cells (monolayer of HeLa cells) under laser irradiation at 633, 670, and 820 nm have been studied by the method of multichannel recording in spectral range 530-890 nm. It has been found that the irradiation causes changes in the absorption spectrum of the cells in two regions, near 754-795 nm (maxima at 757, 775, and 795 nm) and near 812-873 nm (maxima at 819, 837, 858, and 873 nm). Changes occur in band parameters (peak positions, width, and integral intensity). Virtually no changes occur in the red spectral region and a few changes are recorded in the green region near 556-565 nm. The results obtained evidence that cytochrome c oxidase becomes more oxidized (which means that the oxidative metabolism is increased) due to irradiation at all wavelengths used. The results of present experiment support the suggestion (Karu, Lasers Life Sci., 2:53, 1988) that the mechanism of low-power laser therapy at the cellular level is based on the electronic excitation of chromophores in cytochrome c oxidase which modulates a redox status of the molecule and enhances its functional activity.

Index Terms-Cytochrome c oxidase, low power laser therapy, redox-absorbance changes in living cells.

## **Irradiation with diode at 820 nm induces changes in circular dichroism spectra (250-780 nm) of living cells. IEEE J Selected Topics in Quantum Electronics. 2001; 7 (6): 976-981.**

Karu T, Kolyakov S, Pyatibrat L et al.

Abstract-A sensitive method for measuring the circular dichroism (CD) of living HeLa cells in the visible-near infrared (IR) region is developed. The changes in CD spectra from 250 to 780 nm of HeLa cell suspension after the first and second irradiation at 820 nm in dose 9 J/cm<sup>2</sup> are investigated. The CD spectrum of the intact cells is well structured and characterized by a positive signal in the UV (250-290 nm) and visible-near IR (500-780 nm) regions as well as by a negative signal in 300-450 nm region. Distinct maxima in the visible-near IR region are recorded at 566, 634, 680, 712, and 741 nm. As a rule, the peak circular dichroism signals decrease in the irradiated cells except of the area 750-770 nm. Peak positions (except the peak at 680 nm) shift as a rule to the long-wavelength direction. The most remarkable changes in peak positions as well as in CD signals are recorded in the region 750-770 nm: an appearance of the new peak at 767 nm after the first irradiation and its shift to 752 nm after the second irradiation. The peaks at 712 and 741 nm disappear after the irradiation. A new peak appears at 601 nm. It is assumed that the changes in the degree of oxidation of the chromophores of cytochrome c oxidase caused by the irradiation are accompanied by conformational changes in their vicinity. It can be suggested that these changes are occurring in CuB environment. Index Terms-Circular dichroism of cells, cytochrome c oxidase, low power laser therapy.

**Effects of low-level laser therapy on malignant cells: In vitro study. J Clin Med Surg. 2002; 20 (1): 23-26.**

Pinheiro A L, Carneiro Nascimento S, De Barros Vieira A L et al.

The aim of a study by Pinheiro was to assess the effect of 635- and 670-nm laser irradiation on H.Ep.2 cells in vitro using MTT. It was decided to evaluate the effect of increased doses of laser light on these cells. The cells, obtained from SCC of the larynx. The cultures were kept either at 5% or 10% of FBS. Twenty-four hours after transplantation, the cells were irradiated with laser light (5 mW diode lasers; 635 and 670 nm; beam cross section 1 mm at local light doses between 0.04 and 4.8.10(4) J cm<sup>2</sup>. For 670 nm, significant differences in the proliferation were observed between the two concentrations of FBS and between irradiated cultures and controls. Although the results were not significant, 635-nm irradiated cells also proliferated more than non-irradiated ones. This occurred under both conditions of nutrition. It was concluded, that irradiation with 670 nm laser light applied at doses between 0.04 and 4.8104 J/cm<sup>2</sup> could significantly increase proliferation of laryngeal cancer cells.

**[Nizkointensivnaia lazernaia terapiia v detskoi onkologii] Voprosy onkologii. 2000; 46 (4): 459-461.**

Balakirev S A, Gusev L I, Kazanova M B et al.

The study by Balakirev suggests that the application of laser therapy makes it possible to reduce the time needed for the management of radiation injury and chemotherapy complications in pediatric patients 1.5-2-fold. It was shown that exposure to laser caused mononuclear levels of donors' blood to rise, which in turn led to release, in higher concentrations, of IL-1 and FNO cytokins, major factors of immune response development.

**[Low-intensity lasers in pediatric oncology]. Vestn Ross Akad Med Nauk. 2000; (6): 24-27.**

Durnov L A, Gusev L I, Balakirev S A et al

The study by Durnov outlines the outcomes of treatment for complications associated with chemo- and radiation therapy in children with malignant neoplasms by using low-intensity laser radiation. The use of this therapy may reduce the duration of treatment of these complications by 1.5-2 times. The use of low-intensity laser radiation in the treatment of other complications that are common in pediatric oncological care is briefly described.

**[The correction of the subcellular postradiation changes in the hypothalamus and parathyroid gland by using low-intensity laser radiation. An experimental study]. Vopr Kurortol Fizioter Lech Fiz Kult. 2000; (3): 3-4.**

Korolev Iu N, Panova L N, Geniatulina M S

The study by Korolev showed that exposure of the rat adrenals 30 days after radiation (1 Gy) to infrared laser radiation arrested the development of ultrastructural disorders in the cells of the hypothalamus and the parathyroid gland and enhanced subcellular manifestations of adaptation and rehabilitation processes.

**[Effects of low-intensity infrared laser irradiation on the eye an experimental study]. Vestn-Oftalmol. 1996; 112 (1): 31-32**

Prokofeva G L, Kravchenko E V, Mozherenkov-V P.

Prokofeva evaluated the doses of infrared laser exposure for the structures of the eye in rabbit experiments, and the potentials of such lasers in ophthalmology were assessed. Wavelength was 890 nm and doses varied from 0.0001 to 1.0 J/cm<sup>2</sup>, corresponding to exposure duration of 0.3 to 45 min. Experiments were carried out on 20 animals. The right eyes were exposed, and the left ones were control. An increase of intraocular pressure was recorded at a dose of 0.1 J/cm<sup>2</sup> (4.5 min) and higher. Morphological examination showed dilated, well filled and newly formed vessels in the ciliary body and iris, as well as oedema and destruction of the external layers of the retina. Exposure to a dose of 0.05 J/cm<sup>2</sup> and lower did not lead to destruction of any ocular structures or increase of intraocular pressure. The maximal dose causing no side effects for the organ of vision was established at 0.05 J/cm<sup>2</sup>.

**Effects of visible NIR low intensity laser on implant osseointegration in vivo. Laser Med Surg Abstract issue, 2002: 11.**

Blay A, Blay C C, Groth E B et al.

The effects of 680 and 830 nm lasers on osseointegration was studied by Blay. 30 adult rats were divided into three groups; two laser groups and one control. The rats in the two laser groups had pure titanium Frialit-2 implants implanted into each proximal metaphysis of their respective tibias, inserted with a 40 Ncm torque. The initial stability was monitored by means of a resonance frequency analyser. Ten irradiations were performed, 48 hours apart, 4 J/cm<sup>2</sup> on two points, starting immediately after surgery. Resonance frequency analysis indicated a significant difference between frequency values at 3 and 6 weeks, as compared to control. At 6 weeks the removal torque in the laser groups was much higher than in the control group.

**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/cm<sup>2</sup>. 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.**

**Clinical evaluation of the low intensity laser antialgic action of GaAlAs (wavelength=785 nm) in the treatment of the temporomandibular disorders. Laser Med Surg Abstract issue, 2002: 18.**

Sanseverino N T M, Sanseverino C A M, Ribeiro M S et al.

The improved outcome of laser therapy, if higher doses are given, is documented in the study by Sanseverino 10 patients with pain and limitation of movements of the jaw were treated by 785 nm GaAlAs laser, dose 45 J/cm<sup>2</sup>. The joint and tender points in the masticatory and otherwise involved muscles was applied three times per week during three weeks. A control group of 10 patients was given sham laser therapy. The evaluation was performed through subjective pain assessment and measurement of the movements of the jaw. **There was a significant improvement in the laser group only.**

**Gingival healing after gingivectomy procedure and low intensity laser irradiation. A clinical and biometrical study in animal. Laser Med Surg Abstract issue, 2002: 20.**

Amorim J C F, Ribeiro M S, Groth E B.

Amorim selected seven patients who were to undergo gingivectomy on both sides of the jaw. In these patients laser therapy (685 nm, 50 mW, 4 J/cm<sup>2</sup>) was applied on one side only, the other side serving as control. The healing process was monitored clinically and biometrically, using photographs for a period of 35 days. The analysis was performed by three specialists in periodontology. **Biometrical evaluation showed improvement of the healing for the period of 21 and 28 days in the laser group. Clinical evaluation showed better reparation mainly after the third day.**

**Low-energy laser irradiation promotes the survival and cell cycle entry of skeletal muscle satellite cells. J Cell Science. 2002; 115: 1461-1469.**

Shefer G, Partridge T A, Heslop L et al.

Shefer has demonstrated that **HeNe laser can stimulate cell cycle entry and the accumulation of satellite cells around isolated single fibres**, grown under serum-free conditions. It is demonstrated that **laser therapy promotes the survival of muscle fibres and their adjacent cells, as well as cultured myogenic cells**, under serum-free conditions that normally lead to apoptosis.

**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 transected 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 transection of the spinal cord, six remained completely paralysed. **Intensive axonal sprouting occurred in the laser group.** In the control group the transected area contained proliferating fibroblasts and blood capillaries only.

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

Fereydsen E, Samieh M.

**Laser therapy is a valuable supportive therapy after skin resurfacing with CO<sub>2</sub> laser.** In a study by Fereydsen, twenty patients had full face skin resurfacing with superpulse CO<sub>2</sub> laser, 500 mJ/cm<sup>2</sup>. Ten patients had additional 780 nm laser therapy. **This additional therapy lowered complications such as pain, erythema, infection rate and itching.**

**Bone repair of the periapical lesions treated or not with low intensity laser (wavelength=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/cm<sup>2</sup>. 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.**

**In vivo study on mast cells behaviour following low-intensity visible and near infrared laser radiation. Laser Surg Med. Abstract issue 2002, abstract 304.** Silveira L B, Ribeiro M S, Garrocho A A et al.

The effect of laser therapy in periodontal surgery has been reported by Silveira. 20 patients with periodontal disease were subjected to gingivectomies. Gingival biopsies were taken from a non-mineralised wall of a suprabony periodontal pocket. The first sample was taken before laser irradiation, the second after 785 nm laser irradiation and the third after 688 nm laser irradiation (50 mW, 8 J/cm<sup>2</sup>). After biopsy the samples were fixed, cut and stained. **Both laser wavelengths promoted mast cell degranulation as compared to control and there was no statistical difference between the two wavelengths.**

**A comparative study of the effects of low laser radiation on mast cells in inflammatory fibrous hyperplasia coloured or not coloured by the toluidine blue. Laser Surg Med. Abstract issue 2002, abstract 301** Sawazaki I, Ribeiro M S, Mizuno L T et al. A

The effect of toluidine blue and laser in combination has been studied by Sawazaki. Eight patients with inflammatory fibrous hyperplasias caused by ill-fitting dentures were selected for the study. Each hyperplasia was randomly divided into three areas. One was surgically removed without any treatment; one was treated by a 670 nm laser, 15 mW, 8 J/cm<sup>2</sup> and then removed. The third part was dyed with TBO, and laser treated in the same way as part two. **Mast cell degranulation in the control specimens was average 49%, in the laser specimens 87% and in the combined TBO/laser specimens 88%.** With these parameters the TBO did not have any additional effect.

**Low level laser treatment of primary and secondary Raynaud's phenomenon. Vasa - Journal of Vascular Diseases. 2001; 30 (4): 281-284.** Al Awami M, Schillinger M, Gschwandtner M E et al.

The pilot study by Al Awami was performed to evaluate the efficacy of LLLT as a new non-drug non-invasive treatment for patients with primary and secondary Raynaud's phenomenon. Forty patients ( 29 female, 11 male, mean age 51 years) with active primary (28%) and secondary (72%) Raynaud's phenomenon received 10 sessions of LLLT distant irradiation during winter months. Assessment of subjective and objective parameters was performed at baseline, one week after the last session and three months later. Variations of subjective parameters as number of daily acute episodes and severity of discomfort were assessed by a coloured visual analogue scale. A standardised cold challenge test using computed thermography of continuous temperature recordings by means of infrared telethermography was used to assess the digital blood flow. **A significant improvement was noticed clinically and thermographically after 6 weeks and 3 months, respectively**

**Low level laser therapy for tendinopathy. Evidence of a dose-response pattern. Physical Therapy Reviews. 2001; 6: 91-99.** Bjordal J M, Couppe C, Ljunggren E.

To investigate whether low-level laser therapy can reduce pain from tendinopathy, the authors performed a review of randomised placebo-controlled trials with laser therapy for tendinopathy. Validity assessment of each trial was done acc. to predefined criteria for location-specific dosage and irradiation of the skin directly overlying the affected tendon. The literature search identified 78 randomised control trials of which 20 included tendinopathy. Seven trials were excluded for not meeting the validity criteria on treatment procedure and trial design. 12 of the remaining 13 trials investigated the effect of laser therapy for patients with subacute and chronic tendinopathy and provided a pooled mean effect of 21%. If results from only the nine trials adhering to assumed optimal treatment parameters were included, the mean effect over placebo increased to 32%. **Laser therapy can reduce pain in subacute and chronic tendinopathy if a valid treatment procedure and location-specific dose is used.**

**Chemotherapy- and radiotherapy-induced mucositis in head and neck cancer patients: New trends in pathophysiology, prevention and treatment. European Archives of Oto-Rhino-Laryngology. 2001; 258 (9): 481-487**

Bensadoun R J, Magne N, Marcy P Y, Demard F

Mucositis is the intensity-limiting toxicity in the management of locally advanced non-resectable head and neck cancer with radiotherapy and chemotherapy. The addition of chemotherapy introduces systemic toxicity and can exacerbate local tissue reactions when used concurrently with radiotherapy. Mucositis is recognized as the principal limiting factor to further treatment intensification. As local regional control and overall survival are related to dose-intensity in this case, further research into the assessment, analysis, prevention and treatment of mucosal toxicity is not only crucial to improvement in quality of life, but certainly also to improved rates of disease control. Several topical and systemic treatments are directed to the decrease and the acceptance of this acute toxicity, but few have shown a significant preventive effect. The efficacy of low-level laser therapy in the management of such toxicity could hence yield important developments with this method in the field of oncology

**Amelioration of oral mucosal lesions of acute graft-versus-host disease by low-level laser therapy.** *Haematologica*; 2001 Dec;86(12):1321. Ana Chor, Alexandre Barbosa Sotero Caio, Alexandre Mello de Azevedo

A 42-year old male allogeneic bone marrow transplant recipient was diagnosed as having grade III acute graft-versus-host disease (GVHD). On day +50, he had severe oral GVHD, with xerostomia, cheilitis, and lesions on the oropharynx and tongue. Low-level laser therapy (LLLT) was applied on the palate and inferior labial mucosa. In 24 hours, xerostomia had improved, and LLLT was continued, including the tongue. Four days later, cheilitis disappeared, salivation improved, the papillae recovered and oropharyngeal lesions improved, with relief of pain. Unfortunately, systemic GVHD persisted, and the patient died of disseminated aspergillosis. **Prophylactic LLLT can reduce the severity of mucositis in autologous bone marrow transplantation. According to our observation, it may also be useful for treatment of oral lesions in GVHD.**

**Low level laser treatment of primary and secondary Raynaud's phenomenon.** *Vasa - Journal of Vascular Diseases*. 2001; 30 (4): 281-284. Al Awami M, Schillinger M, Gschwandtner M E et al.

This pilot study was performed to evaluate the efficacy of LLLT as a new non-drug non-invasive treatment for patients with primary and secondary Raynaud's phenomenon. Forty patients (29 female, 11 male, mean age 51 years) with active primary (28%) and secondary (72%) Raynaud's phenomenon received 10 sessions of LLLT distant irradiation during winter months. Assessment of subjective and objective parameters was performed at baseline, one week after the last session and three months later. Variations of subjective parameters as number of daily acute episodes and severity of discomfort were assessed by a coloured visual analogue scale. A standardised cold challenge test using computed thermography of continuous temperature recordings by means of infrared telethermography was used to assess the digital blood flow. A significant improvement was noticed clinically and thermographically after 6 weeks and 3 months, respectively.

**Low-power diode laser stimulation of surgical osteochondral defects: results after 24 weeks.** *Artificial cells, blood substitutes, and 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.**

**Optimal dosing of intravascular low-power red laser light as an adjunct to coronary stent implantation: Insights from a porcine coronary stent model.** *Journal of Clinical Laser Medicine and Surgery*. 2001; 19 (5): 261-265. De Scheerder I K, Wang K, Zhou XR et al.

It is believed that restenosis following coronary interventions is the result of endothelial denudation that leads to thrombus formation, vascular remodeling, and smooth muscle cell proliferation. **Low-power red laser light (LPRL) irradiation enhances endothelial cell growth in vitro and in vivo, and reduces restenosis in animal models.** The present study investigated the optimal dose of intravascular LPRL therapy in the prevention of in-stent stenosis in a porcine coronary stent model. Selected right coronary artery segments were pretreated with a LPRL balloon, delivering a dose of 0 mW during 1 min (group I, n = 10), 50 mW during 1 min (group II, n = 10), or 100 mW during 1 min (group III, n = 10) before stenting. Quantitative coronary analysis of the stented vessel was performed before stenting, immediately after stenting, and at 6 weeks follow-up. The pigs were sacrificed, and histologic and morphometric analyses were conducted. At 6 weeks, minimal luminal stent diameter was significantly narrower in the control group compared to the 50-mW dose group ( $p < 0.05$ ). These results were confirmed by morphometric analysis. Neointimal area was also significantly decreased in the 50-mW dose group. **Intravascular LPRL contributes to reduction of angiographic in-stent restenosis and neointimal hyperplasia in this animal model.** The optimal dose using the LPRL balloon system seems to be approximately 5 mW delivered during 1 min.

**Painful piezogenic pedal papules-successful low level laser therapy.** *Acta Dermatovenerologica Alpina, Panonica et Adriatica* Mijailovic B, Karadagic D, Mladenovic T, Popovic L et al.

Painful piezogenic pedal papules may be very difficult to treat. The authors describe **two patients with this condition successfully treated with a low-level laser.** A two-week treatment protocol induced a relatively long-lasting pain relief without any side effects.

**The use of lasers for endodontic applications in dentistry.** *Medical Laser Application*. 2001; 16 (3): 231-243. De Paula Eduardo C, Gouw Soares S

Several applications of lasers in clinical procedures for dental hard tissues are either currently in practice or being developed since newer wavelengths as well as different methods and delivery systems are being applied in the field of dentistry. In endodontic therapy

lasers have been used as treatment coadjuvant with reference to both, low intensity laser therapy (LILT) and high intensity laser treatment (HILT) to increase the success rate of the clinical procedures. The purpose of this article is to review in vitro studies and clinical procedures for the use of lasers in endodontics. Low intensity laser therapy has the ability to produce analgesic, anti-inflammatory and biomodulation effects on the irradiated soft tissue thereby improving the wound healing process and giving the patient a better condition of the postoperative experience.

**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/cm<sup>2</sup> 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.

**Comparison of the low level laser therapy effects on cultured human gingival fibroblasts proliferation using different irradiance and same fluence. Lasers in Surgery and Medicine. 2001; 29(2): 179-184.**

Almeida-Lopes L, Rigau J, Zangaro R A et al.

Low level laser therapy (LLLT) has been used in Dentistry to improve wound healing. In order to analyse the effect of LLLT on the in vitro proliferation of gingival fibroblasts we developed a primary culture of human gingival fibroblasts. The cell line named LMF was grown in Dulbecco's Modified Eagle's medium (DME) with either 5% (nutritional deficit) or 10% fetal bovine serum (fbs). Laser irradiation was carried out with diode lasers with the following wavelengths: 670 nm (L1), 780 nm (L2), 692 nm (L3), and 786 nm (L4). The fluence was fixed in 2 J/cm<sup>2</sup>. For growth analysis, control (not irradiated) and treated cultures (irradiated) were plated in 60 mm diameter culture dishes for 12 h before the irradiation. Results: We found that cells cultured in nutritional deficit condition grown in medium supplemented by only 5% fbs presented a cell proliferation rate significantly smaller than cell grown in ideal culture conditions (10% fbs). However, when irradiated, cells in nutritional deficit presented cell growth similar or higher than that of control cells grown in ideal culture conditions. Using the same fluence, the infrared laser induced a higher cell proliferation than visible laser when the power outputs were different. However, lasers of equal power output presented similar effect on cell growth independently of their wavelengths. Conclusions: The LLLT acts by improving the in vitro fibroblast proliferation and a smaller laser exposure time results in higher proliferation

**Conservative closure of antro-oral communication stimulated with laser light. Journal of Clinical Laser Medicine and Surgery. 2001; 19 (4):181-184. Grzesiak-Janias G, Janias A.**

Sixty-one patients between the ages of 14 and 58 were subjected to biostimulation with laser light. Therapy was performed with a 830 nm laser of 30 mW power. Three cycles of laser irradiation were performed in a continuous mode. During one cycle, 3.5 min of extraoral irradiation of 4J with the contact "sweeping" method or the woodpecker technique" was made through the facial skin to the suborbital region, 3.5 min of intraoral irradiation of 4J with the contact "point" method to the region of maxillary sinus floor, and 3.5 min of intraoral one of 4J with the contact "point" method to the alveolar process at the site of the antro-oral communication. The above cycle of irradiation was repeated for 4 days. After 4 days of laser therapy, a complete closure of antro-oral communication occurred.

**Pulse irradiation of low-power laser stimulates bone nodule formation. Journal of oral science:2001; 43 (1): 55-60.**

Ueda Y, Shimizu N.

Although low-power laser irradiation provides many anabolic effects such as acceleration of bone formation, the effects of different pulse frequencies used during laser irradiation on bone formation have not been elucidated. Osteoblastic cells isolated from fetal rat calvariae were irradiated once with a low-power Ga-Al-As laser (830 nm, 500 mW) in two different irradiation modes; continuous irradiation (CI), and 1 Hz pulsed irradiation (PI). We then investigated the effects on cellular proliferation, bone nodule formation, alkaline phosphatase (ALP) activity, and ALP gene expression. Laser irradiation in both groups significantly stimulated cellular

proliferation, bone nodule formation, ALP activity, and ALP gene expression, as compared with the nonirradiation group. Notably, PI markedly stimulated these factors, when compared with the CI group. Since 1 Hz pulsed laser irradiation significantly stimulates bone formation in vitro, it is most likely that pulse frequency is an important factor affecting biological responses in bone formation.

**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.

**Low intensity laser therapy in wound healing - A review with special respect to diabetic angiopathies. Acta Chirurgica Austriaca. 2001, 33(3):132-137.** Schindl A, Schindl M, Pernerstorfer-Schoen H, Schindl L.

Low intensity laser radiation is characterized by its ability to induce athermic, non-destructive photobiological processes. Albeit in use for about thirty years, this phototherapy is still not an established therapeutic modality in wound healing. We have reviewed the literature addressing both in vitro and in vivo effects of low intensity laser therapy on constituents of the wound healing process. Results: A large number of in vivo studies on the effects of low intensity laser irradiation on wound healing show a lack of accuracy on dosimetric data and appropriate controls. Despite this fact, data from appropriately designed studies seem to indicate that this type of phototherapy should be considered available (adjuvant) therapy for otherwise therapy-refractory wound-healing disorders including such in diabetic patients.

**Low intensity laser therapy (830nm) in the management of minor postsurgical wounds: a controlled clinical study. Lasers in surgery and medicine. 2001; 28 (1) : 27-32.** Lagan K M, Clements B A, McDonough S, Baxter G D.

The stimulatory effects of low intensity laser therapy (LILT) have been widely published for the treatment of chronic ulceration. In contrast to this previous work, the current study investigated its potential efficacy (by using a dosage of 9 J/cm<sup>2</sup>) in the management of acute wounds. For this purpose, uncomplicated postoperative wounds after minor podiatric surgery were examined. The study was designed as a controlled group study. Patients (n = 9) presenting with a total of 12 wounds after minor surgical procedures (partial/total nail avulsions/electrosurgery) were recruited. Patients attended the clinic once per week for assessment and treatment. Weekly irradiation was performed. The physical parameters of the output of the laser were as follows: wavelength, 830 nm; average power output, 30 mW; spot size, 0.1 cm<sup>2</sup>; irradiance, 300 mW/cm<sup>2</sup>; continuous wave output. Wound assessment and recording of pain levels were conducted weekly. Wound measurement was completed by using planimetry and digitising methods. Current findings indicated no statistically significant differences between Laser and Control groups for wound closure digitising; nor for pain levels reported. It would seem that LILT provides no advantages in the management of minor postoperative wounds over current practice.

**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/cm<sup>2</sup> 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 mitochondrial activity 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.

**Lightdosimetric quantitative analysis of the human petrous bone: experimental study for laser irradiation of the cochlea. Lasers in surgery and medicine. 2001; 28 (1) : 18-26.** Tauber S, Baumgartner R, Schorn K, Beyer W.

Application of laser irradiation targeting the inner ear has to be investigated for therapeutic effectiveness in cochlear injury and dysfunction. In vitro data demonstrate low-level laser-induced photochemical and photobiologic cell response, depending on cell type and irradiation parameters such as light dose. The aim of the presented study was to determine the light dose received by the cochlear hair cells by using different irradiation modalities for the human petrous bone. Lightdosimetric assessment was performed in human cadaver temporal bones (n = 13) after removing the cochlear membranous labyrinth. The external auditory meatus, the tympanic

membrane (quadrants), and the mastoid bone were illuminated by a helium-neon laser ( $\lambda = 593 \text{ nm}$ ) and diode lasers of different wavelengths ( $\lambda = 635, 690, 780, \text{ and } 830 \text{ nm}$ ). The spatial distribution of transmitted light in the cochlear windings was measured by means of a retrocochlearly positioned endoscopic CCD camera for image processing and was assigned to acoustic frequencies according to the tonotopic organization of the cochlea. For an estimation of the corresponding space irradiance in an intact cochlea, correction factors have been calculated by a Monte Carlo procedure on the basis of experimentally determined optical properties of skull bone. The transmission of light across the tympanic cavity and the promontory depends strongly on wave-length of the laser and the position of the radiator. Transtympanal irradiation results in spatial intensity variations of a factor 4 to 10 within the cochlear windings. The space irradiance in an intact cochlea is 10 to 20 times the measured irradiance. For an irradiation of the mastoid, the light transmission within the cochlea is 10(3) to 10(5) times smaller compared with an irradiation of the tympanic membrane and is extremely variable for different specimens. The strong dependence of the cochlear light distribution on various irradiation parameters demonstrates the impact of preclinical lightdosimetric investigations for effective individual laser irradiation of the human cochlea. Because of the observed spatial intensity variations, the optimal external light dose has to be chosen with regard to the tonotopy of the human cochlea. The obtained results are enabling us to apply defined laser light doses to different cochlear winding areas. Mastoidal irradiation leads to therapeutically insufficient light doses within reasonable treatment times, whereas transmeatal irradiation is recommendable. Further studies are mandatory for development of clinical devices for transmeatal irradiation of the cochlea.

**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-power laser (LPL) therapy has been claimed to reduce pain in musculoskeletal pathologies, but there have been concerns about this point. 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 restriction 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.

**830-nm irradiation increases the wound tensile strength in a diabetic murine model. *Lasers in Surgery and Medicine*. 2001; 28(3): 220-226.** Stadler I, Lanzafame R J, Evans R, et al.

The purpose of this study was to investigate the effects of low-power laser irradiation on wound healing in genetic diabetes. Female mice received 2 dorsal 1 cm full-thickness incisions and laser irradiation (830 nm, 79 mW/cm<sup>2</sup>, 5.0 J/cm<sup>2</sup> /wound). Daily low-level laser therapy occurred over 0-4 days, 3-7 days, or nonirradiated. On sacrifice at 11 or 23 days, wounds were excised, and tensile strengths were measured and standardized. Nontreated diabetic wound tensile strength was 0.77 +/- 0.22 g/mm<sup>2</sup> and 1.51 +/- 0.13 g/mm<sup>2</sup> at 11 and 23 days. After LLLT, over 0-4 days tensile strength was 1.15 +/- 0.14 g/mm<sup>2</sup> and 2.45 +/- 0.29 g/mm<sup>2</sup> (P = 0.0019). Higher tensile strength at 23 days occurred in the 3- to 7-day group (2.72 +/- 0.56 g/mm<sup>2</sup>) LLLT vs. 1.51 +/- 0.13 g/mm<sup>2</sup> nontreated; P or = 0.01). Low-power laser irradiation at 830 nm significantly enhances cutaneous wound tensile strength in a murine diabetic model.

**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.

**Intravascular low-power laser irradiation after coronary stenting: long-term follow-up. *Lasers in Surgery and Medicine* 2001; 28(3) 212-215.** De-Scheerder-I-K, Wang-K, Kaul-U et al.

A high restenosis rate remains a limiting factor for percutaneous transluminal coronary angioplasty and stenting. The objective of this study was to evaluate the effect of intravascular red laser therapy (IRLT) on restenosis after stenting procedures in de novo lesions. A

total of 68 consecutive patients were treated with IRLT in conjunction with coronary stenting procedures. Mean lesion length was 16.5 +/- 2.4 mm. Reference vessel diameter (RVD) and pre-minimal lumen diameter (MLD) were 2.90 +/- 0.15 mm and 1.12 +/- 0.26 mm, respectively. After treatment, MLD was 2.76 +/- 0.32 mm with no procedural complications or in-hospital adverse events. Angiographic follow-up (n = 61) revealed restenosis in nine patients (14.7%) with rate by artery size of > 3 mm (n = 21) 0%; 2.5--3.0 mm (n = 28) 14.2%; and 2.5 mm (n = 12) 41.6%.

**The use of low intensity laser therapy (LILT) for the treatment of open wounds in psychogeriatric patients: A pilot study. Physical and Occupational Therapy in Geriatrics. 2000, 18/2 (1-19) Verdote-Robertson-R, Munchua-M-M, Reddon-J-R.**

The effect of low intensity laser therapy 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.**

**Efficiency of low-intensity laser radiation in essential hypertension. Klinicheskaia meditsina(Mosk). 2001; 79 (1): 41-44. Velizhanina-I-A, Gapon-L-I, Shabalina-M-S et al.**

In a placebo-controlled study an antihypertensive activity of low- intensive laser radiation (LILR) was evaluated in 52 males with essential hypertension stage I. The placebo group consisted of 14 matched patients. LILR was used as monotherapy of 10 daily procedures. **This treatment significantly lowered systolic, diastolic and mean arterial pressure. Moreover, diastolic arterial pressure did not rise high at submaximal bicycle exercise. Total peripheral vascular resistance also decreased. A good hypotensive effect was achieved in 90.4% cases.**

**Magnetic resonance imaging (MRI) controlled outcome of side effects caused by ionizing radiation, treated with 780 nm-diode laser - Preliminary results. Journal of Photochemistry and Photobiology B: Biology. 2000; 59/1-3 (1-8) Schaffer-M, Bonel-H, Sroka-R.**

Ionizing radiation therapy by way of various beams such as electron, photon and neutron is an established method in tumor treatment. The side effects caused by this treatment such as ulcer, painful mastitis and delay of wound healing are well known, too.

**Biomodulation by low level laser therapy (LLLT) has become popular as a therapeutic modality for the acceleration of wound healing and the treatment of inflammation.** Evidence for this kind of application, however, is not fully understood yet. This study intends to demonstrate the response of biomodulative laser treatment on the side effects caused by ionizing radiation by means of magnetic resonance imaging (MRI). Study design/patients and methods: Six female patients suffering from painful mastitis after breast ionizing irradiation and one man suffering from radiogenic ulcer were treated with ( $\lambda$ )=780 nm diode laser irradiation at a fluence rate of 5 J/cm<sup>2</sup>. LLLT was performed for a period of 4-6 weeks (mean sessions:25 per patient, range 19-35). The tissue response was determined by means of MRI after laser treatment in comparison to MRI prior to the beginning of the LLLT. Results: **All patients showed complete clinical remission.** The time-dependent contrast enhancement curve obtained by the evaluation of MR images demonstrated a significant decrease of enhancement features typical for inflammation in the affected area.

**A new type of very low-power modulated laser:soft-tissue changes induced in osteoarthritic patients revealed by sonography. International Journal of Clinical Pharmacology Research. 2000; 20 (1-2): 13-6. Baratto-L, Capra-R, Farinelli-M et al.**

Patients with symptomatic osteoarthritis of the cervical spine were studied by ultrasound examination. The region of interest was the soft connective tissue layer above the right and the left superior trapezium that revealed a significant difference in thickness between the left and right side. The aching side was treated with a new type of very low-power, modulated laser for 3 min. **Immediately after application, the sonographic examination revealed a significant symmetrization of the subcutaneous tissue.**

**A case report of low intensity laser therapy (LILT) in the management of venous ulceration: potential effects of wound debridement upon efficacy. Journal of Clinical Laser Medicine & Surgery. 2000; 18 (1): 15-22 Lagan-K-M, Mc-Donough-S-M, Clements-B-A, Baxter-G-D.**

This single case report was undertaken as a preliminary investigation into the clinical effects of low intensity laser upon venous ulceration, applied to wound margins only, and the potential relevance of wound debridement and wound measurement techniques to any effects observed. The patient was required to attend 3 times per week for a total of 8 weeks. Treatments were carried out using single source irradiation (830 nm; 9 J/cm<sup>2</sup>) in conjunction with dry dressings during each visit. Assessment of wound surface area,

wound appearance, and current pain were completed by an independent investigator. Planimetry and digitizing were completed for wound tracings and for photographs to quantify surface areas. Video image analysis was also performed on photographs of wounds. The primary findings were changes in wound appearance, and a decrease in wound surface area (range 33.3-46.3%), dependent on the choice of measurement method. Wound debridement emerged as an important procedure to be carried out prior to measuring wounds. Despite fluctuating pain levels recorded throughout the duration of the study, VAS scores showed a decrease of 15% at the end of the study. This hypoalgesic effect was, however, statistically significant. **Low intensity laser therapy at this dosage, an using single source irradiation would seem to be an effective treatment for patients suffering venous ulceration.**

**Assessment of low-power laser biostimulation on chondral lesions: an "in vivo" experimental study. Artificial cells, blood substitutes, and 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/cm<sup>2</sup>, 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.**

**Low power laser protects human erythrocytes In an In vitro model of artificial heart-lung machines. Artificial Organs. 2000; 24 (11): 870-3.** Itoh-T, Murakami-H, Orihashi-K et al.

The protective effect of the low power helium-neon (He-Ne) laser against the damage of human erythrocytes in whole blood was examined in a perfusion model using an artificial heart-lung machine. Preserved human whole blood was diluted and perfused in 2 closed circuits with a double roller pump. The laser irradiated one of the circuits (laser group), and none the other (control group). **In the laser group, erythrocyte deformability and erythrocyte ATP levels were significantly higher, and freehemoglobin levels were significantly lower than those in the control group.** Subsequent morphological findings by means of scanning electron microscope were consistent with these results. **Low power He- Ne laser protected human erythrocytes in the preserved diluted whole blood from the damage caused by experimental artificial heart-lung machines.**

**The efficacy of the transcutaneous magnetic-laser irradiation of the blood in acute salpingo-oophoritis. Voprosy kurortologii, fizioterapii, i lechebnoi fizicheskoi kultury. 2000 (1): 32-35.** Manukhin-I-B, Matafonov-V-A, Mamedov-F-M.

The effect of including transcutaneous low-intensity magnetic-laser radiation of blood in combined antiinflammatory therapy of salpingo- oophoritis was studied. This physiotherapy stimulates phagocytic activity of neutrophilic leukocytes of the peripheral blood, promotes faster normalization of enzymatic and non-enzymatic systems of these cells.

**Effects of low-intensity infrared impulse laser therapy on inflammation activity markers in patients with rheumatoid arthritis. Terapevticheskii arkhiv. 2000; 72 (5): 32-4.** Ilich-Stoianovich-O, Nasonov-E-L, Balabanova-R-M.

To evaluate effects of low-intensity infrared impulse laser therapy (IRILT) on concentration of immunity activation (not readable: see text) (soluble receptors of TNF-alpha and neopterin) and indicator of the inflammation activity (concentration of C- reactive protein) in patients with rheumatoid arthritis (RA). Enzyme immunoassay, radioimmunoassay, enzyme immunoassay and radial immunodiffusion were used to measure soluble receptors of TNF-alpha, neopterin and C-reactive protein in 38 females with verified RA receiving IRILT or sham procedures. **IRILT induced lowering of neopterin, TNF-alpha soluble receptors (p 0.01) and C-reactive protein (p 0.01).** The findings give pathogenetical grounds for IRILT use in RA as this treatment suppresses functional activity of macrophages, which serve the main source of neopterin and the receptors synthesis.

**The effect of intravenous laser irradiation of the blood on the brain bioelectrical activity in patients in the postcomatose period. Vopr-Kurortol-Fizioter-Lech-Fiz-Kult; 2000; (2): 28-31.** Idrisova-L-T, Enikeev-D-A, Vasil-eva-T-V.

The article presents clinical data on therapeutic effects of intravenous laser blood irradiation (BI) in severe alcoholintoxication complicated by alcohol coma. BI effectiveness was assessed by EEG changes within 3 postcomatose days. Changes in brain biopotentials in various postcomatose periods were unidirectional. **Positive results were achieved after low-intensity laser radiation.**

**Laser therapy: a randomized, controlled trial of the effects of low intensity Nd:YAG laser irradiation on lateral epicondylitis. Archives of physical medicine and rehabilitation .2000; 81 (11): 1504-1510.** Basford-J-R, Sheffield-C-G, Cieslak-K-R.

The aim of this study was to assess the effectiveness of low intensity laser therapy in the treatment of lateral epicondylitis. A double-masked, placebo-controlled, randomized clinical trial.: A physical medicine and rehabilitation clinic. Fifty-two ambulatory men and women (age range, 18-70 yr) with symptomatic lateral epicondylitis of more than 30 days in duration and a normal neurologic examination. Subjects were bloc randomized into 2 groups with a computer-generated schedule. All underwent irradiation for 60 seconds at 7 points along the symptomatic forearm 3 times weekly for 4 weeks by a masked therapist. The sole difference between the groups was that the probe of a 1.06-microm continuous wave laser emitted 204 mW/cm<sup>2</sup> (12.24 J/cm<sup>2</sup>) for the treated subjects and was inactive for the control subjects. Subjects were assessed at the beginning, midpoint (session 6), and end (session 12) oftreatment, as well as at follow-up 28 to 35 days after their laser treatment. Pain in last 24 hours, tenderness to palpation, and patient's perception of change (benefit). The treated and untreated groups were well matched demographically. Masking was maintained for subjects and therapists; however, the groups did not vary to a statistically significant extent in terms of the main outcome measures either during treatment or at follow-up. Secondary outcome variables, such as grasp and pinch strength, medication use, and pain with grasp and pinch, also failed to statistically differ significantly between the groups. No significant treatment side effects were noted: Treatment with low intensity 1.06-microm laser irradiation within the parameters of this study was a safe but ineffective treatment of lateral epicondyliti

**Osteochondral lesion repair of the knee in the rabbit after low-power diode Ga-Al-As laser biostimulation: an experimental study. Artificial Cells, Blood Substitutes, and Immobilization Biotechnology. 2000; 28 (4): 321-336.** Morrone-G, Guzzardella-G-A, Torricelli-P et al.

The purpose of this study was to evaluate whether low-power laser biostimulation of the osteo-chondral lesions of the knee could by itself reduce repair healing time. Surgery was performed on eighteen rabbits; a bilateral osteo-chondral lesion of 2.5mm in diameter and 2mm depth was created in the femoral medial condyle with a drill. The left knee of each animal was treated intraoperatively using the diodeGa-Al-As laser (780nm) with the following parameters: 300 Joules/cm<sup>2</sup>, 1 Watts, 300 Hertz, 10 minutes; 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, either treated employing laser energy or left untreated, were examined histomorphometrically. Results after laser treatment showed faster healing of the lesion at week 2) and an overall improvement in cellular morphology while a more regular aspect of the osteocartilaginous tissue was observed at week 12 A relationship between laser biostimulation properties and healing of the osteo-chondral defect has been demonstrated.

**Low-intensity laser therapy in pediatric oncology. Voprosy Onkologii; 2000, 46 (4): 459-61.** Balakirev-S-A, Gusev-L-I, Kazanova-M et al.

Application of low-intensity laser radiotherapy (LILR) allowed cutting down time needed for management of radiation injury and chemotherapy complications in pediatric patients 1.5-2-fold. It was shown that exposure to LILR caused mononuclear (MN) levels of donors' blood to rise which in turn led to release, in higher concentrations, of IL-1 and FNO cytokins, major factors of immune response development.

**In vitro effects of low-level laser irradiation at 660 nm on peripheral blood lymphocytes. Lasers in surgery and medicine 2000; 27 (3): 255-261.** Stadler I, Evans-R, Kolb B, Naim-J-Oet al.

The effects of low-level laser light irradiation are still highly contested, and the mechanisms of its action still unclear. This study was conducted to test the effects of low-level laser irradiation at 660 nm on human lymphocytes and to investigate the possible mechanisms by which these effects are produced.: Whole blood obtained by phlebotomy was irradiated at 660 nm by using energy fluences between 0 and 5.0 J/cm<sup>2</sup>. The lymphocytes were isolated after irradiation of the whole blood. For the control experiment, the lymphocytes were first isolated and then irradiated at the same wavelength and energy fluence for comparison. The proliferation of lymphocytes and the formation of free radicals and lipid peroxides were monitored. Hemoglobin was also irradiated in a cell-free environment to test for the production of lipid peroxides. Lymphocyte proliferation was significantly higher as expressed by a Stimulation Index in samples irradiated in the presence of whole blood compared with lymphocytes irradiated after isolation from whole blood. Free radical and lipid peroxide production also increased significantly when samples were irradiated in the presence of red blood cells. The present study supports the hypothesis that one mechanism for the photobiostimulation effect after irradiation at 660 nm is the reaction of light with hemoglobin, resulting in oxygen radical production.

**Ultrastructure of the blood and lymphatic capillaries of the respiratory tissue during inflammation and endobronchial laser therapy. Ultrastructural Pathology. 2000; 24 (3): 183-189.** Polosukhin-V-V.

For wide application of low-energy laser irradiation in the pulmonary clinic, study of the structural basis of the therapeutic effect is necessary. The aim of this research is to describe the structural changes of the blood and lymphatic capillaries in the respiratory tissues during inflammation and following laser biostimulation. Comparative ultrastructural study was carried out on 127 open respiratory

biopsy specimens from 45 patients with infectious- destructive lung diseases. These patients were divided into two groups, depending on tactic of pre-operative therapy: patients treated by only traditional anti-inflammatory measures and patients receiving additional laser therapy. Heightened permeability of the blood capillary endotheliocytes was noted as the initial stage in the development of the inflammatory reaction. Intensification of the process of permeability is accompanied by interstitial edema, deformation of the interalveolar septa, and structural disorganization of alveolar epithelium cells. Local lesions of microcirculation result in tissue hypoxia and induce processes of fibrosis. **Laser biostimulation promotes reversion of the inflammatory process and stabilizes fibroplastic processes.** Basic principles of pathogenetic therapy were stated. **It was shown that low-energy laser irradiation satisfies these requirements as an additional method in the therapy of destructive lung diseases.**

### **Laser therapy is effective for degenerative osteoarthritis**

Stelian J, Gil I, Habet 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.**

### **UV laser therapy effective for psoriasis**

Source: Bonis, B et al. *Lancet* Vol 350, No 9090, p. 1522, 22 Nov. 1997

In a study by Bonis et al, six psoriasis patients were treated with conventional ultra violet B light therapy (311 nm), five sessions per week with increased dosage each session. During this therapy a part of the skin was covered. After completing the UVB therapy the covered skin area was uncovered and irradiated with Xenon Chloride laser (308 nm). It took an average of 8.33 sessions for laser and 30.1 sessions for UVB to achieve the same therapeutic result. The total energy density of the laser was 4.81 J/cm<sup>2</sup> and 31.3 J/cm<sup>2</sup> for UVB. To lowered energy density and the lowered total dose means that the cumulative dose was 6.46 less in the laser therapy, thus reducing the risk for skin cancer. The laser therapy was also more cost effective.

LaserWorld comment: **HeNe laser therapy would probably also be effective, and would completely remove the risk of side effects.**

**The Japanese Experience in Sumo Wrestling** Toshio Ohshiro (1), Katsumi Sasaki (2), Shouhei Yasuda (2), Shunji Fujii (3), Takafumi Ohshiro (3), Takeo Touno (4), Shigeru Matsumoto (4) 1) Japan Medical Laser Laboratory , 2) Oshiro Clinic, 3) Keio University Dept. of Plast. and Reconst. Surgery, 4) Nihon Sport Science University.

Sumo Wrestling is the only national endorsed sport in Japan. Professional Sumo Wrestlers belong to the Nihon Sumo Kyokai (Japan Sumo Wrestling Association). Sumo Wrestling meets bimonthly, 6 times a year. Each Sumo sessions has 15 days where the Wrestlers must wrestle for 15 consecutive days against 15 different opponents. This national sport is popular and there are many Sumo Wrestling Teams for all ages. The strongest person from these teams are recruited to the Nihon Sumo Kyokai and become professional. Most Sumo Wrestlers have some symptoms such a pain due to prior injuries and their hard training. We recently had the opportunity to perform Laser Therapy on 6 Sumo Wrestlers who were complaining of various symptoms. We would like to explain about the removal of those symptoms by LLLT, and how Laser therapy effected their performance. **All 6 performed better both subjectively and objectively while their symptoms were alleviated by Laser and their winning rate increased following treatment.** We will discuss major and common injuries associated with Sumo Wrestling and the treatment thereof. We would like to comment on treatment methodology and statistical analysis.

**Laser and Sports Medicine in Plastic and Reconstructive Surgery.** Junichiro Kubota M.D. Department of Plastic and Reconstructive Surgery, Kyorin University School of Medicine, Tokyo, Japan.

Flap survival with diode laser therapy: Skin flap or graft surgery are major procedures in Plastic and Reconstructive Surgery. Skin flap necrosis has been a problem for us. **The author reported on the enhanced blood flow following the low reactive laser therapy in skin flaps.** The 830 nm diode laser (20 - 60 mw) irradiated flaps showed a greater perfusion, a greater number of blood vessels, and a higher rate of survival areas than the control flaps in the rat models and clinical cases. Improve of wound healing with diode laser therapy: The diode laser therapy was indicated for traumatic skin ulcers received from sport activities and traffic accidents which had proved resistant to conservative treatment. The diode laser system has a wavelength of 830 nm. And output power of 150or 1000mw in continuous wave. The diode laser was applied with the non-contact method to the area on the wound for one minute once a day

every day during the treatment period. The diode laser was used successfully for the rapid enhanced healing of traumatic skin ulcers in clinical cases. Pain attenuation of the temporomandibular joint with diode laser therapy:

Laser therapy has been applied for temporomandibular joint pain which follows as a result of mal-occlusion, mandibular contusions or mandibular fracture. The diode laser was applied with contact method to the area of around a temporomandibular joint, especially, tender points with pressure for 1 minute to 5 minutes (5 sec. To 15 sec./one point). The pain decreased after one or two treatments. The patients had goods results. Treatment of traumatic tattoos with Q-switched Nd:YAG laser: For many years, the treatment of traumatic tattoos during outdoor sports or traffic accidents has presented a major set of problems to plastic surgeons. I would like to introduce treatment of the traumatic tattoos with Q-switched Nd:YAG laser (wavelengths 1064 nm. Energy density 4 to 6 J/cm). All patients were successfully treated with no scarring and no hyperpigmentation.

Discussion: The majority of patients hope to avoid undergoing a surgical operation, trying instead with conservative treatments for injuries. The diode laser therapy improved the flap circulation and wound healing of severe skin ulcers. And this therapy has been applied for temporomandibular joint pain and we have obtained favorable results. The diode laser therapy has proved to be particularly effective for pain attenuation. The diode laser therapy may well offer an additional convenient, safe and side-effect free method. On the other hand, the Q-switched Nd:YAG laser system applied to the traumatic tattoos, achieving consistently good results concomitant with easy and safe operation, successfully achieving excellent lightening of the target lesions.

**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 (GaAlAs) 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.

**Biophysical methods of the control by efficiency of laser therapeutics.** V. M. LISIENKO. THE URAL STATE MEDICAL ACADEMY.

The fact of existence of liquid Crystals in bioliquids in organism and their ability to structuring are known. In our clinic we studied the morphology L. C. In BL of organism. We established observed Structures in polarizing microscope are changed in rehabilitation process. During pathological process and peak of the disease the great number of various kinds LC structures are revealed in biomedium. Their number is decreasing during the treatment. Massive dendrites are changed by thin crystal structures, big spheroliths disappear. In combinations with clinical refractometric and photometrical data structure analysis of BL gives the possibility to differentiate the standard and the pathology, to estimate the heaviness of patient condition, dynamics of pathological process, to control the effectiveness of treating measures. We established LC are susceptible to low intensive laser irradiation (LILI). Have been revealed, that structures of bioliquids change LC picture with the LILI influence, and LILI exerts not only local but generalized influence upon organism (alteration of bioliquids theory).

On the base of biophysical parameters, the refraction index, determined refractometrically, the new method of determining of individual sensibility of organism to LILI was worked out. Also the method photometry in polarized light was suggested. It gives the possibility to determine in quantitative the expression part of crystal and LC phase in specimen. Good clinical result is achieved by low power of irradiation and optimal time of influence. Methods were approved in clinic in 17647 patients. All these patients were suffering with purulent diseases of soft tissues and with various abdominal pathology. Effectiveness was confirmed on practice in treatment of therapeutic, pulmonologic, dermatologic patients. This diagnostic, prognostic and statistic value proved.

## **PRINCIPLES of TREATMENT And LASER THERAPY.** Mikhailov V.A. SCIENTIFIC - PRACTICAL CENTER of LASER MEDICINE MOSCOW.

In 1988 we have begun researches on usage of a laser therapy for ill with different diseases. Now we possess experience of treatment more than 700 patients with different diseases a crab of different localization, bronchial asthma, autoimmune thyroiditis, different acute and chronic diseases, peptic ulcer, etc. By main problem for any specialist as soon as possible to cure ill. It is reached by usage of the most effective method of treatment or speed key of several different methods of therapy. But at usage of this or that method of treatment the doctor should know following:

1. by what way it is possible to use this method
2. the gear of medical operating of this way of treatment
3. the most effective doses and modes at which one there is a greatest medical effect.

Any organism can exist only at full synchronizations of activity all of his (its) tissues and systems. The regulation of habitability by processing of many different stimulus's, which one, locally affecting on those or diverse receptors and cages, call (cause) local reacting of tissues. The central nervous system processes (treats) the obtained information, causes (urges) an organism to react to the given stimulus in appropriate way. Therefore basis (fundamentals) of habitability of any organism the adequate answer to local reacting of his (its) cages called what or stimulus. Thus, the local reacting are dominating in composite, all-level hierarchy of an organism. The degree of reacting depends from as on a reactivity of an organism, and from force of a stimulus. The reliability of any system is encompass bayed of reliability of its (her) automatic control. In a CNS, the self -sustained oscillations adjusting a homeostasis, implement a hypothalamus, which one is center of federating of vegetative department of a nervous system and endocrine systems of the main (basic) executive links adjusting influencing a CNS on internal environment of an organism. On endocrine a system the hypothalamus exerts influence through a pituitary body. Thus, hypothalamus-hypophyses the system executes automatic control neurohymoral and hormonal processes, which one counter to the permanently varied factors not only internal, but also environment. This self regulation will be realized in the complex (integrated) answer of the gland of an internal secretion and immunocompetent bodies (organs), which one cause (urge) an organism to react to any stimulus.

The forces of reaction of an organism are piled from a basic (initial) reactivity of an organism and force of an external stimulus, transferring (translating) it (him) in operational mode, optimal for maintenance of a homeostasis, at complex (integrated) effect of all stimulus's, both external, and internal.

The basic (initial) reactivity is adjusted (regulated) at the expense of a feedback of all these bodies (organs) and system with a CNS, i.e. permanently there is a self regulation of an organism. The advantage of a laser therapy is encompass bayed volume, that with its (her) help it is possible to affect different bodies (organs) and tissues of and organism, calling (causing) indispensable reacting of these tissues and bodies (organs) and if necessary it is possible to receive the greatest effect in indispensable period. **All this allows to use a laser therapy in sporting medicine for the following purposes:**

1. Treatment of a sporting trauma.
2. In rehabilitation period after traumatic damages.
3. For preventive measures of possible (probable) traumas.
4. For opening-up of the sportsmen for the most relevant competing.

**Treatment of the acute Periarthritis humeroscapular with laserpuncture.** Odalys Gonzáles Álvarez, Main Educational Clinic of Urgencies "Antonio Maceo", Cerro Municipality, Havana City.

The periarthritis humeroscapular is a syndrome that contains very precise affections: the bursitis, the calcified tendinitis of supraespinoso, the bicipital tendinitis, among others. Pain and limitation of the joint movements of the shoulder characterize it. **The treatment with laser of low power can produce resolution of the lesion, whenever it is made in early phases of the disease.** In this study we propose the use of the laserpuncture, due to our accumulated experience in the treatment of these affection in acute phase, with acupuncture. A prospective study was carried out during 2 years (1997 - 1999), where 62 patients were selected because they accomplished the Approaches of Inclusion for the study. The sample was divided by aleatory assignment in 2 Groups of Treatment. Th study Group I was treated with laserpuncture, using Cuban laser equipment of HeNe of 632,8 nm and a dose of joule/cm<sup>2</sup> was applied, and the Control Group II was treated with acupuncture needles. The conventional medical treatment was suspended. Daily sessions were given from Monday to Friday, for two weeks, until a total of 10. **Both techniques demonstrated to be effective in the treatment of these affections, improving the clinical and radiological symptoms significantly when the treatment sessions was concluded.** The patients accepted the laserpuncture better because of its painless character, less time of application, and the absence of bleeding and stress.

**Therapeutic laser in treatment of trophic ulcers (TU) of venous aetiology** . V. M. Lisienko, O. J. Menjajlenko. The Ural State Medical Academy.

The venous system pathology of low extremities is revealed in 15-20 per cent of adult population of Russia. 2 per cent of work age have got TU of venous aetiology.

The variety of medicine, using in traditional conservative treatment of TU of low extremities has not led to common method, preventing recurrence of the disease. The main direction of this treatment of TU is surgical correction of destructive venous blood flow with combination of sclerotherapy and compress therapy. One of methods is laser treatment. **Using of low intensive irradiation (LII) for this category of patients has given the possibility to improve the results of therapy.** Side by side with known theories of LII influence of trauma process, we connect them with biophysical mechanism of laser irradiation influencing on liquid crystal structures of bioliquid of organism and with structure alteration of tissues.

### **Laserpharmacology and Achilles tendinopathy**

Paul Meersman, Private Laser and Sport Medical Center, Kapelle op den Bos, Belgium.

The Achilles tendon, although the largest and strongest in the human body, has since classical times been recognized as a weak point. In the case of Achilles it was severed by an arrow, but for athletes it is the combination of repetitive body load, the whip effect of pronation in the running gait and potential intrinsic weakness or collagen deterioration with age, that makes it so vulnerable. The bad results with conservative therapy and pure LLL therapy pushed us to use a combination of LLLT and local infiltration of concomitant medication. The subjects were 100 successive athletes, with chronic Achilles tendinopathy, these patients already had a conservative treatment for six months without positive results. Our method was a combination of PDT with plenosol I.D. and 904 nm LLLT and afterwards a cooling down treatment with Ubiquinon, Ferrum and Zinc S.C. infiltration with 632,8 nm, 830 nm, and 904 nm LLLT. With an average of 4 treatments within 14 days, we reached a healing time of 16 days, with a success rate of 90%. **These results made us conclude that a good knowledge of interaction between Laser and pharmacology can reduce our treatment and rehabilitation time, even for chronic diseases.**

### **The influence of chemical substance on the effect of Low-power Laser Therapy.**

Paul Meersman, Private Laser and Sport Medical Centre, Kapelle op den Bos, Belgium.

The purpose of this lecture is to conduct a hypothetical and theoretical clinical study and a review of the scientific literature on the potentialising or inhibiting effect of medication in combination with low-power laser therapy (LPLT). Specialist attending LPLT congresses are struck by the fact that LPLT is often combined with all kinds of medication, without paying any attention to the possible interaction between the two types of therapy. In conclusion, we can state that **LPLT and medication are indeed interactive** and that in case of concurrent use of medication administered orally or intraleasionally, LPLT can either be inhibited, (cfr. Aspirine deactivation of PDT) or stimulated. In a second lecture we prove our hypothetical deduction in a clinical study about Achilles tendinopathy.

### **TREATMENT OF MEDIAL AND LATERAL EPICONDYLITIS - TENNIS AND GOLFER'S ELBOW - WITH LOW LEVEL LASER THERAPY: A MULTICENTER, 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 (LLL) 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 outcome 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.

## **PAIN RELIEF AND LASER THERAPY, THE IMPORTANCE IN SPORTS INJURIES.**

KEVIN C. MOORE, THE ROYAL OLDHAM HOSPITAL, OLDHAM, UK.

The patho-physiological effects of acute injury and trauma to the musculo-skeletal system are described with emphasis on both macroscopic and microscopic changes. The process of healing and the various conventional treatment modalities are enumerated. The experimental evidence supporting the mode of action of Laser Therapy (LT) at both cellular and tissue level are summarized and the effect that LT has in promoting soft tissue repair is described. Currently available literature on the use of LT in sports injury clinics and physical therapy departments is reviewed for a wide range of both acute and chronic conditions and a variety of treatment protocols and regimes are assessed for their efficacy. **It is concluded that LT is valuable addition to the treatment modalities used to treat sporting injuries of the musculo-skeletal system.**

## **LASER THERAPY AS A NEW MODALITY IN THE TREATMENT OF INCOMPLETE PERIPHERAL NERVE INJURIES:**

Prospective Clinical Double-Blind Placebo-Controlled Randomized Study

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The research project was an interdisciplinary effort to evaluate an innovative therapeutic strategy, wherein low power laser irradiation was applied for the treatment of severe incomplete peripheral nerve and brachial plexus injuries. The purpose of this clinical trial was to evaluate the effectiveness of this treatment as a non-invasive, low-cost method for improving the functional recovery of patients suffering from incomplete peripheral nerve and brachial plexus injuries. This study evaluated the functional improvement of 18 patients suffering from incomplete peripheral nerve or brachial plexus injuries who received low power irradiation or placebo treatment for 21 consecutive days in a double-blind, placebo-controlled, randomized manner. Clinical and electrophysiological assessments were done at baseline, at the end of the 21 days of treatment and 3 and 6 months thereafter. **The analysis of the results of the double-blind, placebo-controlled randomized study showed statistically significant improvement in motor function (P=0.0001) in the laser-treated group at the end of the 21 days of treatment and at the 3 and 6 month follow-up periods,** compared to the placebo group. No statistical significance was found in sensory function in the laser-treated group, compared to the placebo group. In the laser-treated group, statistically significant improvement was found in motor (P=0.0001) and sensory functions (P=0.035) at the end of the six-month follow-up period, compared to baseline. In the placebo group, no statistically significant improvement was found in motor and sensory functions at the end of the six-month follow-up period, compared to baseline. **Electrophysiological analysis of the laser-treated group showed statistically significant improvement in recruitment of voluntary muscle activity (P=0.006), as well as a trend toward statistical significance in amplitude of compound muscle action potentials (CMAP) (P=0.067) at the end of the 21 days of treatment and at the 3 and 6 month follow-up periods,** compared to the placebo group. In the laser-treated group, statistically significant improvement in recruitment of voluntary muscle activity (P=0.0001), as well as CMAP amplitudes (P=0.049) were found at the end of the six-month follow-up period, compared to baseline. In the placebo group, no significant change in CMAP amplitude was found, but a minor improvement in motor unit recruitment was observed, at the end of the follow-up period compared to baseline.

In conclusion: Our double blind clinical study indicates that **laser therapy enhances the recovery of injured nerve tissue.** The therapeutic results show an objective progressive improvement in nerve function, leading to a significant functional recovery. Laser therapy, a non-invasive low-cost method, may be useful in improving the functional recovery of patients suffering from incomplete peripheral nerve and brachial plexus injuries.

## **HOW DANGEROUS IS LASER LIGHT?**

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Strong sounds can be harmful our sound sensitive ears, strong light can harm our sensitive light detectors - the eyes. A laser can be a strong light source. Some lasers can be dangerous - no doubt. But which lasers and why is it so? How dangerous are for instance therapy lasers? There are examples where the fear of laser is more dangerous than the laser itself. Low Level Laser Therapy can be carried out with either weak or strong lasers. But "Low Level" does not necessarily mean that the light is weak or that it is harmless. Is a 15 watt defocused CO<sub>2</sub>-laser more dangerous than a 500 mW GaAlAs-laser? What about the so-called laser pointers? Why are invisible wavelengths sometimes more dangerous than visible and sometimes less dangerous? How dangerous are reflexes? Are the international rules adequate or should they be more strict? Are there other light sources that may be even more dangerous than lasers? Can laser light cause cancer? Can LLLT stimulate growth of already existing cancer cells? Is it risky to treat something on an eye-lid with LLLT? These and many other questions will be answered and some enlightening demonstrations will be performed. The best protection against eye injury due to laser light is not protection goggles! The best protection is knowledge and understanding of the underlying mechanisms.

## LLLT IN VIVO EFFECTS ON MAST CELLS

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Because of their compounds, basically related to active aminas, Mast Cells (MC) play an important role in inducing vasodilatation. MC's are particularly concentrated in the perivascular areas and their reaction to chemical or physical action is well known, but they can also react to laser stimuli as can be demonstrated by a series of laboratory in vivo experiments. In fact, **vasodilatation is one of the biological effects that indicates the action of low level laser therapy (LLLT) on tissues**. Based on this premise, MC reactions were controlled before and after laser irradiation. Quantitative and morphometric changes were recorded and compared to control groups, detecting tissue changes in the surrounding area to that where laser light was irradiated. By using two lasers of different output, but applying the same energy density, it was observed that MC's reacted more actively when the total energy is delivered in a shorter period of time. Substances contained in MC granules pass into the bloodstream, because of laser irradiation, and produce vasodilatation. This phenomenon has been gauged and might help the therapeutical response to LLLT. By means of Radio Immunology Assay (RIA) irradiated tissue, which was previously pulverised, was analysed quantitatively and statistically for its Histamine content, observing that its level changed at the end of the experiment, compared with the normal level of Histamine of non-irradiated tissue. For this experiment, the tongue of the Swiss mouse (rich in MC's) after 2,4 J/cm<sup>2</sup> He-Ne 632 nm laser irradiation on alternative days (5 sessions) was used, and results obtained confirm the possible non-selective action of LLLT in the degranulation of mast cells. Moreover, it has been observed that Histamine levels in blood vary after laser irradiation and this can occur after just one single laser irradiation of 2,4 J/cm<sup>2</sup>. A dose of a Helium/Neon (632 nm) laser energy was capable of producing vasodilatation and active releasing of MC granules to the interstitial cell medium detected by electron microscopy. These structural changes have been morphometrically evaluated by optical and electron microscopy noticing special active vasodilatation. Interstitial oedema was noticed together with the opening of cell membrane pores between endothelial cells, as well as exocytosis of MC granules, which passed into the bloodstream. Since Histamine is a powerful anti-inflammatory agent as well as having particular effects on blood circulation, creating vasodilatation, it could be used as an explanatory thesis in the chain of mechanisms involved in obtaining therapeutic effects when using LLLT.

## LEVEL LASER THERAPY IN TENDON INJURIES? - A REVIEW OF IN VITRO AND IN VIVO TRIALS

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**Purpose :** To investigate the effect of different laser treatment parametres on fibroblast inflammation and production of collagen fibres.

**Material :** Controlled in vitro or in vivo trials with low level laser therapy (LLLT) Method : Literature search for trials published after 1980 using LLLT on Medline, Embase, Cochrane Library and handsearch of physiotherapy journals in English and Scandinavian languages. Optimal treatment parameters regarding timing, treatment frequency, dose and power density at target tissue were synthesized.

**Results :** The literature search identified 31 controlled trials with LLLT on collagen tissue. Three in vitro trials were performed on stretch-induced and inflammation in fibroblast cultures and five in vitro trials were performed on collagen production. Optimal dose and power density for inhibition of prostaglandin PGE<sub>2</sub> and interleukin 1- beta production was found to be 3.2-6.3 J/cm<sup>2</sup> and 5.3 mW/cm<sup>2</sup> measured at the target fibroblast cells after 5 days of irradiation. Data on upper range limits for anti-inflammatory treatment were inconclusive. Optimal dose and power density for collagen production was found to be in the range 0.2-2.0 J/cm<sup>2</sup> and 2 -20 mW/cm<sup>2</sup> measured at the target fibroblast cells. **Daily treatment for 2 weeks with optimal parameters yielded a maximum increase in collagen production of 37%**. The results from three in vivo trials showed similar increase in collagen production. Doses in excess of 4.5 J/cm<sup>2</sup> and power densities higher than 30 mW/cm<sup>2</sup> inhibited fibroblast metabolism and decreased collagen production.

**Conclusion :** There is evidence of a dose-response pattern for LLLT in the treatment of tendon injuries during the proliferative phase of regeneration.

## LOW LEVEL LASER THERAPY CAN BE EFFECTIVE FOR TENDINITIS: A META-ANALYSIS

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**Purpose:** To investigate if low level laser therapy (LLLT) with previously defined optimal treatment parametres can be effective for tendinitis. **Material :** Randomized controlled trials with LLLT for tendinitis. **Method :** Literature search for trials published after 1980 using LLLT on Medline, Embase, Cochrane Library and handsearch of physiotherapy journals in English and Scandinavian languages. Only trials that compared laser exposure of the skin directly over the injured tendon with optimal treatment parametres with identical placebo treatment were included.

**Results:** The literature search identified 77 randomized controlled trials with LLLT, of which 18 included tendinitis. Three trials were

excluded for lack of placebo control, of which one trial was comparative, another lacked patients with tendinitis in the treatment group, while the last unwittingly gave the placebo group active treatment. Four trials used too high power density or dose, and three trials did not expose the skin directly overlying the injured tendon. The remaining eight trials were included in a statistical pooling, where the mean effect of LLLT over placebo in tendinitis was calculated to 32% [25.0-39.0, 95% CI].

**Conclusion:** Low level laser therapy with optimal treatment procedure/parameters can be effective in the treatment of tendinitis.

## TINNITUS AND VERTIGO - A CASE FOR THE DENTIST?

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The correlation between tinnitus/vertigo and cranomandibular disorders (CMD) has been known for quite some time, yet few dentists seem to be aware of this. It is not natural for the dentist to ask, nor for the patient to inform the dentist about such a situation since it does not appear to be a dental indication. However, quite a number of tinnitus/vertigo patients will be relieved of their symptoms if a proper CMD treatment is performed. Low level lasers have been used to treat tinnitus patients with reasonable success, if sufficient energy and suitable treatment technique is used. These lasers have also proved themselves successful in the treatment of CMD. It is obvious, therefore, that low level laser therapy is an appropriate treatment modality for the yet undefined subgroup of tinnitus/vertigo patients with a CMD background. Laser therapy will reduce pain levels, ease muscular spasms and revert the vicious circle. In some cases laser therapy alone will produce astonishing results, in others it has to be combined with traditional occlusal stabilisation procedures. It is important for doctors to be aware of this subgroup of tinnitus patients since traditional therapies, and even laser therapy of the inner ears, will be ineffective if the CMD is not diagnosed and treated. This presentation will look at the literature documentation for laser therapy of tinnitus/vertigo.

## IS LLLT A PANACEA IN DENTISTRY?

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In the literature more than 30 different indications for Low Level Laser Therapy can be found. A casual reader may get the impression that LLLT is a panacea in dentistry. This is certainly not the case. It is important that the correct diagnosis is made, that tissue condition is considered, that a reasonable dose is applied and that a suitable wavelength is used. As always, a combined knowledge about dentistry, physics and treatment technique will be rewarded clinically. If the parameters above are under reasonable control, LLLT will become a very powerful tool in the hands of any dentist. For some indications laser therapy will be a useful additional treatment modality to conventional methods, for some indications conventional methods may be equal or better and for yet others laser therapy will be the best, if not the only available method. This presentation will review some of the most useful indications for dental LLLT, with suggestions for optimal treatment parameters

## USE OF LOW-LEVEL LASER THERAPY (LLLT) FOR TREATMENT OF THE PATIENTS WITH A CANCER OF A ESOPHAGUS T3N0MX

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In this part of work at 20 patients received the laser therapy (LLLT) in a combination with external radial therapy under the radical program (1group), 15 patients (2 groups) received only one laser therapy, the control group consist of 18 men receiving only external radial therapy on the radical program (3 groups), 10 patients received only symptomatic therapy (4 groups). The stage of disease T3N0MX and spent treatment in skilled and control groups was identical. Radial therapy carried out on kettles "Lutch-1" and "Agat-?" on a procedure from three fields (1 parasternal, 2 and 3 - juxtaspinal under an angle of 40 degrees to a backbone) with a single dose till 90 % on doses by a curve 1,8 Gr and cooperative dose 64-66 Gr. The irradiation was carried out 5 days per one week with a break 2 days. A GaAs semiconductor laser (wavelength 890 nm., pulsed mode, pulse power 5-10 W.) was used for laser therapy. Laser therapy carried out after leading to a tumor of a dose 15-20 Gr. The sessions LLLT carried out 3 times per one week in day. A cooperative dose - 5,8 J/cm<sup>2</sup> The analysis of lifespan of the patients in group receiving LLLT with radial therapy and in control group has shown, that use of laser therapy increases lifespan of the patients: 1 group - up to 10,28 ±2,03 months, in 2 groups up to 11,4 ±3,02 months, in 3 groups it makes 7,35 ±2,4 months, in 4 groups - 6,3 ± 1,94 months. Use LLLT allows to reduce quantity of occurrence of complications after radiation therapy in 2,9 times.

**THE USE OF LASER THERAPY AND ADDITIONAL THERAPEUTIC MODALITIES AFTER ARTHROSCOPY OF THE KNEE AT ALPINE SKI TEAM** Lilic Alen, physiotherapist; 2Kozlevcar Živec Maja, dr. med. spec.fiz.reh.med.; 3Marcan Radoslav, dr.med., spec.ortop 1FIZIO, Ilirska Bistrica, Slovenija, 2Iskra Medical, Ljubljana, Slovenija, 3Ortopedska bolnišnica Valdoltra, Slovenija

In the present article we will review different kind of injuries in the alpine ski sport and we will concentrate on the injuries of the ligamentar part of the knees and meniscs in slovenian ski team. After the description of the injuries follows detailed presentation of the rehabilitational procedures from the first day of the injury till the return in to the competition arena. We will try to explain the modalities of the rehabilitational procedures and their influence in the tissues, their main and side effects. Our main attention will be focused to the use of the biostimulative laser of higher power - 1,2 W and wave length of 830 nm and it's influence on the velocity of recovery in the patients and their succes in following competitions.

**ROLE OF THE CIRCULATING BLOOD IN INITIATION OF THERAPEUTIC EFFECTS OF VISIBLE LIGHT**

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The successful use in Russia of the extracorporeal and intravascular irradiation of the patient`s blood with the laser and non-laser light for the wound healing promotion, immunomodulation, pain relief, etc. suggests that development of these effect in the case of the percutaneous light application also is due to its effect on blood. Such mechanism seems quite possible, as the visible and IR light penetrating the skin at the depth of 2-4 mm reaches a network of small vessels and can affect the blood that circulates here at a low rate. Since during the laser treatment it is possible to irradiate only a small area of the surface body or wound and, correspondingly, of a very small volume of the circulating blood, it is necessary to explain how its photomodification can lead to a wide spectrum of therapeutic effects. For this purpose, we refer to the data obtained at our Laboratory in studying mechanisms of the rapidly developing functional changes induced by retransfusions of a small blood volume (1.5-2.5% of its circulating pool) irradiated extracorporeally with the UV or He-Ne laser light. It has been found out that the optical radiation induces structural-functional changes and activation of blood cells, which results in that a small volume of blood acquires properties of an active preparation able to modulate the state of cells of the autologous blood and other tissues. Indeed, when the photomodified blood is added in vitro to the 10-80-fold volume of the intact autologous blood, it "translates" to it the light-induced changes that, in spite of such a pronounced dilution of blood, not only are not reduced but even are enhanced. As a result, the entire volume of the circulating blood acquires properties of an active preparation. The chief "translators" of the light effects are the irradiated mononuclear leukocytes and platelets, and whereas development of some effects (improvement of hemorheology, activation of all types of leucocytes, etc), is necessarily associated with the presence of irradiated cells, the development of other effects (first of all an enhancement of the growth promoting activity of blood) is initiated by soluble factors secreted by these cells. **By now we have accumulated an evidence for that after exposure of a small area of the body to visible incoherent polarized light, immediate changes occur of the rheological, transport, gas transport, growth stimulating, immunomodulating properties of the circulating blood and that these changes develop mainly as a consequence of the effect of the transcutaneously photomodified blood.**

**EXPOSURE OF THE VOLUNTEERS' SKIN TO VISIBLE POLARIZED LIGHT IS ACCOMPANIED BY INCREASE IN GROWTH PROMOTING ACTIVITY OF THE CIRCULATING BLOOD FOR HUMAN CELLS IN VITRO : DEPENDENCE OF THE EFFECT ON CELL TYPE**

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In analyzing mechanisms of the visible light-induced stimulation of wound healing we studied the growth promoting (GP) activity of the volunteers' blood for cultured human cells after a single exposure of small area of the body (15x15 cm) to therapeutic dose of visible incoherent polarized (VIP) light (Swiss BIOPTRON-2 device, 400-2000 nm, 95% of polarization, 12 J/cm<sup>2</sup>). The exfusion of blood and its centrifugation were performed before and after VIP-session; cell-depleted plasma (2.5-10%) was added to the culture medium instead of fetal calf serum. In the 1st group of the experiments the following cells were used as targets: two primary cultures (keratinocytes, KC, of the donor skin, embryonal fibroblasts, FB) and two continuous lines (endothelial cells ECV304 and epidermoid carcinoma A-431 cells). The number of cells was determined by a colorimetric method. In the 2nd group the primary cultures of the PHA-stimulated blood lymphocytes (Lym) after their damage with X-ray (0.5 Gy) were tested. The mitotic index (MI) and incidence of the chromosome breaks (ChrBr) were determined in these cells after their cultivation in presence of 22% of autologous plasma derived from the same volunteers before and after VIP-treatment. It has been established that in 0.5 hr after the VIP-session, soluble factors appear in the volunteers' blood; they stimulate proliferation of KC (in 57% of the cases, on average, by 20%), FB (in 41%, by 10%), ECV304 (in 53%, by 30%), but not of the tumor cells. The blood drawn from volunteers next day after exposure has a higher GP activity for KC (frequency of the increments is 70%, by 30%) but not for other cells. It is essential that the frequency and degree of the stimulation of FB proliferation are 1.5-2 times lower than those of KC and ECV304, which might be one of the explanations as to why no pronounced hyperproliferation of the connective tissue is observed after the VIP-treatment of wounds. A significant individual variability of the blood GP properties has been revealed, as well as a high degree of dependence of VIP- effects on the

initial level of the blood GP activity: as a rule, it rises at a low indices, while slightly decreases at the high ones. Hence, VIP light produces regulatory effect on the GP activity of the circulating blood for KC, FB, and ECV304. As to X-damaged Lym, cultivation together with autologous plasma of VIP-exposed volunteers resulted to the restoration of the cell mitotic activity, on average, from 82% to the level in non-damaged Lym and simultaneously reduced the ChrBr frequency, on average, by 17%. According to our findings the photomodified platelets can be an important source of factors able to restore the damaged autologous cells. Moreover, a proof has been obtained that platelet - associated growth factors (PDGF and EGF) have such activity. The results are discussed in the connection with VIP-induced changes of the content of some cytokines and growth factors in blood.

## **CHANGES OF THE CONTENT OF SOME CYTOKINES AND GROWTH FACTORS IN CIRCULATING BLOOD OF VOLUNTEERS EXPOSED TO VISIBLE POLARIZED LIGHT AT A THERAPEUTIC DOSE**

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**The promotion of wound healing and immunomodulation are the cardinal indications for laser therapy.** Since these complex phenomena involve participation of immunomodulators and growth factors circulating in blood, it is necessary to study effects of phototherapy their level. Using an ELISA, we determined the plasma levels of IL-1b, TNF-a, INF-g, IL-10, and transforming growth factor (TGF-b) in healthy volunteers (n=15-20) in 0, 0.5, and 24 hr after exposures of their back (400 cm<sup>2</sup>) to a therapeutic dose of visible incoherent polarized (VIP) light (Swiss BIOPTRON-2 device, 400-2000 nm, 95% polarization, 12 J/cm<sup>2</sup>). As a control (Placebo) group, unexposed people were similarly tested after 2 exfusions of blood for study (30-40 ml for 24 hr). There were no changes of the IL-1b level in 0.5 and 24 hr after the VIP-exposure of 17 volunteers, however, the TNF-a content in 0.5 hr changed in 85% of the subjects: a very slight increase was revealed in persons with a low initial cytokine level (50% of all tested) and a more marked decrease, in volunteers with a high initial cytokine level. The inverse dependence of the light-induced effects on the initial TNF-a levels is confirmed by a negative correlation coefficient  $r = -0.67$ . In other 22 volunteers a statistically significant increase in the INF-g level was found in 0.5 and 24 hr: its mean amount changed by 44 pg/ml (from 21 to 65 pg/ml), in some people, by 102-308 pg/ml. Meanwhile, in the Placebo group (n=7) a decrease in the INF-g content was observed, which presumably resulted from the hemoexfusion. There also were changes of the IL-10 and TGF-b levels in 78-85% of volunteers, a high dependence of these changes being found on the initial level:  $r = -0.96$  (IL-10) and  $r = -0.60$  (TGF-b). Indeed, in subjects with the low values of IL-10 (40% of cases) its level increased in 0.5 hr (from 9 to 49 pg/ml) and, to a lesser degree, in 24 hr, while in the group with the high IL-10 content it fell markedly (from 150 to 5 pg/ml); in the Placebo group a significant increase of IL-10 was observed (from 67 to 126 pg/ml in 24 h). As to TGF-b, its content within 0.5 hr decreased almost twice in 40% of cases (from 20.4 to 11 ng/ml) and rose in the 40% of volunteers 1.5 times (from 7.9 to 11.8 ng/ml). In the Placebo group there was an elevation of the TGF-b level in 60% of the people, while a decrease, only in 27% of the tested persons (by 25%). However, in 24 hr the 2-fold fall of the TGF-b content was revealed already in 71% of the control group persons, whereas among the irradiated volunteers, it was revealed only in 40%. Thus, a single VIP-exposure of healthy people immediately increases the plasma INF-g level and produces a regulatory effect on the TNF-b, IL-10, and TGF-b content.

## **CHANGES IN SOME FUNCTIONAL AND BIOCHEMICAL PARAMETERS OF THE CIRCULATING HUMAN BLOOD AFTER PERCUTANEOUS APPLICATION OF VISIBLE POLARIZED LIGHT AT A THERAPEUTIC DOSE**

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Three years ago, our clinics started application of a Swiss phototherapeutic device BIOPTRON that allows an exposure of a small body area to visible incoherent polarized (VIP) light, whose spectrum and power density are close to the Sun visible radiation (400-2000 nm, 95% of polarization, 12 J/cm<sup>2</sup>). To elucidate physiological mechanisms and to specify indications for this type of phototherapy, we analyzed some biochemical parameters in 26 healthy volunteers during the course of 10 daily irradiations of a body area, 400 cm<sup>2</sup>. In the Placebo group (n=16) the irradiation was imitated and 5 exfusions of 140 ml blood for 10 days for study was performed, like in the main group. A rapid statistically significant decrease of the glucose level in 65% of VIP-exposed volunteers (on average, by 10%) has been observed in 0.5 hr after VIP-session but no significant changes in the Placebo group. Subsequently, strongly depending on the initial level, there was a decrease or an increase of this parameter in most VIP-irradiated subjects. The correlation and dispersion analysis has revealed regulatory and normalizing effect of the VIP-sessions on the glucose content. In the Placebo group, this regularity was not detected. Deep changes were in parameters of lipid metabolism: an immediate decrease of triglyceride content, (from 1.14 to 1.00 mmole/l) and its gradual, statistically significant decrease by the end of the course. The analysis indicated both a regulatory and normalizing effect of the VIP-course on the content of these atherogenic lipids. The increase in b-lipoproteins' level was observed in 24 hr as well as by the end of course in both groups. Hence, this effect was due to the hemoexfusion rather than the effect of light. A statistically significant increase of the level of anti-atherogenic lipid a-cholesterol (from 1.76 to 1.98 mmol/l), was found out at all periods of the VIP-course, whereas in the Placebo group this parameter decreased. The data obtained have allowed us to apply the VIP-therapy in 10 patients with X-syndrome. For comparison 10 other patients as well as 12 volunteers were irradiated with therapeutic doses of He-Ne laser light. A small number of examined subjects allows only preliminary

conclusions. Unlike volunteers no significant decrease was revealed in the sugar and triglyceride levels, whereas b-lipoproteins' content decreased soon after the 1st session and by the end of the course of both VIP-therapy and laser treatment (by 32%). As to a-cholesterol, it increased in patients with initially low values and decreased in subjects with high level both after a single exposure to light and by the end of course. There were no significant differences in the studied parameters between the VIP- and laser-treated volunteers.

## RESULTS OF LOW LEVEL LASER THERAPY (LLLT) IN THE TREATMENT OF INNER EAR DISEASES

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The increase of LLL energy quantities in the treatment of a large number of patients has proven a very effective biostimulative result. The energy was transmitted with 3 laser diodes (830nm) and 3 diodes (635nm) via meatus and mastoid. The examination and therapy included 348 patients, 251 right and 187 left inner ear organs (cochlea), 171 patients were female and 231 male Their average age was 56.9 years. The average duration of the disease was 5,9 years. In 391 of the cases the patients suffered from tinnitus. The examination lasted from 24 June 1996 to 9 February 1999, the average treatment phase lasted 61.5 days. The average duration of the therapy was 11.8 hours, the average quantity of the transmitted energy was 6732 joule. Before every series of LLLT the patients hearing capacity (air and bone conduction) was examined by an audiometry test. After the 9th therapy the hearing capacity was again examined by the same method. The resulting readings were evaluated using all test data over 12 frequencies, then the frequency intervals (low-middle and high) and the grouping of patients according to age, duration of the disease, quantity of the transmitted energy and the results obtained by the therapy. In cases of deafness 125 db were used as an auxiliary value. Improvements of the hearing capacity were ascertained in all frequency sectors. The best results were obtained in the low frequency sector (reduction of 11.7 db) and in the high frequency sector (reduction of 14,6 db). The therapy results were better when more energy was transmitted. The correlation of the patients age and the duration of the disease on one hand, and the therapy results on the other, are biologically plausible. If LLL is transmitted in suitable energy quantities to the inner ear (cochlea) biostimulative effects can be well documented.

## IMPORT OF RADIATION PHENOMENA OF ELECTRONS AND THERAPEUTIC LOW- LEVEL-LASER IN REGARD TO THE MITOCHONDRIAL ENERGY TRANSFER

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**Objective:** The authors describe a consistent theoretical model of the cellular energy transfer (respiratory chain) by taking into consideration the radiation phenomena of electrons and therapeutic low level laser. **Summary Background Data:** Biochemical models of the cellular energy transfer regard the classical corpuscular aspect of electrons as the responsible energy carriers thereby ignoring the wave-particle dualism of the electrons and the import of radiation energy of this process.

**Methods:** The authors show the influence of radiation phenomena for the cellular energy transfer explaining consistently some of the intermediate steps of this complex process.

**Results:** Because of the inherent wave-particle dualism of the electrons, it is obvious to regard radiation phenomena in order to explain the cellular energy transfer. The classical biochemical models only use the particle part of the electrons as energy carriers. The connection between the energy transport by radiation and the order in structures may be understood, if, for instance, structurally bound energy is released during the dissolution of structures (Oxidation of foodstuffs) or is again manifested (finally reduction of oxygen to water). Regarding the energy values relevant for the respiratory chain, the import of electromagnetic radiation of characteristic ranges of wavelengths on the cellular energy transfer becomes evident. Depending on its wavelength, electromagnetic radiation in the form of light can stimulate macromolecules, can initiate conformation changes in proteins or can transfer energy to electrons. Low level laser from the red and the near infrared region corresponds well with the characteristic energy and absorption levels of the relevant components of the respiratory chain. This laser stimulation vitalises the cell by increasing the mitochondrial ATP (adenosine-tri-phosphate)-production.

**Conclusions:** With regard to radiation phenomena and its enhanced electron flow in the cellular energy transfer (respiratory chain) it is possible to explain the experimentally found increase of ATP-production by means of low level laser light on a cellular level. Intense researches for this biostimulative effect are required.

## CHANGES IN INTRACELLULAR CALCIUM CONCENTRATION INDUCED BY BIOSTIMULATION OF CARDIAC CELLS GROWN IN CULTURE USING VISIBLE LIGHT OR HYDROGEN PEROXIDE.

Rachel Lubart, Asher Shainberg, Harry Friedman, and Ronit Lavie Bar-Ilan University, Ramat-Gan 52900, Israel Reactive oxygen species (ROS) modulate intracellular calcium ion concentration ( $[Ca^{2+}]_i$ ). In the present study, we have measured the  $[Ca^{2+}]_i$  changes in cardiac cells after illuminating the cells with visible light and compare these changes with those observed in response to hydrogen peroxide ( $H_2O_2$ ) addition to the cell culture. We have found that low level light (LLL) irradiation mimics the effect of low concentrations (10 - 35 mM) of  $H_2O_2$  and both cause an increase in  $[Ca^{2+}]_i$  and accelerated muscle contractions. No damage to the cells was evident 24 hours after the treatment. These results support the idea that photobiostimulation by LLL, is a consequence of

**ROS production in response to visible light absorption.** By comparing changes in  $[Ca^{2+}]_i$  that we observed in response to LLL irradiation to those observed, in some cases, in response to irradiation in the early stage of PDT, one can find that in both cases, there is elevation in  $[Ca^{2+}]_i$  after irradiation moreover the elevation has a transient character. But, while following PDT this elevation is in the range of 100 %, after LLL irradiation, an increase of about 20 % in  $[Ca^{2+}]_i$  is observed.

## **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 CRURIS, BURNS) WITH SYSTEMIC EFFECTS OF LLLT**

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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.

IV. Radiation sensitivity influencing laser effects: Dose dependent stimulation and inhibition. Cell type and status dependent reactions. T-cells: CD8/CD4 cells, C and A neurons, epithel cells/cuboid mucosal cells. Human skin types dependent reactions.

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

VI. Methods of laser irradiation: Laser specific light effects: Monochromatic High photon density Coherent Linear Polarisation Divergence Wave length Penetration Absorption Energy density, power density. Superficial dosis / effective dosis / target volume. Spot irradiation / moving irradiation forms. Frequency of sessions. Cumulative effects, synergistic effects, antagonistic effects. Non-thermal application modalities of high power lasers.

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.

## LASER THERAPY IN RHEUMATOLOGY

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Barabas irradiated first the joints of rheumatoid arthritis (RA) patients without skin ulcer. In the first open study objectively the range of motion and circumference of the treated joints were measured, Ritchie index as semiobjective parameter, subjective parameters as joint tenderness and pain on a visual analogous scale (VAS) were registered. The walking time was registered as a functional disability parameter. Laboratory activity parameters and the 99mTechnetium index was measured. The second part of the clinical study was double blinded, Infra Red (10mW and 100 mW) lasers were used versus dummy devices with the same outlook. The third part of the study were in vitro experiments. Synovial membranes of rheumatoid arthritis patients The DNA/RNA ratio of the RA group was compared to the control group. Significant difference was detected between the two groups. The fourth phase of clinical studies was to detect the effects of laser irradiation in other rheumatic diseases: psoriatic arthritis, sacroileitis, osteoarthritis, entesopathy, tenosynovitis, bursitis calcarea, fibromyalgia, localised muscle spasm, periartthritis humeroscapularis etc. The different wavelengths (604, 630, 660, 670, 690, 750, 780, 790, 820, 830, 904, 1053, 1219 nm,) were compared (30 - 100 mW) with other physiotherapy modalities, like ultrasound. Acknowledgement: The Central Research Institute of the Hungarian Academy of Sciences and LASOTRONIC AG (Switzerland) was helping the research.

## 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 synergically 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.

## LASER ACUPUNCTURE

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Traditionally acupuncture means stimulation of specific points on the surface of the body in order to produce mainly regulatory effects on the functions of the internal organs. The same points have been used to increase or decrease the functional state of different organs. In Traditional Chinese Medicine (TCM) the acupuncture points (AP) are connected by channels or meridians in and under the skin and have deep connections to the internal organs. The selection of the proper points has been as important as the correct type of stimulation, either reinforcement or sedation. In the traditional Chinese medicine the human model has been mainly energetic, physiological, not anatomical. The changes in the energy flow induced by the blocks in the channels or acceleration of the flow leading either to the deficit or excess of the vital energy, Chih, were believed to be the origin of diseases. The APs were the loci to balance the energy flow through needle stimulation. Modern acupuncture has a different nature. For the consensus conference arranged by the National Institutes of Health (NIH) and held in Bethesda, Maryland in November 1997 the term acupuncture was defined as stimulation, primarily by the use of solid needles, of traditionally and clinically defined points on and beneath the skin, in an organized fashion for therapeutic and/or preventive purposes. Application of stimulus to the reactive points (by needle, heat, massage, transcutaneous electric nerve stimulation/TENS, laser, etc.) according to TCM can influence the pathophysiological function of the affected organ-meridian systems. In modern Chinese AP therapy, a combination of local tender points (AHSI) and classical peripheral APs is common. Laseracupuncture (LAP) **Today LAP provides a noninvasive and low risk alternative to needle stimulation.** A combination of local reactive (tender) points or Ahshi points and active muscle TPs form a practical and effective basis for LAP in pain treatment. LAP can replace needles in the treatment of functional disorders and is then directed to classical APs. As a painless modality of acupuncture **LAP is well accepted by children and other sensitive patients.** LAP provides excellent possibilities for clinical studies on acupuncture. Recently Schlager and coworkers confirmed the efficacy of AP Neiguan (PC6) in the prevention of postoperative vomiting in children undergoing strabismus surgery. In another randomized, double-blind placebo-controlled study low-intensity laser therapy effectively prevented the recurrence of Herpes simplex infection. Our study groups at the Universities of Kuopio and Tampere have studied the analgetic effect of peripheral stimulation (needle acupuncture, transcutaneous electrical stimulation/TENS, massage, electric stimulation, low energy laser) applied on APs or TPs using pressure algometry. We have conducted a series of experiments using different wavelengths (633-904 nm) and both coherent and noncoherent irradiation. LEPT

was given directly to TPs (1-2 J/TP) or local tender spots. In blind, cross-over studies both HeNe- and IR-diode (904 nm) lasers elevated pressure pain threshold (PTH). In a follow-up study on 54 MPS patients LEPT (820 nm, 1-2 J/TP) PTH increased from 2.94+1.44 to 6.56+0.96 kg/cm<sup>2</sup> (p<0.001) and MGF from 0.60+0.28 to 1.03+0.29 bar (p<0.05), whereas VAS decreased from 44.6+11.3 to 9.3+6.4 (p<0.001). In this and other series we have found that the effect is greater on the side where PTH and MGF values are initially lower. As in our earlier studies with low and high frequency TENS one sided HeNe-laser irradiation elevated PTH of the corresponding, contralateral nontreated TPs in addition to the response on the treated side. More recently the main emphasis has been turned to the central mechanisms and pathways. In a pilot study LED-light (880 nm, 1J/cm<sup>2</sup>) given to TPs in trapezius muscle (TE15) bilaterally and upon proc. spinosus of C7 (DU14) significantly altered regional cerebral blood flow e.g. in thalamus, caudate nucleus and prefrontal cortex. In our experience less than 1 J/point or 100-200 J/cm<sup>2</sup> given in a contact mode is mainly ineffective in clinical practice when treating musculoskeletal disorders and myofascial pain through TPs. In many well controlled, blind and double-blind cross-over studies showing insignificant results the actual radiant exposure to the target site has been a mere fraction of the dose normally used in clinical practice. When treating APs of low resistance and high sensitivity the irradiation dose should be reduced to about 0.1-0.2 J/point (10 per cent of the normal dose [1-2 J/point] used at muscle TPs).

## THE REGENERATING CAPACITY OF LLLT ON MUSCLE FIBERS AND ON CARTILAGE TISSUE

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**Introduction:** This study concerns the influence of laser treatment on the regeneration process of cartilage tissue and muscle fibers. It is known that damage of cartilage and muscular tissue is a serious problem in, for example rheumatic diseases and sports injuries. The lack of blood supply is one of the most important factors involved. Previous studies have proven the regeneration capacities of laser in wound healing and bone repair. **Material and Methods:** In the first part of this study we have chosen to experiment on cartilage tissue of mice. A 0.4 mm hole was drilled in both ears on 15 mice. The mice were divided into 3 groups, dependent on the duration of treatment (1, 2 or 4 days). The right ears were treated with GaAs IR laser (904nm, 10W) for 3 minutes. The left ears remained untreated and were used as control. Photographs were taken from the histologic sections and were interpreted by using the Bentley method. Parameters were: macrophage activity, fibroblast proliferation, chondrocyte activity, remodeling of cartilage structure and perichondrium activity. The statistical analyses of the results was done by a Chi square test. During the second part of our study we made a longitudinal incision in the anterior muscle of both legs of 20 mice. The injured area could be traced by black-ink spots. The right side was irradiated by means of a GaAs IR laser (904nm) and the left side was used as control. On the 7th and 18th day post injury, the mice were controlled. Microscopic photographs were taken of the injured zone and for histologic interpretation following parameters were used: mononucleated cells, early myotubes, regenerated fibers and degenerated fibers. The results were statistically analysed using Kolmogorov-Smirnov Goodness of fit test and Wilcoxon Matched-Pairs Signed-Rank test. Significant level was always chosen at the 5% level.

**Results:** After 1 day of treatment, no significant differences were found between the irradiated group and control and there was no tendency of cell proliferation. After 2 days of treatment, the drilled hole is filled with cartilage structures and is more filled than the control ear. No activity of perichondrium and a differentiation of chondrocytes and fibroblasts is not notable. A significant activation of the perichondrium is found towards the drilled hole. There is a significant difference between the irradiated and non irradiated side; the untreated ear is filled, but with totally other cell structures than in the treated ear. In our second experimental set-up, we found that after 7 days the injured area was populated by mononucleated cells, but not significant. Laser irradiation did not accelerate early myotubes proliferation, nor did it accelerate the number of regenerating fibers, but significant more number of myotubes were found in comparison with the non-irradiated group. Although very close to the significant level, we found no significant increase of mononucleated cells after 18 days. No acceleration of early myotubes and number of myotubes, although significant after 7 days, is found. Important is the significant increase in number of regenerated fibers in the experimental group.

## 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 underlying tissues disappeared after 10 days in the control group and after 4 days in the experimental group. The local oedema

disappeared in the test group after 8 days, while in the control group it lasted until 10 days. A considerable acceleration of the regeneration of both vein and lymph vessel was seen in the test group

## **NON-INVASIVE LASER THERAPY OF MORBUS PEYRONIE - INDURATIO PENIS PLASTICA**

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Induratio penis plastica is a rare affection of male penis though occurrence is reported in 6 - 9 per cent of male population. From clinical, as well as from theoretical point of view this is very interesting kind of proliferous inflammation. Thus dual mechanism of effect of non-invasive laser beam can be employed in implicating overproduction of fibrin (and its resorption) as well as in direct influence upon inflammatory processes.

In our study 40 patients have been followed for more than a five-year period. We combine classical medicamentous techniques (colchicine, E vitamin) together with non-invasive laser of the following parameters: probes 200 and 300 mW, 50 J/cm<sup>2</sup> continuous mode + 50 J/cm<sup>2</sup> with beam modulated in 5 Hz frequency in one therapy bout. The therapy is applied 20 times in a row, twice a week as introductory series of procedures, followed by, according to clinical results, maintenance series of 3 - 5 procedures 2 - 3 times a year. Furthermore, we have found useful a combination with one more kind of physiotherapy - ultrasound - presumably due to erosion of syndesmotic conjunctions.

Results:

- 100 per cent of patients without painful erection (mostly from second or third procedure on, as it is usually for the pain that patients are stirred to see a doctor, not for the deformity),
- 60 per cent of patients with significant reduction, or even fade of palpable resistance,
- less than 30 per cent of patients with marked effect on deformity of penis in the course of erection. Lesser effect on deformity during erection can be noticed with patients whose palpable resistance fade away completely. Theoretically, we are of the opinion that it is a result of permanent conversion of syndesmotic stroma of cavernous corpora, persisting even after disposal of overproduced fibrin. In general, better prognosis can be expected with patients with a clear causer of the affection (trauma, catheterization) than with idiopathic forms, or even with forms connected with other and overall affections (combination with Dupuytren's contractures)

Conclusions: We consider therapy with non-invasive laser to be absolutely the most effective component of the whole therapeutical complement within the scale of possible therapies of Morbus Peyronie (Induratio Penis Plastica), and therefore we establish it a routine method for all patients suffering from this affection. Its main contribution is high clinical efficacy, with negligible possible rate of theoretical risks (we have not observed any side effects of this therapy), and unique compliance of a method which is not connected with any unpleasant feelings for the patient.

## **CHEMO-AND RADIATION-INDUCED MUCOSITIS : RESULTS OF MULTICENTER PHASE III STUDIES.**

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Considerable buccal toxicity of radiotherapy and/or chemotherapy in patients with cancer can cause patients to become discouraged and can alter their quality of life. In addition, such toxicity often necessitates alterations of treatment planning, with grave consequences in term of tumor response and even survival (concept of dose-intensity). With 5-fluorouracil and head and neck radiotherapy for example, acute mucosal toxic effect is the main limiting factor for which no clinically appropriate prophylaxis or efficacious antidote has been found to date. Management of oral mucositis is currently primarily directed at palliation of the symptoms, and prevention of infections. Low Level Laser Therapy (LLLT) has been reported effective in reducing the severity of oral mucositis lesions in a non-randomized trial, initiated in Nice (France) by Ciais et al. (1). The efficacy of this method in the prevention of chemotherapy induced oral mucositis has been subsequently confirmed in two prospective, double-blind randomized trials, in patients undergoing bone marrow transplant (2 ; 3). These initial findings and the high incidence of radiation-induced mucositis prompted a randomized multicenter trial to evaluate LLLT for the prevention of acute radiation-induced oropharyngeal mucosal lesions. The trial was open to patients with carcinoma of the oropharynx, hypopharynx and oral cavity being treated by external radiotherapy, with a total dose of 65 Gy at a rate of 1 fraction of 2 Gy/day, 5 days a week, from cobalt-60 or linear accelerator photons, without prior surgery or concomitant chemotherapy. Between September 1994 and March 1998, thirty patients entered this double-blind randomized study conforming to the Huriet law. The goal was to determine whether preventive HeNe laser beam applications could reduce or prevent oropharyngeal mucositis caused by radiotherapy.

Patients characteristics: There were 26 men and 4 women. Mean age was 60.4 years (range 36 - 78). Oral examination and preventive dental management were performed prior to radiotherapy. Daily oral hygiene (cleaning of the teeth and dental prosthesis) during treatment was recommended. Patients were assigned to either laser treatment (L+) or sham-treatment (L-) by computer blocked randomization. The protocol called for the inclusion of 30 patients, 15 in each arm. No associated anti-inflammatory or other treatment was authorized. Analgesics could be prescribed, but not during the 2 days preceding each week evaluation. Patients received HeNe laser applications daily for five consecutive days (Monday to Friday) each week, during the seven weeks of radiotherapy. The malignant tumor had to be located outside the areas selected for randomized preventive LLL application. Laser was delivered to the tissues by a straight optical fiber with a 1.2 mm spot size. The 9 treatment areas included : posterior third of buccal mucosa, soft palate

and anterior tonsillar pillars. Laser illumination consisted of a continuous beam (wavelength: 632.8 nm; power: 60 mW), calibrated at the end of the optical fiber every day. The treatment time (t) for each application point was given by the equation :  $t \text{ (sec)} = \text{energy (J/cm}^2) \times \text{surface (cm}^2) / \text{Power (W)}$ . The average energy density delivered to the treatment areas was 2 J/cm<sup>2</sup>, and was applied on these nine points, equally distributed on the treated surfaces, for 33 s per point (each specific LLL session lasted approximately 5 minutes). The 60 mW lasers were designed and produced by Fradama S.A. (Geneva, Switzerland). All laser illuminations were performed by the same individual in each center. This operator was the only person to know whether or not the patient was sham-treated, and did not participate in the evaluation and scoring mucositis. During the sessions, patients wore wavelength-specific dark glasses and were instructed to keep their eyes closed, to assure that they did not know whether they were sham-treated or whether they received laser applications. The laser made the same noises, and the probe was held in the mouth exactly the same way, when treating control subjects and when treating laser patients. The whole irradiation field, the oral cavity and the visible oropharynx were inspected weekly during seven weeks by the same physician (head and neck surgeon, or radiation oncologist), blinded to the result of randomization. The evaluation of mucositis and pain was performed on the oropharyngeal areas (9 points). Criteria for evaluation were the standard WHO scale for mucositis in the oropharynx; and a segmented visual analogic scale for pain (patient self evaluation). In this phase III study, no adverse effect was noted with the use of a 60-mW HeNe laser, though it is important to emphasize the importance of preventing retinal damage by the use of wavelength-specific goggles. This is consistent with previous reports. Laser applications delayed time of onset, attenuated the peak severity and shortened the duration of oral mucositis. The difference between L+ and L- patients was statistically significant from week 4 to week 7. With the total delivered dose of 65Gy, conventionally fractionated, all L- patients developed mucositis at week 2, with a peak at week 5 (13 with grade 3 mucositis, and 2 with grade 2 mucositis). All L+ patients also had mucositis at week 2, with a peak at week 5 (5 with grade 3 mucositis, 9 with grade 2, 1 with grade 1). During the 7 weeks of treatment, the mean grade of mucositis in L+ patients was significantly lower ( $p=0.01$ ) than the mean grade in L- patients. Results on decrease in pain intensity were also quite convincing. Laser applications reduced the incidence and duration of morphine administration. Ability to swallow was also improved. These results confirm previous data collected with this method, especially for patients undergoing bone marrow transplant (BMT). In a prospective study, Barasch et al. (2) used a 25- mW laser on one side of the mouth only and reported a statistically significant reduction in oral mucositis on that side, according to the scoring system they used. In the Barasch study, each patient was his or her own control, which could be of importance, since mucosal damage on the sham-treated side could have benefited also from a distant systemic laser effect. Cowen et al. (3), using a 60 mW HeNe laser, performed a double-blind randomized phase III trial, in which laser was administered to the treatment group during conditioning, prior to the day of transplant. This study showed a 33% reduction of grades 3 and 4 mucositis in L+ patients. In this trial, mucositis was scored according to an oral examination guide, with a 16 items scale, of which 4 were assessed by the patients themselves. Daily mucositis index was significantly lower in L+ patients ( $p < 0.05$ ) from d+2 to d+7 after BMT. The duration of grade 3 stomatitis was also reduced in L+ patients ( $p = 0.01$ ). Oral pain was lower ( $p = 0.05$ ), and L+ patients required less morphinomimetics ( $p = 0.05$ ). Finally, xerostomia and ability to swallow were improved among L+ patients ( $p = 0.05$ , and  $p = 0.01$ , respectively). All these results were in keeping with previous observations, suggesting the efficacy of the method (1, 4). Schubert et al. for example (4), identified a trend towards lower oral mucositis scores, on all examination days, in an interim results report of a phase I/II study, in which laser application was performed prophylactically during conditioning before BMT.

In conclusion, **LLLT seems to be a safe and efficient method for the prevention of chemo- and radiation-induced mucositis**, with a tremendous potential interest for combined modality treatment. The concomitant use of chemo- and radiotherapy is becoming the new standard of care in advanced head and neck cancer, with very encouraging results, even in nonresectable cases. Since the main limiting factor of these combined protocols is the acute mucositis, this complementary treatment option with low level HeNe laser could be important in enhancing the feasibility of such regimens, and especially in the conservation of dose-intensity effect. At Nice, where the method is now used routinely during head and neck radiation, we project a new study testing LLL in patients being treated with concomitant chemo- and radiotherapy for advanced head and neck cancer. **Even more than the improvement of patient comfort, the therapeutic index of combined specific treatment should be increased by the use of LLLT**, besides standard supportive care, oral care and enteral nutrition (5). During this study, other laser wavelengths and powers could be tested, and compared to 60-mW HeNe laser.

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## MECHANISMS OF LOW-POWER LASER LIGHT ACTION ON CELLULAR LEVEL

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Cytochrome c oxidase is discussed as a possible photoacceptor when cells are irradiated with monochromatic red to near-IR radiation. Four primary action mechanisms are reviewed: changes in the redox properties of the respiratory chain components following photoexcitation of their electronic states, generation of singlet oxygen, localized transient heating of absorbing chromophores, and increased superoxide anion production with subsequent increase in concentration of the product of its dismutation, H<sub>2</sub>O<sub>2</sub>. A cascade of reactions connected with alteration in cellular homeostasis parameters (pHi, [Cai], cAMP, Eh, [ATP] and some others) is considered as a photosignal transduction and amplification chain in a cell (secondary mechanisms).

## SEMICONDUCTOR LASER RAYS THERAPY FOR THE TREATMENT OF CHRONIC PROSTATITIS

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**Introduction:** Chronic prostatitis (ACP) hasn't a universally successful therapy yet. A lot of studies demonstrated that LASER therapy has an anti-inflammatory effect on tissues and can increase lymphatic and venous drainage reducing inflammatory swelling. For this reasons in the early 90s we proposed a new therapeutic system for ACP using semiconductor LASER rays consisting of a gallium-arsenide diode. At the beginning an endorectal probe was used; then we invented a particular endourethral probe for laser therapy. This is a brief abstract of what we achieved during these years.

**Histological preliminary studies:** Many authors studied biological effects of LASER on animal tissues (1). Before clinical practice LASER therapy was tested on a cancer cell line (SW 626) in order to evaluate if laser stimulation could increase mitosis cell rate (2) and therefore have a carcinogenic-like effect. We didn't observe any change in mitosis cell rate. Another study (3) was made on rabbits to test in vivo any immediate histopathological damages and temperature rising in rectal ampulla using transrectal probe. Temperature rising was about 2/10th of a degree centigrade. No histopathological alterations of rectal wall and the prostate were observed with particular care of signs of swelling, flogosis or fibrosis.

**Materials and methods:** The gallium-arsenide diode in use has a wave length of 904 nm and a frequency of 3000 Hz. The Laser beam reaches the prostate with a special optic probe. This is divided in two sections: one contains the laser generator, the other has five optic fibers and it is screwed onto the first creating a single body of reduced dimensions. It can be sterilized and it is atoxic. We experimented 2 different approaches to the prostate: the first was an endorectal approach and the second was an endourethral approach. At the beginning we used a "Laser Super Sonic" machine with endorectal probe according to Strada. The treatment schedule was 1 treatment every two days (treatment's time of 12 minutes, wave length 3000 Hz) for a total of 12 applications. Transrectal laser therapy was not indicated in prostate larger than 4 cm because this is the maximum depth of the laser beam's efficacy. Then we experimented an urethral probe (Med 130 Lasotronic â Wave length 820 nm, power 30 mW) in order to reduce energy leakage and increase patient's tolerability. In this case patients underwent 1 treatment every 3 days for a total of 8 applications (treatment's time of 4 minutes). From 1990 to 1999 more than 200 patients underwent this kind of treatment. We published results in previous studies (4-5).

**Clinical results:** More than 65% of the patients obtained a symptoms' relief even at 6 months after treatment. We observed a decrease in IPSS score and an improvement in maximum and mean urinary flow rate. We analyzed spermatic fluid before and after treatment (6) and we found that there was an increase in total germinal cells count, improvement in motility and in morphology. Concentration of zinc, fructose and citric acid was higher after treatment (Zinc:9.5 mg% vs 5.5 mg%; Fructose: 64.5 mg% vs 58 mg%; Citric acid: 360 mg% vs 305 mg%). Prostate ultrasounds allowed to appreciate a consistent reduction of prostate volume (21.9 cc vs 29.9 cc), probably due to resolution of oedema. Conclusion: In our experience laser therapy for chronic prostatitis can be an effective treatment in improving symptoms and modifying clinical and sonographyc parameters.

## BIOPHYSICAL ASPECTS OF LOW LEVEL LASER THERAPY

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Biophysical aspects of low level laser therapy will be discussed from two points of view: from the electromagnetic and the thermodynamical point of view. From electromagnetic point of view, living systems are mainly governed by the electromagnetic interaction whose interacting particles are called photons. Each interaction between molecules, macromolecules or living cells is basically electromagnetic and governed by photons. For this reason, we must expect that electromagnetic influences like laser light of proper wavelength will have remarkable impact on the regulation of living processes. An impressive example of this regulating function of various wavelengths of light is found in the realm of botany, where photons of 660 nm are able to trigger the growth of plants which leads among other things to the formation of buds. On the other hand, irradiation of plants by 730 nm photons may stop the growth and the flowering. Human phagocytting cells are natively emitting light which can be detected by single photon counting methods. Singlet oxygen molecules are the main sources of this light emitted at 480, 570, 633, 760, 1060 and 1270 nm wavelengths.

On the other hand, human cells (leukocytes, lymphocytes, stem cells, fibroblasts, etc) can be stimulated by low power laser light of just these wavelengths. From thermodynamical point of view, living systems - in contrast to dead organisms - are open systems which need metabolism in order to maintain their highly ordered state of life. Such states can only exist far from thermodynamical equilibrium thus dissipating heat in order to maintain their high order and complexity. Such nonequilibrium systems are called dissipative structures proposed by the Nobel laureate I. Prigogine. One of the main features of dissipative structures is their ability to react very sensibly on weak influences, e.g. they are able to amplify even very small stimuli. Therefore, we must expect that even weak laser light of proper wavelength and proper irradiation should be able to influence the dynamics of regulation in living systems. For example, the transition from a cell at rest to a dividing one will occur during a phase transition already influenced by the tiniest fluctuations. External stimuli can induce these phase transitions which would otherwise not even take place. These phase transitions induced by light can be impressively illustrated by various chemical and physiological reactions as special kinds of dissipative systems. One of the most important biochemical reaction localized in mitochondria is the oxidation of NADH in the respiratory chain of aerobic cells. A similar reaction has been found to be a dissipative process showing oscillating and chaotic behaviour capable to absorb and amplify photons of proper wavelength. A great variety of experimental and clinical results in the field of low level laser therapy supports these two biophysical points of view concerning the interaction between life and laser light. Our former, but also our recent experimental results on the effects of low level laser light on human cells are steps in this direction. By using cytometric, photometric and radiochemical methods it is shown that the increase or decrease of cells growth depends on the applied wavelengths (480, 570, 633, 700, 760, 904, 1060, 1270 nm), on the irradiance (100 - 5000 J/m<sup>2</sup>), on the pulse sequence modulated to laser beams (constant, periodic, chaotic pulses), on the type of cells (leukocytes, lymphocytes, fibroblasts, normal and cancer cells) and on the density of the cells in tissue cultures.

Our experimental results support our hypothesis which states that triplet oxygen molecules are able to absorb proper laser light at wavelength at wavelengths 480, 570, 633, 700, 760, 904, 1060, 1270 nm thus producing singlet oxygen molecules. Singlet oxygen takes part in many metabolic processes, e.g. catalytic oxidation of NADH which has been shown to be a dissipative system far from thermodynamical equilibrium and sensitive even to small stimuli. Therefore, laser light of proper wavelength and irradiance in low level laser therapy is assumed to be able to excite oxygen molecules thus influencing or amplifying metabolism and consequently influencing and supporting fundamental healing processes.

## **LOW INTENSITY LASER THERAPY (LILT) IN THE MAXILLOFACIAL REGION**

Paul Bradley The Royal London School of Medicine and Dentistry, London, England

The region of the face and mouth is well suited to Low Intensity Laser Therapy (LILT) in view of ease of access. It is also an area associated with a variety of painful conditions and intractable ulcers which have proved amenable to LILT in a total of around 500 cases. Our practise is based on several postgraduate research projects:

1. Studies of depth penetration of 820nm. These have been undertaken using a CCD camera to demonstrate penetration depths in non vital tissue specimens augmented by observations in the living subject with isotropic detectors.
2. Investigation of vascular response. A thermographic camera has been used for local heating effects while laser doppler has been employed to measure microcirculatory flux. Ultrasound doppler allowed monitoring of arterial status. A variety of wavelengths and fluxes have been investigated.
3. Double blind clinical trial in temporomandibular joint disorder pain. Methods have included algometry for pressure point thresholds, electromyography for muscular activity and sensor tracking for mandibular movement.
4. Study of effect on osseointegration of implants in jaw and femur. Research methods have involved mechanical push out testing, radiovisiography, x-ray microtomography and histomorphometry in the rabbit experimental model. On the basis of the data acquired clinical practise has been undertaken particularly in the following conditions:
  1. Post Herpetic Neuralgia,
  2. Temporomandibular Joint Disorder Pain
  3. Trigeminal Neuralgia
  4. Atypical Facial Pain,
  5. Pain from Acute Maxillofacial Trauma
  6. Palliation of Pain from Unresectable Orofacial Cancer,
  7. Intractable Oral Ulcerations,
  8. Nerve Lesions,
  9. Cavernous Haemangiomas Of the Facial Region in Infants

The results of this clinical practise are described and analysed.

## **ACTION OF 904 NM DIODE LASER IN ORTHOPAEDICS AND TRAUMATOLOGY**

Giuseppe Tam, M. D. Specialist in Legal/Insurance Medicine, Laser Center Tolmezzo - Italy

**Objective:** The semiconductor or laser diode (GaAs, 904 nm) is the most appropriate choice in pain-reduction therapy.

**Summary Background Data:** Low power density laser acts on the Prostaglandins synthesis, increasing the change of PGG<sub>2</sub> and PGH<sub>2</sub> Peroxidos into PGI<sub>2</sub> (also called Prostacilyn or Endoprostol). The last one is the main product of the Arachidonic acid into the endothelial cells and into the smooth muscular cells of the vessel walls having a vasodilating and anti-inflammatory action.

**Methods:** Treatment was carried out on 447 cases and 435 patients (250 women and 185 men) in the period between 20.05.1987 and 31.12.1999. The patients, whose age ranged from 25 to 70, with a mean age of 45 years, were suffering from rheumatic, degenerative and traumatic pathologies as well as cutaneous ulcers. The majority of the patients had been seen by orthopaedists and rheumatologists and had undergone x-ray examination. All patients had received drug-based treatment and/or physiotherapy, with poor results. Two thirds were experiencing acute symptomatic pain, while the others presented a chronic pathology with recurrent crises. We used a pulsed diode laser, GaAs 904 nm wavelength. Frequency of treatment: 1 application per day for 5 consecutive days, followed by a 2-day interval. In the evaluation of the results the following parameters have been considered: disappearance of spontaneous and induced pain, anatomic and functional evaluation of the joints, muscular growth, verbal rating scales, hand dynamometer, patient's pain diary.

**Results:** Very good results were achieved especially with cases of symptomatic osteoarthritis of the cervical vertebrae, with sport-related injuries, with epicondylitis, and with cutaneous ulcers; also, last but not of least importance, with cases of osteoarthritis of the coxa.

**Conclusions:** Treatment with 904 nm diode laser has substantially reduced the symptoms as well as improved the quality of life of the patient, thus postponing the need for surgery

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## **METHODS OF MEASUREMENT OF SELECTED OPTICAL PARAMETERS OF HUMAN TISSUES USING OPTICAL FIBER PROBE**

A.Kukwa<sup>2</sup>), Z.Jankiewicz<sup>1</sup>), D.Podniesinski<sup>1</sup>), M.Skórczakowski<sup>1</sup>), M.Tulibacki<sup>2</sup>), A.Zajac<sup>1</sup>) 1) Institute of Optoelectronics, Military University of Technology, 2 Kaliski St., 00-908 Warsaw, POLAND, tel. (48#22) 685- 93-28, fax (48#22) 666-89-50, e-mail masteer@sec.polbox.pl 2) Medical University, 30 Filtrowa St., 00-908 Warsaw, POLAND, tel. (48#22) 841-05-05,

The data available in literature concerning optical properties of tissues are for the linear absorption range, i.e., the absorption characteristics are determined for low intensity and for dead tissues sample using various measuring methods 1,2. The new optical methods of real time measurements the actual values of absorption coefficient or scattering coefficient in tissues are presented in this paper. The changes of scattering coefficient caused by laser heating of the tissue resulting in its coagulation have been measured by the method illustrated in Fig.1.

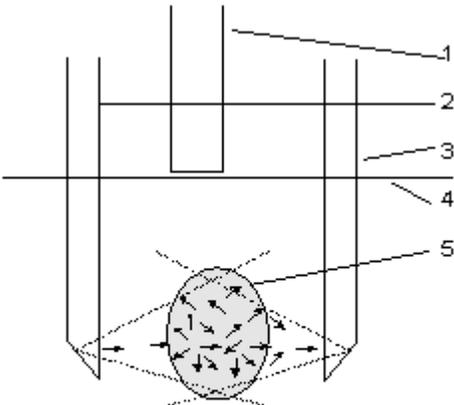


Fig. 1. Refractive fiber probe from detection of coagulation region.  
 Notations: 1 - energetic fiber, 2 - transmitting fiber, 3 - detection fiber, 4 - tissues surface, 5 - coagulated region

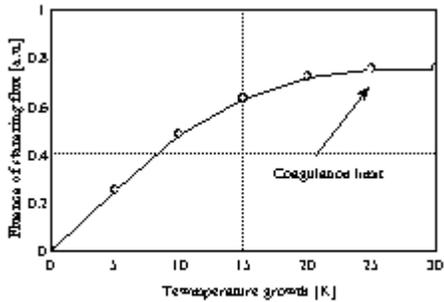


Fig. 2. The effect of coagulation moment detection

In this method the moment of stabilization of the tissue transmittance is detected (Fig.2) what corresponds with the moment of coagulation. Table 1. Measurements results of real absorption coefficient for the chosen tissues Laser type Tissue kind Threshold energy[mJ] Defect area[mm<sup>2</sup>] Absorption coefficient [cm<sup>-1</sup>] CTH:YAG liver 78 3.46 112.1 muscle 80 5.72 180.7 Er:YAG liver 10 0.82 2072 muscle 7 0.34 1228 Another method consists in detection of the moment of ablation the irradiated tissue surface - Fig.3. At the moment the backscattered light distribution is rapidly disturbed because of the vaporization of the tissue. For the vaporization process the energy is necessary the value of which can be calculated from relationship:  $E = \rho \cdot c \cdot S \cdot x$ , where S is an interaction area, x is the light penetration depth of the tissue,  $\rho$  and c is the specific density and specific heat of the tissue,  $E_p$  is the energy of tissue vaporisation. From the other side for exposition with radiation beam in the medium of volume of the energy will be absorbed the value of which depends on the value of absorption coefficient. It is expressed by:  $E = E_0 \cdot S \cdot a \cdot x$ , where  $E_0$  is the energy incident on the surface S, a is the medium absorption coefficient. Due to it for limiting (boundary) transition for  $x \rightarrow 0$  we have peak density of energy causing destruction of tissue surface, where the value 2527.2 ([J/cm<sup>3</sup>]) is results from energy balance of a phase change (from temperature 36.60C to temperature of total vaporisation). The exemplary results of the measurement are presented in Table1.

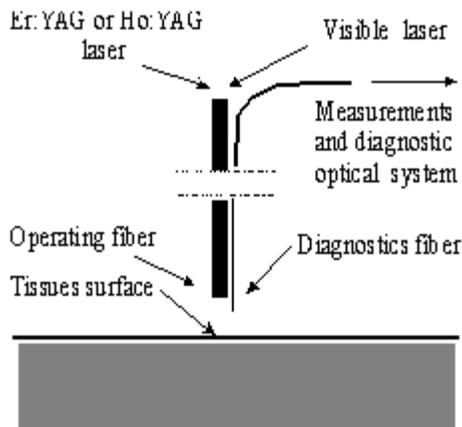


Fig.3. Scheme of a measuring system used for analysis of values of absorption coefficient during a laser treatment and for measurement of indicative beam.

Table 1. Measurements results of real absorption coefficient for the chosen tissues

Laser type	kind	Threshold energy [mJ]	Defect area [mm <sup>2</sup> ]	Absorption coefficient [cm <sup>-1</sup> ]
CTH:YAG	liver	78	3.46	112.1
	muscle	80	5.72	180.7
Er:YAG	liver	10	0.82	2072
	muscle	7	0.34	1228

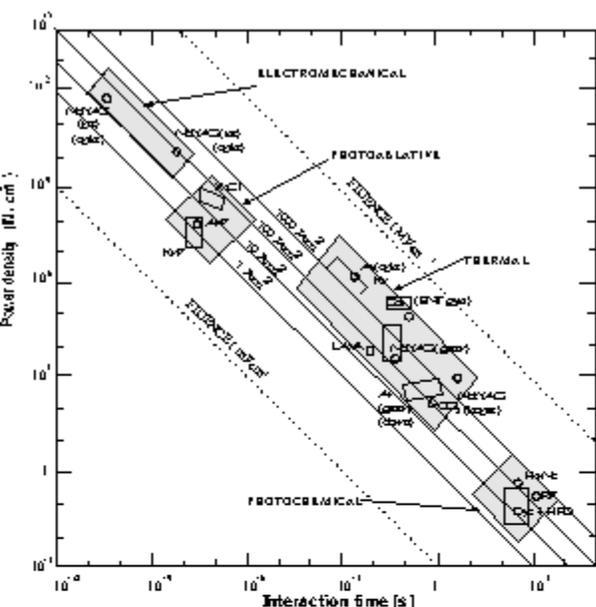


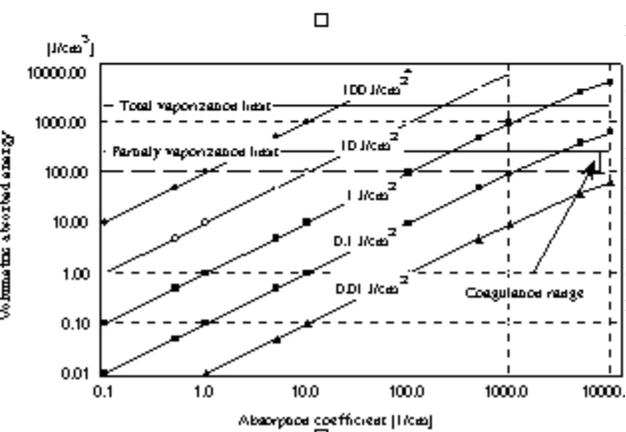
Fig.1. Typical diagram to characterized the physical processes coexist from a laser beam interaction with tissues

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### NEW METHOD OF CHARACTERISATION OF LASER BEAM INTERACTION EFFECT WITH TISSUES

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There are many laser sources emitting in the spectral range from 200 nm to 10,6mm, which are applied in medical equipment. In such a wide spectral range biological tissues change their optical parameters significantly especially the value of absorption coefficient of radiation varies considerably. In last years the scientific researches have been started in order to apply laser sources of near infrared radiation (NIR) (of wavelengths from 2000nm to 3000nm) in medical equipment. The main representatives of laser sources in this range are the following lasers: CTH:YAG (l=2080nm), Tm:YAG (l=2100nm), Er:YAG (l= 2940nm). These lasers are characterized by extremely high values of absorption coefficient in tissues (especially Er:YAG laser radiation). The typical method of classifications laser radiation interaction with tissues which is used up to now is based on well known Ledukhov's diagram [1]. In this approach the value of intensity [W/m<sup>2</sup>] or energy density [J/cm<sup>2</sup>] is the base to categorize the mechanism talking place during the interaction of radiation with biological tissues - fig.1. [2]. Fig.2. The volumetric energy density vs. tissue absorption coefficient for different fluence of laser radiation In the spectral range from 800nm to 3000nm the value of absorption



coefficient a changes from 0.174 cm<sup>-1</sup> to 13245 cm<sup>-1</sup> respectively and is extremely high or low in all optical range [3]. It is obvious that for such a huge variation of absorption coefficient we can not use the only one model of interaction of radiation with the tissue - even in the cases when the physical mechanism of absorption are identical for any sources. As the result the certain diagrams proper for the specific radiation sources are constructed. These models may be proper also for the sources characterized by comparable depth of light penetration in tissues. To characterize the processes of laser radiation interaction with tissues more precisely the new diagram has been constructed assuming that the volumetric energy density absorbed in tissues is the objective parameter, which determines the process of the interaction. In this approach it is possible to take into account the phase conversion processes such as coagulation and vaporization of biological tissues. The diagram presented on fig.2. allows to predict the results of interaction of laser radiation with tissue precisely taking into consideration the actual value of absorption coefficient characteristic for real levels of beam's fluence not as in hitherto approaches where only value of linear absorption coefficient has been considered.

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### WOUND HEALING IN ANIMALS AND HUMANS WITH USE OF LOW LEVEL LASER THERAPY-TREATMENT OF OPERATED SPORT AND TRAFFIC ACCIDENT INJURIES:

A Randomized Clinical Study. 1Zlatko Simunovic, M.D., F.M.H., 2Anthony D. Ivankovich, M.D., 3Arsen Depolo, M.D., Ph.D  
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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:** A randomized controlled study in rabbits initially evaluated the effects of laser irradiation on the healing of surgical wounds. The application of LLLT to human tissues is comparable to animal tissues of similar physiological structure, so a clinical evaluation was subsequently conducted. After surgical therapy for injuries involving the ankle and knee bilaterally, Achilles tendon, epicondylus, shoulder, wrist, or interphalangeal joints of hands unilaterally, LLLT was used in 74 patients for 18 days. Infrared diode laser (GaAlAs) 830 nm continuous wave was used for treatment of Trigger Point (TP) and HeNe 632.8 nm combined with diode laser 904 nm pulsed wave laser for scanning procedures, both applied as monotherapy during the current clinical study. The presence of redness, heat, pain, swelling and loss of function were assessed.

**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, main advantages of LLLT of postoperative sport- and traffic- related injuries are reduced exposure to side effects of drugs, significantly accelerated functional recovery, earlier return to work, training and sport competition, with cost benefit compared to control patients.

### LOW LEVEL LASER THERAPY IN DENTISTRY

1 Kresimir Simunovic, D.M.D., 2Zlatko Simunovic, M.D., F.M.H. 1Private dental practice, Locarno-Zürich, Switzerland 2Pain Clinic-Laser Center, Locarno, Switzerland

In recent years there has been increasing number of dentists using laser technology, either low or high-energy level lasers. There is no laser yet developed that totally replaces the conventional rotary instruments, but some routine work in dental practice can now be done with use of lasers This lecture will give a brief overview of dental disorders, where LLLT proved to be an efficient therapeutic procedure, whether applied as monotherapy or complementary treatment modality LLLT is mainly used for the treatment of soft tissues inside oral cavity, in order to relieve the pain or to induce wound healing, or as a diagnostic device for dental diseases like early detection of caries. Effects of LLLT are based upon biostimulative-regenerative effect, anti-inflammatory and analgesic effect

Here are some of pathological changes, which can successfully be treated with LLLT:

- Wounds after extractions
- Recovery after dental and periodontal surgical procedures
- Open and closed wound healing after minor and major oral surgery
- Lip wounds and combustions
- Abscess
- Scar tissue
- Alveolitis sicca
- Haemathoma

- Herpes labialis
- Aphthae
- Ragadae
- Mucositis
- Dentitio difficilis
- Damages of the mucosa due to the incorrectly sitting prosthesis
- Crown preparation
- Nerve lesions
- Acute and chronic disease of periodontal tissue
- Neuralgia n. trigemini
- Temporo
- mandibular joint disorders
- Trismus

This lecture will bring you exact irradiation techniques and efficient energy densities, which are determined after many years spent in the clinical application of LLLT in dentistry.

## PAIN AND PRACTICAL ASPECTS OF ITS MANAGEMENT

Zlatko Simunovic, M.D., F.M.H. Pain Clinic-Laser Center, Locarno, Switzerland

It took more than 2000 years to understand what does the pain mean. Modern technology enabled detailed investigation of pain, facilitating its better comprehension and helping us to understand that the pain, especially acute one, is a useful information. The most frequent aches are back pain and headache, followed by the neck pain, toothache and stomachache. Back pain is wide-spread condition, especially in the industrially developed countries, where it has become almost an epidemic. 30-40% of population between 10 and 65 years of age visits their physician at least once a month due to the back pain. But, as much as pain is an unpleasant sign, it is very useful and essential for the preservation of life. Pain is a warning signal, which clearly demonstrate that something goes wrong with that particular part of the body. Simply, pain is an emergency call. There are two types of pain: acute pain, which has an identifiable source and is limited in duration, and chronic pain, which develops when certain diseases associated with pain become chronic from unknown reasons or when pain mechanism goes awry. Acute pain is a symptom, while chronic pain is a disease itself. There are also different types of pain according to its origin: stress induced pain, neuropathic, nociceptive, reflected, referred, transferred, visceral, psychosomatic pain, etc. Graphic presentations of each type of pain will be discussed during the lecture. This lecture will also bring you an overview about the physiology of pain, standardised medical approaches to the patient with pain, current approaches to the treatment of pain and dysfunction, as well as different modalities currently in use for pain intensity measurement (Visual Analogue Scale-VAS, Verbal Rating Scale-VRS, 101 rating scale, McGill's Pain Questionnaire, etc). **Low Level Laser Therapy (LLLT) has been used for decades in order to relieve the pain**, as monotherapy or complementary treatment modality. One of its main mechanisms of action on the human body refers to the analgesic effects of laser beam. This effect can easily be achieved if proper application methods and technique are used, with adequate and optimal energy densities applied on human body. LLLT acts on cellular and histological level when applied on human body, where mechanisms of analgesic effect will be discussed in details. Optimal and individual range of energy densities and irradiation techniques recommended for the treatment of the musculoskeletal system will be presented in this lecture.

## LASER THERAPY - A NEW MODALITY IN THE TREATMENT OF PERIPHERAL NERVE INJURIES (Twenty-five years experience from basic science to clinical studies)

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Since our first publication (Rochkind 1978), we have been studying and testing low power laser irradiation as a means to treat peripheral nerves, using both in vitro and in vivo methods. We have reached the clinical stage and are treating a variety of peripheral nerve injuries. This study is a review of my personal experience over the last twenty-five years in the use of laser therapy in treating these conditions.

### I. Influence of Low Power Laser Irradiation on Nerve Cells

A study was done using direct 632.8nm HeNe laser irradiation to determine the effect of focused laser beams on aggregates of rat fetal brain cells and rat adult brain. The direct HeNe laser irradiation 3.6J/cm<sup>2</sup> caused a significant amount of sprouting of cellular processes outgrowth in aggregates, compared to small amounts produced by non-irradiated controls. This observation suggests that **low power laser irradiation applied to the area of an experimentally injured nerve may induce axonal processes sprouting, thereby improving nerve tissue recovery**. The mechanism of low power laser on nerve tissue is not completely understood, but some studies partially explain the photochemical effect of laser irradiation on the biological system. Cytochromes are affected, thereby stimulating redox activity in the cellular respiratory chain, thereby causing increases in ATP production which activates Na<sup>+</sup>, K<sup>+</sup> -ATPase and other ion carriers, thereby increasing cell activation.

## II. Animal Studies - influence of laser therapy on the severely injured peripheral nerve

A radiation method for treating lesions in both the peripheral and central nervous systems was proposed in 1978 by Rochkind and modified over the years. The model used in this work was the rat sciatic nerve. Low power laser irradiation then was delivered to the crushed nerve either transcutaneously or directly. The effects of this laser therapy were measured both in the short-term, i.e. minutes and in the long-term, i.e. days and months. Short-term model: direct irradiation of the nerve was done through the open wound directly to the crushed injured nerve and the compound nerve action potential was measured. A variety of wavelengths and powers were applied and 540nm, 632.8nm and 780nm were found most effective ( $p=0.01$ ). Long-term model: We found electrophysiological activity dropped as expected in the non-irradiated nerves following the crush injury, but the use of low power laser irradiation prevented or decreased this phenomenon ( $p=0.001$ ), both immediately after the crush and in the long term. Furthermore, this investigation showed that when laser treatment was delivered to both the crushed nerve and the corresponding segments of the spinal cord, the recovery time and the quality of regeneration of the crushed sciatic nerve improved, compared to the application of irradiation to the nerve alone. Histological studies supported the electrophysiological findings: low power laser irradiation was found to prevent or decrease scar tissue formation in the injured area. Laser irradiation enhanced axonal sprouting in the crush-injured sciatic nerve, thus accelerating recovery of the severely injured peripheral nerve. In addition, a beneficial effect of low power laser irradiation was found not only in the laser-treated nerve, but in the corresponding segments of the spinal cord as well. Such laser treatment has been found to decrease significantly the degenerative changes in the corresponding neurons of the spinal cord and induce proliferation of neuroglia, both in astrocytes and oligodendrocytes. This suggests a higher metabolism in neurons and a better ability to produce myelin under the influence of laser treatment. Also, low power laser irradiation exerts pronounced systemic effects on severely injured peripheral nerves and corresponding regions of the spinal cord.

## III. Double-Blind Randomized Study Evaluating Regeneration of the Rat Sciatic Nerve after Suturing and Post-Operative Laser Therapy

The therapeutic effect of low power laser irradiation on peripheral nerve regeneration after complete transection and direct anastomosis of the rat sciatic nerve was studied recently. A 780nm laser wavelength was applied transcutaneously 30 minutes daily for 21 consecutive days to corresponding segments of the spinal cord and to the injured sciatic nerve immediately after closing the wound. Positive somato-sensory evoked responses were found in 55% of the irradiated rats and in 11% of the non-irradiated rats. Immunohistochemical staining in the laser-treated group showed more intensive axonal growth and better quality of the regenerative process due to an increased number of large and medium diameter axons. IV. Clinical Pilot Studies The group of patients who were treated in the Department of Neurosurgery at Tel Aviv Sourasky Medical Center had been suffering from severe peripheral nerve and brachial plexus injuries for more than two years. Each of the 59 patients received laser treatment CW, 780nm, five hours daily for 21 consecutive days with the use of a laser system specially developed for our treatment method. Criterion for laser treatment in these cases was as follows: patients who suffered from partial motor and sensory disturbances and where surgery was not indicated. Fifty-six percent of the laser-treated patients showed good to excellent results in their motor function. V. Clinical Double-Blind Placebo-Controlled, Randomized Study of Low Power Laser in the Treatment of Peripheral Nerve Injuries Since our previous pilot clinical results were positive, a final evaluation of the response to treatment was in order. Therefore, we performed a double-blind, placebo-controlled randomized study of patients who had been suffering from incomplete peripheral nerve and brachial plexus injuries from 6 months up to several years after injury. The protocol of this study was done with the permission of the Helsinki Committee of the Tel Aviv Sourasky Medical Center and with the approval of the Ministry of Health of Israel and by a grant from the Rehabilitation Department of the Ministry of Defence of Israel. The study evaluated the functional recovery of these patients after undergoing low power laser or placebo treatment. Recovery was classified by comparing each of the deficits present before and after surgery. The post-laser or post-placebo grade was determined by the change in strength compared to the pretreatment levels. In almost all cases, the level of motor function was minimal to poor pre-treatment. In the laser-treated group, statistically significant improvement was found in motor functional activity  $P=0.0001$ , compared to the placebo group). The electrophysiological findings also showed statistically significant improvement in the laser-treated group. Our twenty-five years of experience indicates that Laser Therapy is a low-cost, non-invasive method and will be recognized as standard additional treatment for improving the functional recovery of patients with peripheral nerve and brachial plexus injuries. According to our clinical experience, the main advantages of Laser Therapy are the enhancement and acceleration of the recovery of injured nerve tissue. The therapeutic results show that an objective progressive improvement appears in nerve function, leading to a significant and earlier recovery.

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

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Among the other treatment modalities of medial and lateral epicondylitis, Low Level Laser Therapy (LLLT) has been promoted as a highly successful method. The aim of this clinical study was to assess the efficacy of LLLT using trigger points (TPs) and scanning application techniques under placebo controlled conditions. The current clinical study was completed at two laser centers (Locarno, Switzerland and Opatija, Croatia) as a double-blind, placebo controlled, crossover clinical study. The patient population ( $n=324$ ), with

either medial epicondylitis (Golfer's elbow; n=50) or lateral epicondylitis (Tennis elbow; n=274), was recruited. 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, and (3) Combination treatment (i.e., TPs and scanning technique). Bilateral cases of either type of epicondylitis (n=41) were subject to crossover, placebo controlled conditions. Laser devices used to perform these treatments were infrared (IR) diode laser (GaAlAs) 830nm continuous wave for treatment of TPs and HeNe 632.8nm combined with IR diode laser 904nm pulsed wave for scanning technique. Energy doses were equally controlled and measured in Joules/cm<sup>2</sup> either during TPs or scanning technique sessions in all groups of patients. The treatment outcome (pain relief and functional ability) was observed and measured according to the following methods: (1) short form of McGill's Pain Questionnaire (SF-MPQ); (2) Visual analogue scale (VAS); (3) Verbal Rating Scale (VRS); (4) Patient's pain diary; and (5) hand dynamometer. Total relief of the pain with consequently improved functional ability was achieved in 82% of acute and 66% of chronic cases, all of which were treated by combination of TPs and scanning technique.

This clinical study has demonstrated that the best results are obtained using combination treatment (i.e., TPs and scanning technique). Good results are obtained from adequate treatment technique correctly applied, individual energy doses, adequate medical education, clinical experience and correct approach of laser therapists. We observed that under- and over-irradiation dosage can result in the absence of positive therapy effects or even opposite, negative (i.e. inhibitory) effects. The current clinical study provides further evidence of the efficacy of LLLT in the management of lateral and medial epicondylitis.

## LOW LEVEL LASER THERAPY IN DERMATOLOGY: AN OVERVIEW OF THERAPEUTIC POSSIBILITIES

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The first application of Low Level Laser Therapy (LLLT) was completed on dermatological disorders like skin ulcers, in early sixties. In the meantime, dermatological indications for LLLT have increased. Particular effects of LLLT are observed when laser beam is applied on the open wound, which healing can be significantly accelerated especially in patients with delayed or impeded wound healing like patients with circulatory disorders, diabetic patients, etc. LLLT triggers biostimulative-regenerative processes inside the cell and subsequently causes revitalisation of the issue as well. Second effect of LLLT refers to the vasodilatation and neovascularisation of local blood and lymph vessels, thus causing a better removal of waste products and, on the other hand, improved oxygenation and nutrition of damaged tissue. Analgesic and anti-inflammatory effects of LLLT are also significant when irradiating certain dermatological changes. All effects mentioned before will be discussed in details during the lecture. Therefore, LLLT is used today in dermatology in the treatment of the following conditions: - Ulcus cruris - Burns - Herpes infections - Scar tissue - Keloid - Sclerodermia - Rosacea - Neurodermitis - Eczema - Lichen ruber planus and scrofulosus - Psoriasis - Haemathoma - Etc. Each pathological condition will be explained, and optimal and individual energy densities will be presented in this lecture.

## AESTHETIC TREATMENTS WITH LOW LEVEL LASER THERAPY

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If taking into the consideration the list of aesthetic disorders which can be treated with either Low Level Laser Therapy (LLLT) or surgical lasers, it is justified to say that laser is also the light of beauty. Although its first applications were focussed on serious diseases like skin ulcers and painful conditions, employment of LLLT in aesthetics has initiated in mid seventies. Aesthetic changes are mainly benign and they won't seriously damage the health state of patient's body, but aesthetic problems are strictly subjective and the same problem causes different psychological reaction in different persons. Development in modern medicine and technology brought many new techniques and devices, which are successfully used in aesthetics today. Laser is one of the highlights in aesthetics today where it is applied mostly for facial rejuvenation, because the face is psychologically the most sensitive aesthetic area of each person. Facial rejuvenation can be achieved with surgical lasers, which remove superficial layer of atrophic skin, leaving that area to be self-regenerated. It is an invasive method, while the process of regeneration can last few weeks even months, with a prohibition of disposing to the sunlight. On the other hand, skin rejuvenation can be completed with use of LLLT or athermal lasers like HeliumNeon (HeNe) or infrared (IR). The first one is mostly applied in the treatment of superficial changes, while the IR laser is used for irradiation of deeper structures. LLLT obtains good results in aesthetics due to its three main effects: biostimulative-regenerative, analgesic and anti-inflammatory effect, which will be presented in this lecture. LLLT can be applied in aesthetics like monotherapy or complementary treatment modality to the topic medications. Frequent indications for LLLT in aesthetics are as follows: - Acne - Cellulite - Striae - Alopecia - Wrinkles - Lentigo senile This lecture will cover all relevant details related to LLLT and each condition, with application techniques and recommended individual optimal energy densities.

## LOW LEVEL LASER THERAPY WITH TRIGGER POINTS TECHNIQUE: A CLINICAL STUDY ON 243 PATIENTS

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Among various methods of application techniques in Low Level Laser Therapy (LLLT), there is also very promising trigger points (TPs) technique. Trigger points are myofascial zones of particular sensibility and of highest projection of focal pain points due to ischaemic conditions. The effect of LLLT and the result obtained after clinical treatment of more than 200 patients turn out to be better than we have ever expected. The pathological conditions treated in this study comprised: headaches, facial pain, musculoskeletal ailments, myogenic neck pain, shoulder-arm pain, epicondylitis humeri, tenosynovitis, low back pain and radicular pain and Achilles tendinitis. According to clinical parameters, it has been observed that the rigidity decreases, the mobility is restored (functional recovery) and that the spontaneous or induced pain decreases or even disappears by movement, too. LLLT improves local microcirculation and it can also improve oxygen supply to hypoxic cells in the TPs area, while at the same time it can remove collected waste products. The normalisation of the microcirculation obtained thanks to laser application, interrupts the circulus vitiosus of the origin of the pain and its development (Melzack: muscular tension>pain>increased tension>increased pain>etc.). Results (measured according to the VAS/VRS/PTM): by acute pain-diminishment more than 70% and by chronic pain more than 60%. Clinical effectiveness (success of failure) depends upon the correctly applied energy dose - over/under dosage produces opposite, negative effects on cellular metabolism. We haven't observed any negative effects on human body and the use of analgesic drugs could be reduced or completely excluded. LLLT showed us that the laser beam could be used in the form of monotherapy or as a complementary treatment to other therapeutic procedures, above all by chronic pain treatment.

### **WHAT ARE THE THERAPEUTIC POSSIBILITIES OF LOW LEVEL LASER THERAPY IN GYNAECOLOGY, UROLOGY, AND NEUROLOGY?**

Zlatko Simunovic, M.D., F.M.H. Pain Clinic-Laser Center, Locarno, Switzerland

This lecture is based upon more than twenty years of clinical experience in Low Level Laser Therapy (LLLT) of its author. LLLT can be successfully applied in gynaecology and urology due to the specific histologic characteristics of the mucus membrane. Laser beam easily passes through the mucus membrane, thus achieving good results in the therapy of genital herpes, various types of inflammatory diseases especially in vagina and portio uteri, accelerated wound healing, etc. Particularity related to each of those fields of medicine as well as optimal energy densities and therapeutic techniques will be discussed in this lecture. Neurology is a field of medicine where LLLT can be applied either on inflammatory or degenerative (painful) disorders. The application of LLLT on the nerve system disorders is mainly due to its analgesic and anti-inflammatory effect. Here is the list of neurological diseases, which can be treated with LLLT: - Carpal tunnel syndrome - Trigeminal neuralgia - Headache - Paresis n. facialis - Radiculopathy of the spinal cord - Neuralgia post herpes zoster - Ischialgia - Paresis of various nerve branches - Peripheral nerve injury This lecture will bring you scientific explanations of LLLT treatments as well as optimal, individual energy densities and treatment techniques.

### **APPLICATION OF LOW LEVEL LASER THERAPY ON CHILDREN**

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The specificity of paediatric patients lies within their psychological and physiological differences from adults. Physiologically there is a difference in their metabolic process, hormone balance, the thickness of the skin, etc. Psychologically, children in general "see things with their own eyes" and are afraid of the physician, while the visit to the medical office represents a stress to the small patient. Children can be treated with Low Level Laser Therapy (LLLT) without causing any damage to the tissue. They accept this treatment modality very well because it is a painless and non-invasive therapeutic procedure. Indications are the same as those for adults. The only difference in the treatment of an adult and a child is in applied energy densities. This lecture will present special approach to the child and conditions, which have to be fulfilled prior to the treatment itself. Recommended energy densities will be discussed in details, with the explanation of particular contraindications in children.

### **Poster Session TREATMENT OF EPISIOTOMY USING DIFFERENT FORMS OF PHOTOTHERAPY**

Kymplova, J., Skopek, J., Navratil, L., Knizek J. Laser Centrum THERAP-TILIA, Prague, Czech Republic

Clinical section of the Department of Biophysics, 1st Medical Faculty, Charles University, Prague, VLA Hradec Kralove, Czech Republic E-mails: kymplova@atlas.cz; skopek@cesnet.cz; leos.navratil@atlas.cz Recently, we can see an increasing interest in the use of light therapy as a medical tool. It is a therapy with only minimal side effects and therefore it could be widely recommended. The problem is, that well developed and generally accepted medical protocols are not available. Broad variety of medical centers and private physicians use their own protocols, differentiate one from the other, based on more or less scientifically verified information. Gynecology and Obstetrics is one of the fields in which phototherapy is being used and the goal of our study was to make an objective

review of the possible effectiveness of different types of phototherapy in this field. Episiotomy has been chosen as the most common surgery in Obstetrics (as reported within almost 90 % of deliveries). Women giving birth were divided into four groups as follows: 1st group, as a control group, 2nd group, where polarized light of 400 - 2000 nm was used, 3rd group, in which monochromatic light (660 nm) and pulse magnetic field (8 mT, 100 Hz) were applied simultaneously, and 4th group with application of therapeutic laser (685 nm). Results of the study are summarized in the table :

Group	No of patients (n)	No of complications	
		(n)	%
Control	592	58	9,8%
Polarized light	581	3	0,5%
Combined therapy	715	8	1,1%
Laser therapy	72	1	0,7%

Acknowledgements: This study has been financially supported by Ministry of Education, grant No.: FJ MSM 111100005 (New technologies and approaches in diagnostic, prevention and treatment).

**Effect of helium-neon laser on wound healing. Indian journal of experimental biology. 1999; 37(2): 187-189  
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/cm<sup>2</sup> 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.

**Biostimulation of human chondrocytes with Ga-Al-As diode laser: 'In vitro' research. Artificial Cells, Blood Substitutes, and Immobilization Biotechnology. 2000; 28(2):193-201. Morrone G, Guzzardella G A, Tigani D et al.**

The aim of the study was to verify the effects of LLL performed with GaAlAs (780 nm, 2500 mW) on human cartilage cells in vitro. The cartilage sample used for the biostimulation treatment was taken from the right knee of a 19-year-old patient. After the chondrocytes were isolated and suspended for cultivation, the cultures were incubated for 10 days. The cultures were divided into four groups. Groups I, II, III were subject to biostimulation with the following laser parameters: 300J, 1W, 100Hz, 10 min. exposure, pulsating emission; 300J, 1W, 300Hz, 10 min. exposure, pulsating emission; and 300J, 1W, 500Hz, 10 min. exposure, pulsating emission, respectively. Group IV did not receive any treatment. The laser biostimulation was conducted for five consecutive days. The data showed good results in terms of cell viability and levels of Ca and Alkaline Phosphate in the groups treated with laser compared to the untreated group. The results obtained confirm our previous positive in vitro results that the GaAlAs Laser provides biostimulation without cell damage.

**Low-level laser effect on neurosensory recovery after sagittal ramus osteotomy. Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics. 2000; 89(1):12-18. Miloro-M, Repasky-M.**

This study examined the potential benefit of perioperative and short-term postoperative low-level laser (LLL) therapy on objective and subjective neurosensory recovery after bilateral sagittal split osteotomy surgery. Six consecutive patients undergoing bilateral sagittal split osteotomy procedures were enrolled in this prospective study. A complete preoperative clinical neurosensory test, consisting of brush stroke directional discrimination, 2-point discrimination, contact detection, pin prick nociception, and thermal discrimination, was performed on each patient; and a subjective assessment of neurosensory function was made by using a visual analog scale (VAS). The protocol for LLL treatments consisted of real LLL (4 x 6 J per treatment) along the distribution of the inferior alveolar nerve at 4 sites, for a total of 7 treatments, delivered immediately before surgery; at 6 and 24 hours after surgery; and on postoperative days 2, 3, 4, and 7. The clinical neurosensory test and VAS were completed just before each of the treatment sessions and on days 14 and 28, by one examiner. When the results of the patients treated with LLL were compared with published values for neurosensory recovery after orthognathic surgery, there was a significant acceleration in the time course, as well as in the magnitude, of neurosensory return. Brush stroke directional discrimination approached normal values by 14 days, whereas 2-point discrimination and contact detection showed significant improvement at 14 days and returned to near-normal values by 2 months. The results of thermal discrimination and pin prick nociception revealed few neurosensory deficits; however, those patients who were affected showed a slower recovery trend and remained neurosensory-deficient for up to 2 months. The VAS analysis revealed a rapidly progressive improvement in subjective assessment, showing a 50% deficit at 2 days and only a 15% subjective deficit at 2 months. This study demonstrates that neurosensory recovery after bilateral sagittal split osteotomy procedures can be significantly improved, both in terms of time course and magnitude of return of function.

**[Cytological parameters of bronchoalveolar lavage in patients with chronic obstructive bronchitis exposed to laser radiation of blood].** *Terapevticheskii arkhiv.* 1999; 71(11): 65-67. Ananchenko V G, Khanin A G, Gostishcheva O V.

Clinicocytological evaluation of the efficacy of combined treatment of chronic obstructive bronchitis (COB) in exacerbation with application of laser radiation of blood was performed. Combined treatment with the use of He-Ne intravenous and transcutaneous radiation of blood was given to 32 patients with COB. 27 COB patients treated without blood irradiation served as control. In addition to conventional methods of examination and control of the treatment effect, cytological and bacteriological tests of BAL precipitate smears were made. Combined COB treatment with the use of laser blood radiation has an antiinflammatory action, promotes normalization of mucociliary transport, activation of phagocytosis and immune defense, cleansing of bronchial tree, reduction of obstruction effective management of exacerbations. Hospitalization decreased 3-4 days. Blood irradiation has the advantages as a noninvasive method.

**Effects of 780 nm diode laser irradiation on blood microcirculation: Preliminary findings on time-dependent T1-weighted contrast-enhanced magnetic resonance imaging (MRI).** *J Photochemistry and Photobiology B: Biology* 2000; 54(1): 55-60. Schaffer M, Bonel H, Sroka-R et al.

To explore the effect of a low-power diode laser ( $\lambda = 780 \text{ nm}$ ) on normal skin tissue, time-dependent contrast enhancement has been determined by magnetic resonance imaging (MRT). In the examinations, six healthy volunteers have been irradiated on their right planta pedis (sole of foot) with  $5 \text{ J/cm}^2$  at a fluence rate of  $100 \text{ mW/cm}^2$ . T1-weighted magnetic resonance imaging is used to quantify the time-dependent local accumulation of Gadolinium-DPTA, its actual content in the local current blood volume as well as its distribution to the extracellular space. Images are obtained before and after the application of laser light. When laser light is applied the signal to noise ratio increases by more than 0.35 plus-or-minus sign 0.15 (range 0.23-0.63) after irradiation according to contrast-enhanced MRT. It can be observed that, after biomodulation with light of low energy and low power, wound healing improves and pain is reduced. This effect might be explained by an increased blood flow in this area. Therefore, the use of this kind of laser treatment might improve the outcome of other therapeutic modalities such as tumour ionizing radiation therapy and local chemotherapy.

**[The treatment of posttraumatic uveitis with low-intensity laser Radiation].** *Vestnik oftalmologii.* 1999;115 5): 20-21. inkova G A, Ionin A P, Ionina G I.

Eighty-two patients with severe posttraumatic uveitis (eye inflammation) which could not be treated by traditional antiinflammatory therapy were exposed to LLLT. The patients were divided into 3 groups: - infrared laser exposure semiconductor pulsed laser, - intravenous exposure of the blood to a He-Ne laser and - both treatments. The treatment efficacy was monitored by measuring lipid peroxides and superoxide dismutase in the lacrimal fluid. The treatment proved to be effective. The best results were attained by applying both methods of exposure, as was shown by sooner normalization of the content of lipid peroxidation products and activity of superoxide dismutase.

**Relief of low back pain with low-reactive laser acupuncture techniques.**  
Kurland H D. *Aku.*1999; 27(4):24.

12 patients who had refractory low back pain problems related to spinal arthritis and complicated by herniated discs were treated with GaAs laser acupuncture. Nogier frequencies 2.82 and 146 were mainly used. Used points not indicated in abstract. Effectiveness was observed with immediate improvement in pain and muscle spasms. Elimination of pain medication and improvement in functional activities was progressive in 10 of the 12 patients. Two patients with spinal stenosis failed to maintain improvement for more than a brief period. One had surgical relief of the stenosis and then responded with relief of post-operative symptoms.

**Complex treatment of non-specific ulcerative colitis with low-level HeNe laser used transanally**  
Dubinkin V A, Mimrikova E G.

81 patients (average age 42) with non-specific ulcerous colitis were treated with trans-anal HeNe laser. After 10-12 sessions 72% of the patients noted a reduction of pain and the stool became rare. Colonoscopy showed that the mucous membrane regenerated rapidly with an increased vascular picture.

**The comparative analysis of using lowpower laser radiation, magnetic therapy and electrical stimulation in stabilization of visual functions in primary open-angle glaucoma.** Listopadove N A et al.

127 men with primary open-angle glaucoma (POAG) were treated with either L/LLT, magnetic therapy or electrical stimulation. The examination included visus, visiocontrastometry and automatic static perimetry. The field of sight at an initial stage of POAG was 56% of laser, 52 for magnetic therapy and 27 for electrical stimulation. In the advanced stage the figures were 39, 37 and 18, respectively.

### **Treatment of myopia with helium-neon laser stimulation. Rabadanova M G et al.**

A new technique of stimulating the ciliary muscle in cases of progressing myopia is described. The positive results have been confirmed through measurement of the intraocular pressure, refraction reduction and increase of visual acuity.

### **Low-intensive laser therapy in complex treatment of patients with astrakhn rickettsial fever in the period of convalescence. Kasatkin S N et al.**

LLLT in the complex treatment of patients with astrakhn rickettsial fever caused a quicker disappearance of arthromyalgias and an improvement in the general health of the patients.

### **Dynamics of lipid metabolism and peripheral blood flow rates in patients with atherosclerosis in conjunction with renal dysfunction after the course of combined laser therapy. Kovalyova T V et al.**

During an 8 year period patients with atherosclerosis and renal dysfunction have been treated with intravenous laser blood irradiation (ILBI). The study has demonstrated a decreased level of total cholesterol, LDL cholesterol and triglycerides with an simultaneous increase of HDL cholesterol levels. No pharmaceuticals were given during the treatment period. The authors state that ILBI results in a stable hypolipidemic situation which prevents atherogenesis in patients with metabolic disorders, particularly in patients with renal pathologies.

### **Clinical-pathogenetical aspects of combined laser therapy efficiency use in patients with diabetes mellitus, as compared with pharmacologic therapy. Kovalyova T V et al.**

Long-term observations of the effect of ILBI in the treatment of patients with diabetes mellitus is reported. ILBI decreases the need for sugarcorrecting medications in patients with DM I and DM II 1.5-2 times, already after the first treatment. ILBI also improves microdynamics, macrodynamics and hemorheology in patients with diabetic anginopathies. A period of 3-6 month is needed to stop the progress of diabetic angiopathies.

### **Dynamics of hyperlipidemia and peripheral blood flow in patients with diabetes mellitus after the course of combined laser therapy in ambulatory-polyclinic conditions. Oprysko T V et al.**

218 patients with DM were treated with laser blood irradiation. 93 patients had DM I type and 125 DM II type. A HeNe laser of 2 mW was used intravenously. In addition an infrared 890 nm laser (5-20 mW) was used for irradiation over the projections of the liver, spleen and pancreas. Treatment was given daily for a period of 8 days. Repeated sessions were given at 3 and 6 months. Sugar correcting medications were decreased 200%. From the first day the patients' extremities grew warmer, pain decreased and symptoms of encephalopathy decreased. Levels of total blood cholesterol, LDL cholesterol and triglycerides decreased to normal values with a simultaneous increase of alpha-LP. Sugar concentration in blood also decreased.

### **The effect of laser therapy in complex treatment of patients with rheumatoid arthritis. Korolkova O M et al.**

115 patients with rheumatoid arthritis (RA) of II-III degrees were treated with basic RA medications and infrared laser. In a control group of 20 patients only basic medication was given. 10 areas of the body were irradiated daily, increasing the dose every day during a period of 8-10 days. The effectiveness of the therapy was controlled through laboratory tests on i.a. inflammatory agents and the activity of lipid peroxidation. The results were statistically significant. The best effect was found in patients with degree II RA. Steroid medication could be reduced 8-10 days earlier in this group of patients and in some cases the medication could even be excluded. Degree III patients had a more moderate benefit of the laser treatment.

### **Longterm experience of endovascular laser irradiation in myocardial infarction. Maximov N I et al.**

HeNe intravenous laser irradiation is reported to decrease the reinfarction rate in patients with a story of myocardial infarction. A 2 mW HeNe laser was used, 40 min. duration each session

### **The transforming role of biological acceptor in the reaction of a low-intensive laser irradiation. Burlakov A B et al.**

The influence of low level laser on unfertilized oocytes and spermatozoons of fish was studied. HeNe and GaAs 862 nm was used. High quality eggs (fertilization above 70%) were not influenced by laser light. The development in eggs of mean quality (fertilization 30-60%) was boosted and the best effect was found in poor quality eggs (below 20%). The fertilization rate and the reduction of the number of abnormal developing embryos was measured. After temperaturational inactivation both oocytes and spermatozoons, the

irradiation not only restored the movability and fertilizing capacity, but also promoted the development of inactivated oocytes after fertilization by the irradiated spermatozoons. Red and infrared light had different effects.

#### **Cellular mechanisms of low power laser therapy. Karu T I.**

Cytochrome c oxidase is discussed as a possible photoacceptor when cells are irradiated with monochromatic red to near-IR radiation. Five primary action mechanisms are reviewed: changes in the redox properties of the respiratory chain components following photoexcitation of their electronic states; generation of singlet oxygen, localized transient heating of absorbing chromophores release of NO, and increased superoxide anion production with subsequent increase in concentration of the product of its dismutation, H<sub>2</sub>O<sub>2</sub>. A cascade of reactions connected with alternation in cellular homeostasis parameters (pHi, [Ca<sup>2+</sup>], Eh, [ATP] and some others) is considered as a photosignal transduction and amplification chain in a cell (secondary mechanisms)

#### **Experimental study of low level laser radiation effects on human blood cells. Siposan D, Adalbert L (Bucharest, Roumania).**

Fresh blood from 40 apparently healthy individuals has been irradiated with a low level HeNe laser, using EDTA anticoagulant. Doses ranged between 0-54 J/cm<sup>2</sup>. The authors watched the relative variation to the received doses of hemoreological constants - erythrocytary and leukocyetary indices, as well as the variation of some erythrocytary aggregability indices-viscosity, BSR. Following irradiation a lowering of the erythrocytary aggregability (viscosity), BSR, and changes of some erythrocytary and leukocyetary indices have been observed. The effect of low-level laser radiation on the red cell confirms the non-resonant mechanism of this bio-stimulating radiation effect by the changes in the cell membrane, in our case the blood cells, by revitalizing the red blood cell functional capacities and by several biochemical effects on the membrane level, that are to be studied thoroughly in future studies. It is concluded that the physical-biochemical and biological effects on blood can influence the physical-chemical parameters needed for long storage of blood products as well as the quick revitalization of the erythrocytary membrane aggressed physically and biochemically, in order to perform its oxophoric function in transfusion procedures.

#### **Human gingival fibroblast proliferation enhanced by LLLT. Almeida-Lopes L. [Analysis in vitro of the cellular proliferation of human gingival fibroblasts with low level laser.] 1999. Dissertation at Universidade do Vale do Paraíba, São Paulo, Brazil.**

Human gingival fibroblast were cultured in Petri dishes with different Fetal Bovine Serum concentration, 5% or 10%. Four irradiations of 2 J/cm<sup>2</sup> were given with 12 hours intervals. Lasers with 670, 692, 780 and 786 nm were used. Cells in 5% FBS profilerated better than in all control groups whereas the cells in the 10% FBS did not proliferate better than controls. The 670 and 692 visible lasers caused a higher improvement in cell proliferation that the infrared lasers. This study confirms the fact that cells in a less-than-optimal stage react better to LLLT than cells in an optimal nutritional stage. It also confirms that visible red is the best wavelength for suferficial wound healing.

#### **PhD dissertation on TMD problems**

Dr Sajee Sattayut of The Department of Oral & Maxillofacial Surgery, St Bartholomew's and the Royal London School of Medicine and Dentistry (professor Paul Bradley) has put forward his PhD thesis on the effect of 820 nm low level laser on patients with TMD (temporo-mandibular-joint-disorders). In a double blind study on 30 female TMD patients one group was given placebo laser, one a low dose from a 60 mW laser and the third a high dose from a 300 mW GaAlAs laser. Three treatments were given during one week. The patients in the high energy density group had significantly increases in Pressure Pain Threshold and EMG amplitude, recorded from voluntary clenching. A significantly greater number of patients recovered from myofacial pain and TMJ arthralgia as assessed clinically in the higher energy group. At a period of 2 to 4 weeks review after LLLT, there was an average 52% reduction of pain as assessed by Symptom Severity Index pain questionnaire. In an in vitro study laser was observed to reduce IL-1 stimulated PGE<sub>2</sub> production.

#### **Navrátil L, Navrátilová B. Possibilities of the treatment of certain diseases in stomatology with the help of non-invasive laser therapy.**

382 dental patients were evaluated. The results demonstrated the contribution of therapeutic laser to the treatment of herpetic affections, aphtae, erosions, decubiti on the mucous membrane, conditions after difficult extractions, papilitis, wounds after teeth resection, lingua geographica, scar and dentintal hypersensitivity.

#### **Passeniouk A M, Michailov V A. A comparison between laser therapy and drug therapy in the treatment of vaginitis**

30 women with non-specific vaginitis and vaginal candidiasis were treated with LLLT and topical chlorhexidine application daily for ten days. 20 women with the same condition were treated with metronidazole (10 g as course dose) and fluconozole (150 mg single dose) and vaginal application of metronidazole. The results suggest that local laser therapy is able to remove signs of vaginitis more

efficiently than drug therapy. Repair of normal vaginal microflora was significantly faster in the laser group. There were no side effects in the laser group whereas there were women on drug therapy who reported side effects.

#### **Ailioaie C, Ailioaie L. The treatment of bronchial asthma with LLLT in attack-free period in children.**

98 patient aged 10-18 years, diagnosed with moderate or severe asthma were divided into three groups. -Group 1: 35 patients received laser acupuncture using extrameridian acupuncture points plus scanning. Lasers used were 670 and 830 nm, 50 and 200 mW respectively, in continuous mode. Treatment was given twice daily 10 days per month, 3 months in total. No other therapy was given. - Group 2: 33 patients inhaled Salmeterol xinofoat 2 x 25, twice daily for 3 months. -Group 3: 30 patients were treated with Theophylline retard 15 mg/kg every 12 hr for 3 months. Results: A noticeable improvement in the clinical, functional and immunological characteristics were observed in 83% of the patients in group 1, 70 in group 2 and 53 in group 3. There were no side effects in the laser group.

#### **Simunovic Z, Ivankovich A D, Depolo A. 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.**

A wound healing study on rabbits suggested that 4 J/cm<sup>2</sup> 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.

#### **Schaffer M et al. Effects of 780 nm diode laser irradiation on blood microcirculation - study by time dependent T1-weighted enhanced magnetic resonance imaging (MRI).**

Six healthy volunteers were irradiated on their right planta pedis with 5J/cm<sup>2</sup> and a fluence rate of 100 mW/cm<sup>2</sup>. T1-weighted MRI was used to quantify the time-dependent local accumulation of Gadolinium DPTA, which semi-quantitatively reflects local blood flow. Images were obtained before and after laser application. LLLT resulted in an increase of signal to noise ratio of more than 0.34 (range 0.23-0.63) after irradiation according to contrast enhanced MRI. Increased blood flow offers an explanation for the clinical observation of improved wound healing and reduced pain after LLLT. The effect might complete and improve the outcome of other therapeutic modalities such as tumor ionizing radiation therapy and local chemotherapy.

#### **Schaffer M et al. Magnetic resonance imaging (MRI) controlled outcome of ionizing radiation side effects treated with 780 nm diode laser, preliminary results.**

Three women with painful mastitis after breast ionizing irradiation and a man with an ionizing ulcer were treated with 780 nm, 5 J/cm<sup>2</sup>. The healing of the ulcers was controlled using MRI measurement before and after treatment. In all patients a complete clinical remission was noted following LLLT. The results were confirmed by a decrease in inflammatory changes as depicted in MRI imaging.

#### **Tunér J, Hode L. 100 double blind studies- enough or too little?**

There are more than 100 positive double blind studies in the field of Low Level Laser Therapy. This is more than the critics seem to be aware of. However, in a thorough Medline search only 26 of these studies were found. 34 of the 100 studies have only been found as abstracts and another ten only as references. The average rating for parameter account (1-5 with 5 high) was 3.0. The 56 fully published studies had a better score, 3.6. The number of indications studied was 18. In conclusion, the positive double blind studies are more than usually expected but they are difficult to find.

#### **Bjordal J M. Low level laser therapy can be effective for tendinitis: a meta-analysis.**

A literature search identified 77 randomized clinical trials with LLLT, of which 18 included tendinitis. Three trials were excluded for lack of placebo control, of which one was comparative, another lacked patients with tendinitis in the treatment group, while the last unwittingly gave the placebo group active treatment. Four trials used too high power density or dose, and three did not expose the skin directly overlying the injured tendon. The remaining eight trials were included in a statistical pooling, where the mean effect of LLLT over placebo in tendinitis was calculated to 29.5% (19.5-39.0). LLLT with optimal treatment procedure/parameters can be effective in the treatment of tendinitis.

#### **Hode L, Tunér J. Low Level Laser Therapy (LLLT) contra Light Emitting Diode Therapy (LEDT) - what is the difference?**

While LEDT has been found to be a good treatment modality for many indications such as wound healing and pain, no study, so far, has demonstrated that LEDT is better than LLLT, nor that it is as effective as LLLT. In the literature, 15 studies have been identified, comparing coherent and non-coherent light therapy. In all these studies LLLT has been shown to give better results. Yet, it is not uncommon for LEDT salesmen to make reference to LLLT research, as LEDT and LLLT would be the same. Coherent light gives typical laser speckles, small zones of polarized light. The coherence is not lost (as often claimed) when laser light penetrates tissue, but the length of coherence is reduced. The penetration of the coherent light can be studied in the following manner: A specimen of freshly minced beef is placed between two pieces of glass. On one side a red laser, a light torch and a red LED light is placed. When activated the three light zones can be seen on the reverse side of the beef plate. All light zones are red (demonstrating the penetration capacity of red light), but only the laser light demonstrates speckles. Thus, the coherence has been maintained even after the penetration of the meat.

#### **Prochazka M, Tejska R. Comprehensive therapy of patients suffering from tinnitus.**

37 patients suffering from tinnitus (age 18-86 years) were treated in three ways: 1. Rehabilitation: mobilisation, physical training, physiotherapy. 2. Same as 1 but with placebo laser added. 3. Same as 1 but with functional laser added. Laser used was 830 nm 300 mW. 2-3 treatments per week were given, total 10 treatments. Treatment protocol: 90 J/cm<sup>2</sup> CW on mastoideus, 45 J/cm<sup>2</sup> 5 Hz on mastoideus, 50 J/cm<sup>2</sup> CW on acoustic duct, 25 J/cm<sup>2</sup> 5 Hz on acoustic duct. Tebokan Egb 761 ginkgo medication was added to treatment. Results were classified as no effect/less than 50% relief/more than 50% relief/no more tinnitus. The percentwise outcome for the three groups was: 1. 29.4/44.1/17.6/8.9 2. 25.8/48.4/25.8/0 3. 19.4/19.4/35.5/25.8

#### **Beyer W et al. Light dosimetry and preliminary clinical results for low level laser therapy in cochlear dysfunction.**

The light distribution inside the cochlear windings produced by irradiation of the tympanic membrane was quantitatively measured ex vivo for wavelengths of 593, 612, 635, 690, 780 and 805 nm by means of video dosimetry. The transmission of light across the tympanic cavity and the promontory depends strongly on the wavelength. Spatial intensity variations of a factor of 10 and more inside the cochlear windings have been measured. The clinical study was performed with 30 patients suffering from chronic permanent tinnitus. 5 irradiations within 2 weeks each with a space irradiation of 4J/cm<sup>2</sup> were applied at the cochlear position to be treated. Diode lasers of 635 or 830 nm, 15 patients each, were used. During and after irradiation there was no significant change of hearing. However, 40% of the patients reported a slight to significant attenuation of the tinnitus loudness of the treated ear. There was no difference between the two wavelength groups. A double blind controlled study is in preparation.

#### **Schindl A, Neuman R. Low-intensity laser therapy is an effective treatment for recurrent herpes simplex infection. Results from a randomized double-blind placebo controlled study.**

J Investigative Dermatology. 1999; 113 (2): 221-223.

50 patients with recurrent perioral herpes simplex infections (at least once a month for more than 6 months) were treated with 690 nm, 80 mW laser, 48 J/cm<sup>2</sup>, in a double blind study. Patients received daily irradiations for two weeks, 10 treatments. The treatment was given in a recurrence-free period and the irradiation was given at the site of the original herpes simplex infection. If both lips were involved, both upper and lower lips were treated. Patients were monitored for 52 weeks. The mean recurrence-free interval in the laser group was 37.5 weeks (range; 2-52 weeks) and in the placebo group 3 weeks (range 1-20 weeks). No side effects were noted.

#### **Review article: Marks R, de Palma F. Clinical efficacy of low power laser therapy in osteoarthritis.**

Physiotherapy Research International. 1999; 4 (2): 141-57.

Of the various physical interventions used to relieve the symptoms of osteoarthritis, a common degenerative joint disease causing considerable pain and disability, low power laser therapy has been reported to be extremely successful in Russia and Eastern Europe. Although the overall number of studies was small, this literature review and analysis highlights the relevant controlled clinical trials and related basic research in English-language publications. This review indicates that, despite their shortcomings, the six studies analysed did report post-treatment improvements in a variety of osteoarthritic problems, including pain, mobility, tenderness and function, with few adverse effects. Possible mechanisms documented for the observed results included peripheral nerve stimulation, resolution of inflammation, enhanced chondrocyte proliferation and increased matrix synthesis. Not all studies were affirmative and few detailed how reliable their measurements were. Clearly, much more work is needed in this area.

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 8mm circular full thickness hole. The irradiated rats received the 630nm 5 J/cm<sup>2</sup> 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.

**The interauricular laser therapy of rheumatoid arthritis. Sidorov-V-D, Mamiliaeva-D-R, Gontar-E-V, Reformatskaia-SIu.** Vopr-Kurortol-Fizioter-Lech-Fiz-Kult. 1999; (3): 35-43.

Investigations have proved the ability of interauricular low- intensity infrared laser therapy (0.89  $\mu\text{m}$ , 7.6 J/cm) to produce anti-inflammatory, immunomodulating action in patients with rheumatoid arthritis. The method has selective, pathogenetically directed immunomodulating effect the mechanism of which is similar to that of basic antirheumatic drugs and of intravenous laser radiation of blood. This laser therapy can be used as an alternative to intravenous blood radiation being superior as a noninvasive method. Interauricular laser therapy can potentiate the effects of nonsteroid anti-inflammatory drugs, cytostatics and diminish their side effects.

**.Low-intensity laser therapy for benign fibrotic lumps in the breast following reduction mammoplasty. Nussbaum-E-L.** Physical Therapy. 1999; 79 (7): 691-698.

Fibrotic masses in the breast secondary to fat necrosis or hematoma are a complication of breast reduction mammoplasty. The treatment commonly recommended for this condition is early surgical debridement of necrotic tissue from the entire area, which causes scarring. This case report describes the use of low- intensity laser therapy for fibrotic lumps following reduction mammoplasty. Case Description: The patient was a 46-year-old woman who had breast reduction surgery 80 days prior to referral for physical therapy. At the time of referral, the largest mass was 8.0 cm in diameter. The patient reported pain and said she was distressed about the breast disfigurement. Laser irradiation was initiated at an energy density (ED) of 20J/cm<sup>2</sup> and a pulse repetition rate of 5,000 pulses per second. The laser settings were adjusted during the 8-month treatment period. The final ED was 50J/cm<sup>2</sup>. The mass was 33% of its original size after 3 treatments over the initial 11-day period. Pain relief was immediate. The rate of resolution decreased after the initial period. The patient had some tissue thickening at the time of discharge after 6 months of treatment.

**Laser therapy: a randomized, controlled trial of the effects of low-intensity Nd:YAG laser irradiation on musculoskeletal back pain. Basford-J-R, Sheffield-C-G, Harmsen-W-S** Arch-Phys-Med-Rehabil. 1999; 80 (6): 647-52, .

This study was assessed to investigate the effectiveness of low-intensity Nd:YAG laser therapy in the treatment of musculoskeletal low back pain as a double-masked, placebo-controlled, randomized clinical trial. 63 ambulatory men and women between the ages of 18 and 70 years with symptomatic nonradiating low back pain of more than 30 days' duration and normal neurologic examination results took part. Subjects were bloc randomized into two groups with a computer-generated schedule. All underwent irradiation for 90 seconds at eight symmetric points along the lumbosacral spine three times a week for 4 weeks by a masked therapist. The sole difference between the groups was that the probes of a 1.06 micron Nd:YAG laser emitted 542mW/cm<sup>2</sup> for the treated subjects and were inactive for the control subjects. The treated group had a time-dependent improvement in two of the three outcome measures: perception of benefit and level of function. These results were most marked at the midpoint evaluation and end of treatment but tended to lessen at the 1-month follow-up. Lumbar mobility did not differ between the groups at any time. Treatment with low-intensity 1.06 micron laser irradiation produced a moderate reduction in pain and improvement in function in patients with musculoskeletal low back pain. Benefits, however, were limited and decreased with time.

**Laser's effect on bone and cartilage change induced by joint immobilization: an experiment with animal model. Akai M, Usuba M, Maeshima T, Shirasaki Y, Yasuoka S.** Lasers Surg Med. 1997. 21(5): 480-4.

The influence of low-level (810 nm) laser on bone and cartilage during joint immobilization was examined with rats' knee model. The hind limbs of 42 young Wistar rats were operated on in order to immobilize the knee joint. They were assigned to three groups 1 wk after operation; irradiance 3.9 W/cm<sup>2</sup>, 5.8 W/cm<sup>2</sup>, and sham treatment. After 6 times of treatment for another 2 wk both hind legs were prepared for 1) indentation of the articular surface of the knee (stiffness and loss tangent), and for 2) dual energy X-ray absorptiometry (bone mineral density) of the focused regions. The indentation test revealed preservation of articular cartilage stiffness with 3.9 and 5.8 W/cm<sup>2</sup> therapy. Soft laser treatment may possibly prevent biomechanical changes by immobilization.

**Clinical results evaluation of dentinary hypersensitivity patients treated with laser therapy. Brugnera A, Cruz FM, Zanin FA & Pecora JD.** Proc. SPIE Vol. 3593, 1999, p. 66-68.

300 human teeth were treated for hypersensitivity during the period 1995-1997. Pulpal vitality was verified using thermal tests, and only reversible processes were treated. HeNe and GaAlAs lasers were used. All teeth received 4 J/session, up to 5 sessions. 79% of the patients were treated in 3 sessions with success; 8.6% were cured in 4 sessions; and 4.3% were successfully treated in 5 sessions, obtaining 92% success in total.

**Stimulatory effect of 660 nm low level laser energy on hypertrophic scar-derived fibroblasts: possible mechanisms for increase in cell counts. Webb C, Dyson M, Lewis WH.** Lasers Surg Med. 1998; 22(5):294-301.

The experiments investigated the effect of a 660 nm, 17 mW laser diode at dosages of 2.4 J/cm<sup>2</sup> and 4 J/cm<sup>2</sup> on cell counts of two human fibroblast cell lines, derived from hypertrophic scar tissue and normal dermal tissue explants. Estimation of fibroblasts utilized

the methylene blue bioassay. Post-660 nm-irradiated hypertrophic scar fibroblasts had very significantly higher cell counts than controls.

### **Histometrical Evaluation of the Healing of the Dental Alveolus in Rats After Irradiation with a Low-Powered GaAlAs Laser**

Rosane F. Z. Lizarelli\*; Tereza L. Lamano-Carvalho\*\*; Luis G. Brentegani\*\* \*Physics Institute of São Carlos, University of São Paulo, São Carlos, SP, Brazil. 13560-970 \*\*College of Dentistry of Ribeirao Preto, University of São Paulo, Ribeirao Preto, SP, Brazil. 14.040-000 LIZARELLI, R. F. Z.; LAMANO-CARVALHO, T. L.; BRENTEGANI, L. G.

Histometrical evaluation of the healing of the dental alveolus in rats after irradiation with a low-powered GaAlAs laser. in Lasers in Dentistry V, John D. B. Featherstone, Peter Rechmann, D.D.S., Daniel Fried, Editors, Proceedings of SPIE Vol. 3593, p. 49-56, 1999. ABSTRACT The aim of the present work was to evaluate histometrically the effect of the irradiation with semiconductor diode GaAlAs 790 nm low-powered laser in the chronology of alveolar repair of rats.

Lasers of low intensity possesses an eminently analgesic, anti-inflammatory and bioestimulant effect, producing an increase of the local micro-circulation and in the speed of healing. Groups of five animals had their upper right incisors extracted under anesthesia and the mucous sutured; three groups received 1.5 J/cm<sup>2</sup> of irradiation immediately after the extraction with laser for sweeping on the operated area. After that, the animals were sacrificed in the periods of 7, 14 and 21 days after the dental extraction. The material was decalcified and processed for inclusion in paraffin. Longitudinal sections of 7 micrometers in the alveolus were made and stained with HE. The histometric analysis was performed with the Merz grid, and 2000 points were counted in each cervical, middle and apical thirds of the alveolus, assessing the percentage of the bone tissue. The results shows that low-powered intensity laser produced acceleration in osseous formation (10%) in some periods. The influence of low-powered laser on the healing process is more significant when we can apply the laser light just after the tissue trauma. Cells with a lower than normal pH, where the redox state is shifted in the reduced direction, are considered to be more sensitive to the stimulate action of light than those with the respective parameters being optimal or near optimal. The proposed redox-regulation mechanism may be a fundamental explanation for some clinical effects of irradiation, a consequence of this was the difference between the groups of 7 days is more significant than between the other groups.

### **Wound healing Waynant R, US Food & Drug Administration: results from a preliminary wound healing trial.**

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

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 8mm circular full thickness hole. The irradiated rats received the 630nm 5 J/cm<sup>2</sup> 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.

### **Lymphadenitis**

Oasevich I A, Shargorodskii A G. (Low-intensity infrared laser radiation in the diagnosis and combined treatment of acute nonspecific lymphadenitis of the face and neck in children) Infrakrasnoe nizkointensivnoe lazernoe izluchenie v diagnostike i kompleksnom lechenii ostrogo nespetsificheskogo limfadenita litsa i shei u detei. Stomatologiya (Mosk). 1999; 78 (2): 28-30,

The clinical course of acute nonspecific lymphadenitis of the face and neck was studied in 241 patients aged 1-14 years, in order to improve the diagnosis and therapy of this condition. General clinical examinations were supplemented by laser biophotometry and assessment of the activities of some local defense factors (lysozyme, beta-lysine, secretory and serum IgA). Multiple-modality treatment for the first time included magnetic laser therapy (MLT), and its efficacy was assessed. Results of biophotometry helped define the objective criteria for the diagnosis and evaluation of the treatment efficacy in children with acute lymphadenitis of the face and neck. MLT proved to be a highly effective treatment modality, decreasing the inflammation and correcting oral factors. Use of MLT accelerated all phases of the inflammatory process, promoted its regression at the serous stage, and decreased the incidence of suppurative forms of acute lymphadenitis by 40%.

### **Nerve effects**

a) Ohno T. Pain suppressive effect of low power laser irradiation. A quantitative analysis of substance P in the rat spinal dorsal root ganglion. J Nippon Med Sch. 1997; 64 (5): 395-400. (In Japanese with English abstract)

Under anesthesia, the right sciatic nerve of 41 rats was exposed. 13 rats received laser irradiation and electrical stimulation, 16 rats only electrical stimulation and 12 served as control. Immediately after the electrical stimulation, with or without laser irradiation,

DRG of the 4th to 6th lumbar spinal roots were excised. Immunohistochemical substance P staining and substance P-like immunoreactivity (SP-LI) quantification were done in the excised DRG. There was a statistically significant difference of SP-LI between the control group and the stimulated group. There was no statistically significant difference between the laser irradiation only group and control. These results suggest that **laser irradiation suppresses the excitation of the unmyelinated C-fibers in the afferent sensory pathway.**

**b) Tsuchiya K et al. Diode laser irradiation selectively diminishes slow component of axonal volleys to dorsal roots from the saphenous nerve.** Neuroscience Letters. 1993; 161: 65-68.

GaAAs laser irradiation inhibited the action potentials in the dorsal roots elicited from the saphenous nerve of the rat. After 830 nm irradiation to the nerve, the amplitude of slower conduction parts of action potentials (<12 m/s) were suppressed. The suppression was dose dependent. After 3 minutes of irradiation the slowest conduction velocity group (<1.3 m/s) were totally diminished and the 1.3-12 m/s group were reduced to 12-67%. In contrast, faster component (>12 m/s) was unaffected by the irradiation. It is suggested that laser irradiation may selectively target fibers conducting at slow velocities which include afferent axons from nociceptors.

**Dental Kurumada F. A study of the application of Ga-As semiconductor laser to endodontics. The effect of laser irradiation on the activation of inflammatory cells and the vital pulpotomy.** J Clinical Pediatric Dentistry. 1995; 19: 232.

The effects of GaAs on the activation of macrophages and fibroblasts were examined by determining the rate of glucose utilization into the cell and the activity of lactate dehydrogenase in culture supernatant. The irradiated macrophages that had been prepared from the peritoneal exudate cells, did not show any enhancement of activity, whereas the fibroblast cell line was activated by laser irradiation.

These findings suggest that GaAs **irradiation was effective for the growth of fibroblasts and induced suppressive effects for macrophages.** Further, the effects of laser on the vital pulpotomy were investigated. It was observed that **irradiation induced enhancement of calcification in the wound surface and stimulated formation of calcified tissue.** These observations indicate that **laser irradiation is a useful method for the vital pulpotomy.**

#### **Laser acupuncture reduces postoperative vomiting.**

In a double blind, randomized, placebo controlled study the effectiveness of **point P6 acupuncture** on postoperative vomiting in children undergoing strabismus (eye) surgery, was studied. A 10 mW 670 nm laser was used and the P6 point was irradiated for 30 seconds 15 minutes before anesthesia and 15 minutes after arriving in the recovery room. **In the laser group the incidence of vomiting was 25%. in the placebo group 85%.**

Schlager A et al. Laser stimulation of acupuncture point P6 reduces postoperative vomiting in children undergoing strabismus surgery. Br J Anesth. 1998; 81 (4): 529-532.

#### **Abstracts of ICMART '97 International Medical Acupuncture Symposium, Nicosia, Cyprus, March 26-29 1997:**

1) **Low energy laser in the treatment of low back pain** S. Nikolic, Z. Trojancanec, I.J. Milankovic Institute of ME Physiology, Faculty of Medicine, Skopje, F.Y.R.O.M

Low back pain is felt in the low lumbar, lumbosacral, or sacroiliac region. Most low back pain is related to acute ligamentous (sprain) or muscular (strain) problems, which tend to be self limited, or to the more chronic osteoarthritis or ankylosing spondylitis of the lumbar area. The aim of the study was to explore the pain-alleviating effect of low level laser in low back pain. Thirty-five patients with low back pain have been treated with helium-neon laser type "Bistra" with wavelength 630 nm, average output 15 mW and an irradiance of 250 mW/cm<sup>2</sup>. The laser was locally applied to 11 sites on and around the low back. After scanning each point was treated for 30 sec, five times weekly for a total of ten treatments. **The statistical analysis showed that the laser treated patients had a significant faster pain-alleviating effect compared with the 30 patients treated with medicaments only.** Subjective response have been achieved after first three treatments. **Irradiation laser treatment may be a valuable therapy in low back pain and low energy laser can be employed as a pain relieving method.**

2) **Laserpuncture in patients with rheumatoid arthritis.**

Poliakova A.G., Gladkova N.D., Triphonova T.D. Russia 603155 N. Novgorod., V. Volznskava Nab., 18., Research Institute of Traumatology & Orthopedics

The purpose of this investigation: to determine of laserpuncture (LP) clinical effectiveness among other LT methods in RA concerning pain and articular inflammation. Results of treatment in 330 patients with diagnosed RA in acute phase in resistance of bases therapy

(Voltaren, Indometacin in 100-150 mg during 24h.) were studied.

(1) The investigations were carried out with double-blind controlled placebo tests. (2) Intravascular radiation (IR) with wavelength 633 nm, articular surface radiation (ASR) with wavelength 820 nm in continuous regime and (3) with 890 nm (LP) in pulsed modulated regime with frequency 1-100 Hz methods were compared.

Assessment results of treatment in all groups was performed in accordance with integral clinical value and blood indexes dynamics. **Results indicated positive effects (65%) in patients treated with ASR and LP**, and were similar. However, ASR method requires 100 points/session versus 10 points/session in LP. Methods of ASR and LP in doses 0,004-0,02 Dj/cm<sup>2</sup> (density of energy flow) provided maximal analgesic effect without any side effects and complications. Usage of IR was less effective (12%) and in two cases status impairment or pain and articular syndrome activation were seen.

Conclusion: LP is an optimal supplementary method (in above mentioned parameters) in RA treatment, In our opinion, IR method of LT has some disadvantages and less efficiency. Thus, this method should not be recommended in RA treatment.

### 3) Application of laser acupuncture in the treatment of periarthritis humeroscapularis.

Branka Nikolic., spec. Sport's med. Address Zavod za zdravstvenu zastitu radnika ZTP-a "Beograd", 11000 Beograd, Slobodana Penezica Dr. 23 Yugoslavia

The effect of low intensity semi conductor laser was used as treatment methods for periarthritis humeroscapularis. The CC laser (Computer Controlled laser) was applied.

**Laser therapy has positive biological effects and antiinflammatory, antioedema effects and analgesia.** We treated 18 patients with periarthritis humeroscapularis, 14 were female patients.

The laser was locally applied at the AC points Sj 14, Sj 15, Li 15, Li 10, Sj 5, Si 3, three times a week for the first week and twice a week for the second and the third week. After first treatment 12 of patients had pain - alleviating effect. **After 6-7 treatments all had pain - alleviating effect and complete recovery of shoulder's motor activity.** Low intensity therapy has its place for treatment of periarthritis humeroscapularis.

### 4) Laser therapy and immunostimulators in patients with acute orofacial infections.

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The acute orofacial infections often are therapeutical problem. The complex treatment of such patients include antimicrobial agents, surgical intervention, immunostimulation with Oxyrich and laser therapy.

Laser system "Six - L - IR" class IIIB, with active medium GaAs, 10w peak power, 904 nm was used. Two methods were applied: 1) distant, local with 100% power, 4000 Hz per 5 min and 400 Hz per 3 min and 2) laser puncture for 60 sec in BAP V43, GI4, T14, E36 and point 55 of the ear. Patients were treated for 10 days.

33 patients were tested for their phagocyte activity before and after the treatment. Nitro - blau - tetrazolium test (NBT) for enzymatic activity of the leucocytes was included also. The antiinflammatory and biostimulating effect of the laser therapy is discussed.

These **preliminary results emphasize the positive results from complex therapy including laser puncture** and immunostimulators in patients with acute orofacial infections

### 5) Low level laser in the treatment of ulcus cruris

Z. Trojancanec, S. Nikolic, Z. Handziski Institute of ME Physiology, Faculty of Medicine, Skopje, FYROM

Ulcus cruris is a complication following deep vein incompetence and the terms "postphlebotic leg" or "stasis syndrome" are applied. The ulceration is usually small, superficial, and very painful because of exposure of nerve endings. Varicose veins may be seen or palpated close to or continuous with the ulcer. These ulcerations may start after minor trauma to an area of pigmentation, induration, eczema, or edema, and are usually chronic by the time they are seen.

The influence of low level laser under the skin has been examined in large number of laboratory and clinical studies, considering that the skin is a big area for absorbing a great amount of photons. The aim of the study was to explore the role of low level laser in the treatment of slowly healing ulcus cruris. Ten patients with slowly healing ulcus cruris have been treated with helium-neon laser type "Bistra" with wavelength 630 nm, average output 15 mW and an irradiance of 250 mW/cm<sup>2</sup>. All patients have been previously treated with other therapeutic modalities for six months but without result. **Complete healing was achieved in eight patients and two patients showed significant diminution of their lesions. Irradia laser treatment may be a valuable therapy in dermatologic diseases, especially in slowly healing wounds**

**Reports from The IXX Annual Meeting of The American Society for Laser Medicine and Surgery, Lake Buena Vista, Florida. April 16-18, 1999. Lasers in Surgery and Medicine. Supplement 11, 1999.**

1. Report on more than eight years of low level laser therapy of **chronic inner ear diseases**. Lutz Wilden, Sabine Schübel, Germany. 348 patients (402 ears) were treated with low level laser. Most patients had tinnitus. This study, however, only reports on the objective outcome of the audiometry, taken before and after therapy. **The hearing capacity of the patients was improved in all frequency sectors (average value = 20.6%)**. The best db-reductions were obtained in the low frequency sector (11.7 db) and in the high frequency sector (14.6 db). There was a close correlation between the improvement of the hearing capacity and the age of the patients and the duration of their disease. In conclusion it can be stated that if LLLT is administered in sufficiently high dosages to the inner ear (cochlea), it is possible to obtain and document significant biostimulative effects.
2. Lack of stimulatory effect of laser irradiation 660 nm at various radiant exposures upon a radiation impaired wound healing model in murine skin. Lowe A S et al, N. Ireland. Experimental wounds in radiation-impaired (20 Gy) murine skin was exposed to 0.5, 1.5 or 4.0 J/cm<sup>2</sup> 660 nm laser irradiation three times weekly until closure was complete (15 mW, 5 Hz). Wound size was analysed using a video image analysis system. No evidence of stimulatory effects could be observed at these parameters.
3. The effect of low-level laser irradiation on lymphocytes from peripheral blood. Stadler I et al, New York, USA. Lymphocyte suspensions were irradiated with argon-dye laser (660 nm) or diode laser (830 nm) at doses varying from 0-5 J/cm<sup>2</sup> in the absence or presence of erythrocytes. **Irradiation at 660 nm in the presence of erythrocytes significantly enhanced the proliferation response of lymphocytes**. The maximal response was detected at 3 J/cm<sup>2</sup>. Laser irradiation at 830 nm resulted in a maximal interaction at fluences of 1.5 J/cm<sup>2</sup>. In absence of erythrocytes the effect of irradiation showed a weak dose-response relation. No significant change could be detected in cell mediated cytotoxicity. The results indicate that the catalyzed reactive-oxygen-substances play an integral role in laser light interaction with whole blood.
4. **Soft tissue injury during sport activities and traffic accidents** - treatment with low level laser therapy: A multicenter double blind, placebo controlled clinical study on 132 patients. Simunovic Z, Trobonjaca T, Switzerland/Croatia. 132 patients were treated with lllt as a monotherapy. Indications were distortion and sprain of the ankle; lesion of the Achilles tendon; dislocation of the knee, shoulder and interfalangeal joints; wrist and cervical spine injuries and both types of epicondylitis. All patients represented acute cases. Two types of irradiation techniques were used: skin contact for trigger points (830 nm) and scanning technique (633/904) for larger surface areas. The laser group was compared to a group of patients treated with conventional therapies. **In the lllt group the recovery progress was accelerated by 35-50% in 85% of the patients**, as compared to the control group. More abstracts will follow

**Low-energy laser irradiation affects satellite cell proliferation and differentiation in vitro. Ben-Dov N et al. Biochimica et Biophysica Acta. 1999- 1448: 372-380.**

The process of skeletal muscle regeneration following injury is characterized by necrosis of muscle tissue, local inflammation and proliferation of satellite cells that further fuse to form multinucleated myotubes. Satellite cells, considered as the precursor cells in the process of muscle regeneration following injury, are normally quiescent, and are activated by factors released from the injured muscle fibers. In a in vitro study by Ben-Dov et al HeNe **laser irradiation was shown to significantly promote the proliferation of satellite cells** in a dose-dependent manner. Too high doses caused an inhibition. It is suggested that HeNe irradiation activates early cell-cycle genes in satellite cells leading to increased proliferation and to a delay in cell differentiation.

**LLLT is as well documented as NSAIDs and steroid injections for shoulder tendinitis/bursitis and epicondylalgia.**

**The Norwegian physiotherapist Jan M Bjordal published his thesis “Low level laser therapy in shoulder tendinitis/bursitis, epicondylalgia and ankle sprain” in 1997, at the Division of Physiotherapy Science, University of Bergen. It has also been published in Physical Therapy Reviews. 1998; 3: 121-132.**

Here is the Conclusion of the thesis: “A systematic review has been performed on the effect of LLLT for three diagnoses. LLLT was evaluated on similar criteria for methodological assessments of trials as previously established for medical interventions. No evidence was found to indicate that randomized controlled trials on LLLT for tendinitis/bursitis of the shoulder, lateral epicondylalgia and ankle sprains were methodologically inferior to RCTs on medical interventions. The clinical effects of LLLT were found to be supported by scientific evidence regarding short (0-4 weeks) and medium term (<3 months) efficacy for subacute or chronic lateral epicondylitis, and short term efficacy (>3 months) for subacute or chronic lateral epicondylitis, and short term efficacy (> 3 months) for subacute or chronic shoulder tendinitis/bursitis. The evidence of effect from LLLT for acute ankle sprain is inconclusive, although there seems to be a slight tendency in favour of LLLT. Adverse effects of LLLT are rarely seen and only in minor forms (nausea, headache) compared to medication, where more serious gastrointestinal discomfort or ulcers are not uncommon. It has also been shown that trials in favour of active treatment had more treatments per week than the trials showing no difference in effect. In short one could say that LLLT should be used much in the same way as NSAID are used for short periods of time. Most trials showing significant effects used an IR 904 nm laser, but some results in favour of IR lasers with wavelengths of 780, 820 and 830 nm were also observed. Clinical effects of LLLT were best in subacute conditions. In chronic conditions a higher dosage and more treatments seem to be needed. The

results of the high quality LLLT trials were all in favour of treatment with confidence intervals not including zero, and the trials came from several different research groups. Evidence was found to be at the highest or the second highest level depending on what level of clinical significance is decided according to the classification of Oxman (1994) and McQuay (1997). The review found little support for the alleged large placebo effects of LLLT. In chronic cases the placebo effect is probably less than 10%, after the natural history of the complaints is taken into account.”

In the “Summary of discussion on clinical effect estimates for LLLT” the author writes:

“The majority of the included LLLT-trials found significant clinical effect from LLLT. Seven of the eleven LLLT-trials with acceptable methods included calculations of 95% confidence limits above zero, and one LLLT-trial on ankle sprain included zero (Axelsen & Bjerno 1993). The clinical effect estimates from LLLT-trials for shoulder tendinitis/bursitis are similar or higher than for NSAID or steroid injections. For lateral epicondylalgia estimates for short term clinical effects are similar or lower for LLLT than for steroid injections, but medium clinical effect estimates are similar or higher for LLLT. Recurrence of symptoms in lateral epicondylalgia is less likely after LLLT than after steroid injections. Evidence of clinical effects from ankle sprain is inconclusive. Adverse effects from LLLT are seldom seen and they appear less serious than for patients treated with NSAID and steroid injections.”

**Here are some selected mini-abstracts from the 2nd Congress World Association for Laser Therapy, September 2-5, 1998. Kansas City, MO, USA.**

**Parizotto tenectomized the Achilles tendons in 32 rats and resutured the skin.**

After 24 hours HeNe laser was applied, daily for ten days. Doses of 0.5, 5 and 50 J/cm<sup>2</sup> were used. HeNe laser enhanced the intra- and intermolecular hydrogen bonding in the collagen molecules. The treated tendons were more organized than controls. Parizotto N A, Baranauskas V. Structural analysis of collagen fibrils after He-Ne laser photostimulated regenerating rat tendon. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 66

**Onac compared the effect of HeNe laser and monochromatic light at 618 nm.**

The intact skin of guinea pigs was irradiated with different doses. The monochromatic light had similar effects as that of HeNe, but weaker. Further on, monochromatic light at low doses had no effect at all and at high doses caused nodular hyperplasia and focal epidermic hypertrophy. Thus, the therapeutic window seems to be narrow for monochromatic light. Onac I et al. Histological study regarding the effects of He-Ne (632.8 nm) laser biostimulation upon the tegument of Cavia Cobia as compared with that of monochromatic red light (618 nm). Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 52-53.

**Asagai reports on the use of GaAlAs (100 mW) laser treatment in a group of 1000 patients with cerebral palsy.**

The laser reduces muscle spasm and increases the mobility of the muscles. Although the duration of the LLLT effect was limited to one to several hours, it can be applied in conjunction with conventional functional therapies, thereby enhancing the effects of the latter. Asagai Y et al. Application of low reactive-level laser therapy (LLLT) in the functional training of cerebral palsy patients. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 99-100.

**Katsuyama studied the effect of 830 nm laser in a neuropathic pain model of rat.**

The left side sciatic nerves of two groups of rats were ligated loosely to produce a neuropathic pain. The latency of the foot withdrawal reflex to noxious heat stimuli was measured before the ligation, immediately after laser/placebo radiation and at 14 days after ligation. The laser group received 72 J through the dermis. This group showed a significant reduction in left foot withdrawal immediately after irradiation and at 14 days, the right foot being unchanged. Placebo irradiation did not change the latency in the ligated in the ligated group, nor in non-ligated rats. Katsuyama I et al. Laser irradiation suppresses hyperalgesia in neuropathic rats. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 28

**Phantom pain after amputations is a severe problem.**

Taguchi reports that laser therapy has been the most effective way of releasing the phantom pain of an amputee. Taguchi Y. Clinical experiences of laser applications in physical therapy. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 106

**In a study by Amaral 15 mice received a single muscular injection of myotoxin in the tibialis anterior muscle of both legs.**

One group received HeNe 2.6 J, another 8.4 and the third 25 J/cm<sup>2</sup> on one leg, while the other was sham irradiated. The 2.6 J group showed a significant difference with evidence of a greater concentration of mitochondria in the treated muscle, whereas the higher doses did not produce this effect. The laser treated mice also showed an increase of cross-section area of the muscle fibers. Amaral A C et al. He-Ne laser action in the regeneration of the tibialis anterior muscle of mice. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; pp 18-19.

**In an animal study by Kobayashi the effect of GaAlAs laser on the blood flow in flaps was studied through laser speckle flowgraphy (LSF).**

40 rats were divided into four groups. Two groups had random pattern flaps, two had axillary pattern flaps with the dominant vessels intact. Flaps were raised and peripheral blood flow assessed through LSF. Laser irradiation was performed in two groups, either directly on the dominant vessel or at one point on the distal part of the flap. The blood flow directly after irradiation was higher than before irradiation. At day 5 there was a clear difference between the irradiated and the non-irradiated flaps. The flaps irradiated at the dominant vessels had a slightly better outcome than those irradiated at the Kobayashi M et al. Studies of the diode laser therapy on blood supply in the rat model. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 70-71.

#### **Schindl treated a chronic radiation ulcer with HeNe laser, 30 J/cm<sup>2</sup>.**

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

#### **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 D., Morga B. Laser therapy in ambulatory patients with venous stasis ulcers. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 31-32.

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

The exclusion criterias 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/cm<sup>2</sup> 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.

#### **The effect of different approaches for laser therapy of acute nonspecific epididymitis** was studied by Gomberg .

In a previous study by Reznikov [682], transscrotal HeNe irradiation had proved beneficial. Gomberg compared transscrotal, endolymphatic and laser acupuncture for the treatment of a group of 28 patients. The endolymphatic treatment was performed via a small quartz fiber, inserted into the regional lymphatic node, 0.15 J in total. The transdermal dose was maximum 2.7 J. Laserpuncture (Hegu and Zusanli) was performed using a maximum of 30 J per point. The clinical outcome as well as the polymorphonucleocyte/lymphocyte index, main population and subpopulations of lymphocytes were evaluated. Endolymphatic irradiation was found to be more efficient than trans-scrotal laser therapy. The former required 4 procedures each with an interval of 24 hours, whereas trans-scrotal irradiation required 1-3 days longer. Laser acupuncture was not effective. Gomberg V G et al. Endolymphatic laser therapy in management of acute nonspecific epididymitis. Proc. 2nd Congress World Assn for Laser Therapy, Kansas City, September 1998; p. 27

#### **"How negative are the negative studies?"** Tunér J, Hode L.

It's all in the parameters: a critical analysis of some well-known negative studies on low-level laser therapy. J Clinical Laser Med & Surg. 1998; 16 (5): 245-248.

Studies failing to find any effect of LLLT are often used as support for the alleged non-efficacy of LLLT. The authors have selected some of the most quoted negative studies and analyzed them. It turns out that the failure to find an effect too often depends on mistakes in the design of the studies. Doses in the range 0.0007 - 0.1 J have been used for a variety of indications where therapeutic doses are 100 times or more. Patients with psychosomatic pain have been treated, HeNe laser has been used as a "placebo" laser, treatment technique has been inadequate, powers density extremely low, calculation of dosages incorrect, systemic effects and tissue condition have been disregarded etc. Meta-analyses disregarding such pitfalls are also less useful. A combined knowledge of physics and medicine seems to be an important factor in the design of LLLT studies.

#### **LLLT in male genital disorders**

Gasparyan L et al. Low level laser therapy of male genital tract chronic inflammations. Proc. 2nd Congress World Association for Laser Therapy, Kansas City, USA, September 2-5 1998; p. 82-83.

Male genital tract chronic inflammations were treated by combinations of transdermal, transrectal (prostate gland) and intravenous

HeNe laser irradiation. The energy of a 2 mW HeNe laser was applied via a light guide into a vein. The projections of the male genital organ and the inguinal areas were irradiated with a 890 nm 5W peak power cluster probe. For the transrectal prostate gland irradiation a 890 nm 15W peak power laser was used. 36 patients were given conventional medical therapy and another 36 were given LLLT in combination with medical therapy. Clinical and laboratory findings were statistically better in the LLLT group and relapse rate was lower. It is suggested that LLLT increases the local circulation and thus also improves the effect of antibiotics.

#### **Bürgers disease improved by laser therapy**

Sasaki K et al. Low level laser therapy (LLLT) for thrombongitis obliterans. Proc. 2nd Congress World Association for Laser Therapy, Kansas City, USA, September 2-5 1998; p 95-96 .

In this case report a patient with thrombongitis obliterans (Bürgers disease) was treated with a 60 mW 830 nm laser and a defocused 20 W Nd:YAG laser. Ulcers were remarkably improved. Agonizing pain and ischemia were relieved. In the MRA findings, sudden arterial obliteration disappeared. In the thermographical findings, skin temperature increased to normal level.

#### **LLLT in the dental clinic**

Pinheiro A et al. Low-level laser therapy is an important tool to treat disorders in the maxillofacial region. J Clinical Laser Med & Surg. 1998; 16 (4): 223-226.

241 patients with different disorders in the maxillofacial region were treated with LLLT. Indications were temporomandibular disorders, trigeminal neuralgia, muscular pain, aphtae etc. Lasers of 633, 670 and 830 nm were used. Most treatments consisted of a series of 12 applications (twice a week). Average dose was 1.8 J/cm<sup>2</sup>. At the end of treatment 154 patients were asymptomatic, 50 improved considerably and 37 were symptomatic.

#### **Laser is effective for medial and lateral epicondylitis**

Simunovic Z, Trobonjaca T et al. Treatment of medial and lateral epicondylitis - tennis and golfer's elbow - with low level laser therapy: a multicenter double blind, placebo controlled clinical study of 324 patients. J Clinical Laser Med & Surg. 1998; 16 (3): 145-151.

In a two center study 324 patients with unilateral medial or lateral epicondylitis were treated with LLLT. Trigger points were treated with 830 nm. 633 and 904 nm in combination was used in the scanning mode. Total pain relief was obtained in 82% of the acute cases and 66% in the chronic cases. A combination of trigger points (TP) and scanning was more effective than TP alone and TP alone were more effective than scanning alone. One of the centers had slightly less powerful lasers and the outcome was a bit lower, although the dosage was the same in both centers.

#### **HeNe laser reduces mucositis**

a) Barasch B et al. Helium-neon laser effects on conditioning-induced mucositis in bone marrow transplantation patients. Cancer. 1995; 76 (12): 2550-2556.

Oral mucositis is a common complication of bone marrow transplantation conditioning therapy. Different drugs are given in order to reduce rejection of the implant. These drugs induce an oral mucositis. The mucositis is painful and complicates nutrition. Sometimes the intake of the drug has to be stopped due to complications. In the study above 20 patients received HeNe to their oral mucosa, either right or left of midline. One side was sham irradiated. Laser treatment was well-tolerated and reduced the severity of oral mucositis.

b) Cowen D et al. Low energy helium-neon laser in the prevention of oral mucositis in patients undergoing bone marrow transplant: results of a double blind randomized trial. Int J Radiat Oncol Biol Phys. 1997; 38 (4): 697-707. Significant reduction of oral mucositis using a 60 mW HeNe laser

#### **“Medium Level Laser Therapy (MLLT)”?**

The advent of “high power low-power laser” tests the validity of the term “Low Level Laser Therapy”. We have seen a rather slow power output development from the early commercial equipments, using sometimes only a couple of mW. With the advent of the GaAlAs diode, the output powers of these lasers have increased rapidly. 30 mW used to be a rather high power; then there were lasers of 100 and even 200 mW. Now we have GaAlAs lasers of 500 and even 1 000 mW commercially available. Is this still “Low-power” laser? Yes and no. The fact that we are using 1 000 mW does not necessarily mean that we use higher doses. 1-4 J/cm<sup>2</sup> is still a normal dose. But to reach that dose in seconds is quite something! And since the energy density is considerably higher, we might obtain better effects. And we are also able to reach deep lying tissues, previously hardly within reach of the early lasers. So, are we still using “Low Level” lasers? Or should we coin the term “Medium Level Laser Therapy (MLLT)”? There is so far scarce literature

on these high powered lasers. Hoteya et al (Report on the first IALSM Meeting. *Laser Therapy*. 9 (4): 185) reports on the use of a 1 W GaAlAs laser (670 mW/cm<sup>2</sup>) in the field of orthopedics. When using it in a group of patients with chronic pain, the efficacy rate was 75.5% and the "no change" was 24.5%. Another earlier double-blind study for the same indication, using a 150 mW GaAlAs laser resulted in an efficacy rate of 70.6%. So the outcome is more or less the same. But treatment time must have been considerably reduced. In conclusion it can be said that the advent of "MLLT" seems very promising and practical but there is a great need of controlled studies.

### **New hope for patients with spinal cord injuries.**

Rochkind S, Shahar A, Nevo Z. An innovative approach to induce regeneration and the repair of spinal cord injury. *Laser Therapy*. 1997; 9 (4): 151. An Israeli research group has investigated an innovative method of repairing injured spinal cords. In a rat model the spinal cords were transected in 31 animals (between T7/T8). In vitro constructed composite implants were used in the transected area. These implants contained embryonal spinal cord neuronal cells dissociated from rat fetuses, cultured on biodegradable microcarriers. After being embedded in hyaluronic acid the implants were ready to be placed into the injured area. The whole lesion area was covered with a thin coagulated fibrin-based membrane. Control animals underwent the same laminectomy but did not receive any implant. In all animals the wound was closed normally. Laser therapy was started immediately after surgery. It was continued daily for two weeks using 780 nm, 200 mW, 30 minutes daily. One group received the implant but no laser. During the 3-6 months follow up, 14 of the 15 animals that received laser (A) showed different degrees of active movements in one or both legs, compared to 4 of 9 animals in the group who had received implants but no laser (B). In the group receiving no implant and no laser (C), 1 out of 7 showed some motor movements in one leg. Somatosensory evoked potentials were elicited in 10 of the 15 rats in group A at three months, and on one side in one animal in group B. Axon sprouting was observed as soon as three days post surgery, in group A only.

### **LLLT improves nerve injuries**

Dr. Shelley M Khullar of the Department of Oral Surgery, Faculty of Dentistry, Oslo, Norway presented her dissertation in February 1997. The title of the dissertation is "Reinnervation after nerve injury: The effects of low level laser treatment". The conclusion of the five published studies are: \*A course of 20 LLL treatments using a GaAlAs laser (=820 nm) on an area of long-standing paraesthesiae in the orofacial region induced an objectively evaluated significant improvement in fine mechanosensory perception and a decrease in the area of paraesthesiae. \*The significant improvement in mechanosensory perception was also perceived as a subjective improvement by the patients. \*A course of 20 LLL treatment with a GaAlAs laser (=820 nm) induced no change in thermoperception in an area of paraesthesiae. \*Daily LLL treatment over a 28 day period, with a GaAlAs laser accelerated motor nerve reinnervation as assessed by return of motor function subsequent to a standardised axonotmesis injury in the rat sciatic nerve. \*LLLT treatment with a GaAlAs (=820 nm) laser enhanced sensory reinnervation of peripheral target tissues subsequent to an IAN axotomy injury in the rat model. The findings are demonstrated immunohistochemically by the presence of CGRP positive neurones.

### **Biomodulation of normal and tumor cells**

*J Photochem Photobiol B: Biology*. 1997; (40): 253-257 In a study by Schaffer et al. various cells were irradiated by 805 nm laser light. The cells were (1) murine skeletal myotubes, (2) normal urothelial cells, (3) human squamous carcinoma cells of the gingival mucosa and (4) urothelial carcinoma cells. Mitotic index for 1, 2 and 4 increased at fluences of 4 J/cm<sup>2</sup> while irradiation at 20 J/cm<sup>2</sup> resulted in a slight decrease. The no 3 cells showed a decrease of the mitotic index with both fluences. The most interesting observation is the different reaction of the two carcinoma cells.

### **Promising results using LLLT for tinnitus and inner ear diseases *Auris Nasus Larynx*. 1997; 24 (1): 39-42.**

Shiomi et al. used a 40 mW GaAlAs laser in a group of 38 patients suffering from tinnitus, resistant to several medical therapies for more than six months. 21.6 J was given each time through the auditory meatus toward the cochlea. Ten treatments or more were given. Only 26% of the patients reported improved duration, but 58% had reduction of loudness and 55% reduced annoyance. The authors conclude: "Laser therapy seemed to be worth trying on patients with intractable tinnitus". Editorial note: The results can be improved if much higher doses are given. Dr. Lutz Wilden of Bad Füssing, Germany reported on his 6 years of experience at a recent lecture before the members of the Swedish Laser Medical Society (Stockholm, May 1998). Dr. Wilden is using three different lasers. One is directed through the meatus, two are positioned over the mastoid. Total dosage 2000-4000 (sic) joules per treatment (60 minutes per session, 30 minutes per ear). Doses may seem very high, but the thick bone behind the ear absorbs about 95% of the energy before reaching the inner ear. For more info, see <http://home.t-online.de/gbl-hc/ez>.

### **Laser therapy plays a role in bone healing**

*Lasers Surg Med*. 1998; 22: 97-102.

Luger et al. studied the effect of HeNe laser on the healing of tibial bone fractures in rats. 63 J (35 mW) was given transcutaneously daily over the fracture area. After 4 weeks the tibia was removed and tested at tension up to failure. The maximal load at failure and the structural stiffness of the tibia were found to be elevated significantly in the irradiated group, whereas the extension maximal load was reduced. In addition, gross non-union was found in four fractures in the control group, compared to none in the irradiated group.

### **GaAlAs laser treatment evaluated for trigeminal neuralgia, paresthesia, atypical facial pain and temporo-mandibular joint pain in a 5 year study.** - *Tandlægebladet*. 1994; 98 (2): 526-529.

In Danish. - Eckerdal A, Lehmann Bastian H. Can low reactive-level laser therapy be used in the treatment of neurogenic facial pain?

A double-blind, placebo controlled investigation of patients with trigeminal neuralgia. Laser Therapy. 1996; 8: 247-252. At the Odense University Hospital, Denmark, Arne Eckerdal has evaluated the effect of 830 nm, 30 mW, laser treatment for a number of indications. Patients suffering from trigeminal neuralgia (n = 36) had a positive result in 81% at the end of treatment, 42% at 1-year control. Patients having received previous alcohol blocks (n = 14) responded less favourably to the treatment. 50% were pain free at the end of the treatment period, 20% at 1 year control. Patients with non-specific facial pain (n = 63) were pain free at the end of treatment, 44% at follow up one year later. In a group of 22 patients with paresthesias (n = 22), only 5 were successful at end of treatment, 4 were improved and 13 were not improved. The result at 6 and 12 months were the same. Patients with temporo-mandibular pain (n = 40) were improved in 73% and at 1 year control still 70% were pain free.

#### **Can HeNe laser improve fertility?**

Abstracts LASERmed 97; p. 138, no 112 The fertilizing potential of mouse spermatozoa was positively affected by HeNe laser in vitro. Cohen et al at the Bar-Ilan University, Israel found that the Ca<sup>2+</sup> uptake, mainly in the mitochondria, was improved after LLLT. The results suggest that the effect of 630 nm laser irradiation is mediated through the generation of hydrogen peroxide by the spermatozoa and that this effect plays an important role in the augmentation of the sperm cell's capacity to fertilize in vitro.

#### **Are there "good" and "bad" free radicals?**

Abstracts LASERmed 97; p. 138, no 110

There is considerable evidence that photobiostimulation proceeds via enhanced production of reactive oxygen species (ROS) by the photoexcited respiratory chain. Increased amounts of free radicals are produced in the blood of patients with acute respiratory illness or leukemia. However, irradiation with 633 or 830 nm reduces the amount of free radicals produced in the anomalous blood cells. Friedmann and Lubart therefore suggest two categories of free radicals: 1. the "good" ones, which may produce biostimulation and which tentatively would be the superoxide anion radicals. 2. the "bad" ones, which collectively are designated by R. The reduction of the quantity of free radicals by LLLT is then ascribed to the reaction  $R + O_2^- = R^- + O_2$ . It is possible that many of the therapeutic effects of low-power laser irradiation are due to this reaction.

#### **GaAs is effective in chronic low back pain.**

Two abstracts from Lasers Surg Med. 1998; Suppl. 10, p. 6 1) Prof. Soriano in Rosario, Argentina, performed a double blind trial with elderly people suffering from chronic low back pain. After a thorough medical examination the patients were divided into two groups. One received GaAs 4J per point and one received sham irradiation. Ten consecutive sessions were done, one every day. Pain was evaluated through a VAS scale at the beginning and at the end of the treatment period. Treatment was effective in 71% in the laser group and 36% in the sham group. The pain disappeared completely in 45% in the laser group and 15% in the sham group. During the follow up 35% of the patients in the laser group who had relieved their pain more than 60% relapsed, compared to 70% in the control group. There were no side effects. 2) Effects of low energy laser therapy on herniated lumbar discs. Gruszka M et al. Gruszka (Buenos Aires) treated 15 patients with one or more protruded lumbar disc herniations with GaAs 904 nm, with a dose of 9J on each point, 20 to 25 points on the lumbar spine and on referred radicular pain points, 3 to 5 times a week during 4 months. Pain was relieved in 100%, gait and neurological signs improved in all patients, EMGs improved and CAT scans showed less protrusion of the herniated discs.