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Cellular effect of low-level laser therapy on the rate and quality of bone formation in distraction osteogenesis of the mandible

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short version

Objective: Therapeutic lasers have been shown to affect bone physiology and repair. The aim of the present study was to evaluate the use of a GaAlAs laser (k: 810 nm) in distraction osteogenesis.

Background data: To reduce the problems associated with distraction osteogenesis and to shorten the time required for treatment, it is desirable to speed up the process of bone formation.

Materials and Methods: FE Eighteen male rabbits underwent mandibular corticotomy and custom distraction devices were used. After a latency period of 5 days, the mandibles were elongated by 0.5 mm / day for 10 days. The rabbits were divided into two groups. A GaAlAs laser beam (k: 810 nm) with the parameters power (P), 200 mW; Energy Density (ED), 3 J / cm2; Time (T), 7.5 s; Power density (PD) 400 mW / cm2; Energy (E) 1.5 J and spot diameter, 0.8 mm, was directed medially and laterally in the study group; the control group did not receive any laser treatment. Exposure was continued with six additional doses every other day. Three rabbits from each of the two groups were euthanized on days 10, 20 and 40 after the distraction (consolidation).

Results: Both light microscopic and scanning electron microscopic (SEM) analyzes showed a significant improvement in new bone formation in the study group on the 10th and 20th day compared to the control group, but the difference was on the 10th. On the 40th day there were no significant differences between both groups.

Conclusions: This study shows that a low-level GaAlAs laser (k: 810 nm; P, 200mW) accelerates new bone formation only in the early stages of the consolidation phase of distraction osteogenesis and has no significant effect in later stages.

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Effect of the low-level laser on guided tissue regeneration in the treatment of intraosseous defects in horses with bones and membranes: a clinical study

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short version

Objective: The aim of the present study was to evaluate the clinical results of guided tissue regeneration (GTR) after the application of bone and membranes from horses alone or in combination with low-level laser therapy (LLLT) for the treatment of periodontal defects.

MATERIALS AND METHODS: This study was an intra-individual longitudinal study of 6 months duration using a split-mouth and randomized design. In 13 periodontitis patients with bilateral intraosseous periodontal defects, one defect site was treated with GTR plus LLLT (1064 nm, 100mW, with an energy density of 4 J / cm2), while the contralateral defect site was treated with guided GTR alone. The GTR was performed with a combination of horse bone and membrane. The LLLT was used both intra- and post-operatively. The clinical probing depth (PPD), the clinical attachment level (CAL), the clinical gingival recession level (REC),

Results: The treatment of periodontal intraosseous defects with horse bone and membrane during surgery with GTR alone or GTR plus LLLT in combination resulted in a statistically significant PPD education, an increase in CAL and a lower SBI score at the end of the study (p <0 , 05). In addition, GTR plus LLLT resulted in a statistically significant lower REC (p = 0.025), lower SBI (p = 0.008) score, greater reduction in PPD (p = 0.009) and a CAL gain (p = 0.002) compared to the GTR alone in the control in the 6th

Conclusions: This study showed that GTR is an effective treatment for periodontal regeneration and that LLLT can improve the effects of GTR in treating periodontal defects.

Photomedicine and Laser Surgery Volume 30, Number 5, 2012

Low-level laser therapy improves the stability of orthodontic mini-implants through bone formation related to BMP-2 expression in a rat model

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short version

Objective: The aim of this study was to investigate the stimulating effects of low-level laser therapy (LLLT) on the stability of mini-implants in rat tibiae. Background data: In adolescent patients, loosening is a notable complication of mini-implants used for anchorage in orthodontic treatments. The stimulatory effects of LLLT on bone formation were previously reported; here it was investigated whether the LLLT increases the stability of mini-implants through peri-implant bone formation.

Materials and Methods: Seventy-eight titanium mini-implants were placed in both tibiae of 6 week old male rats. The mini-implants in the right tibia were exposed to LLLT with a gallium-aluminum-arsenide laser (830 nm) once daily for 7 days and the mini-implants in the left tibia served as non-irradiated controls. After 7 and 35 days after implantation, the stability of the mini-implants was examined with the diagnostic aid (Periotest). The new bone volume around the mini-implants was measured on days 3, 5 and 7 using in vivo microfocus CT. Bone morphogenetic protein (BMP) -2 gene expression in the bone around the mini-implants was also analyzed using real-time reverse transcription polymerase chain reaction assays.

The results: The Periotest values were significantly lower (0.79 to 0.65 times) and the volume of newly formed bone was significantly higher (1.53 times) in the LLLT group. The LLLT also stimulated significant BMP-2 gene expression in peri-implant bone (1.92-fold).

Conclusions: LLLT improved the stability of mini-implants in rat tibiae and accelerated peri-implant bone formation by increasing the gene expression of BMP-2 in the surrounding cells.

Photomedicine and laser surgery

Effect of laser therapy on bone tissue that has been subjected to radiation therapy: experimental study in rats

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Objective: The aim of this study was to investigate the effect of laser therapy (Î "= 780 nm) on bone tissue that has been exposed to ionizing radiation.

Background data: The biostimulation effect of the laser in normal bone tissue has already been successfully demonstrated; however, their effect on bone tissue that has received radiation therapy has not yet been studied.

The Methods: Twenty-two Wistar rats were randomly divided into four groups: Group I, control group (n = 4) which was only irradiated; Group II, start of laser 1 day before radiation therapy (n = 6); Group III, laser onset immediately after radiation therapy (n = 6); Group IV, laser onset 4 weeks

after radiation therapy (n = 6). Cobalt 60 was used as the source of ionizing radiation, which was applied to the femur in a single dose of 3000 cGy. The laser groups received seven applications with a 48-hour interval at four points per session with DE = 4 J / cm2, P = 40 mW, t = 100 s and a beam diameter of 0.04 cm2. All animals were sacrificed 6 weeks after radiation therapy.

Results: The clinical examination showed cutaneous erosions in the test groups (II, III and IV) from the 6th week after radiation therapy. The radiological findings showed a higher bone density in groups II and IV (p <0.05) compared to the control group. The results also showed an increase in bone marrow cells and the number of osteocytes and Haversian canals in experimental groups II and IV (p <0.05). There was also an increase in osteoblastic activity in groups II, III, and IV (p <0.05).

Conclusions: Laser therapy on bone tissue in rats showed a positive biostimulant effect, especially when applied before or 4 weeks after radiation therapy. However, the use of the laser should be used with caution with the above parameters due to epithelial erosion.

Photoengineering of bone repair processes

Apr 2006, Volume 24, No. 2: 169-178, Photomedicine and Laser Surgery

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Objective: This thesis is intended to represent the state of the art in terms of photo-engineering of bone repair using laser therapy. Background data: Laser therapy has been described as an important tool for positive stimulation of bone both in vivo and in vitro. These results suggest that the photophysical and photochemical properties of some wavelengths are primarily responsible for tissue reactions. The use of correct and appropriate parameters has been shown to be effective in promoting a positive bio-modulatory effect in bone healing. The Methods: A number of papers on the effects of laser therapy on bone cells and tissues are presented, and new and promising protocols are presented,

Results: The results of our and other studies indicate that bones that are mainly irradiated with infrared (IR) wavelengths have increased osteoblastic proliferation, collagen deposition and new bone formation compared to non-irradiated bones. In addition, the effect of laser therapy is more effective when the treatment is carried out in the early stages, when there is high cell proliferation. Vascular responses to laser therapy have also been suggested as one of the possible mechanisms responsible for the positive clinical outcomes observed after laser therapy. It is still uncertain whether bone stimulation by laser light is a general effect or whether isolated stimulation of osteoblasts is possible.

Conclusion: It is possible that the effect of laser therapy on bone regeneration depends not only on the total radiation dose, but also on the radiation time and the radiation mode. The threshold parameters energy density and intensity are biologically independent of each other. This independence explains the success and failure of laser therapy at low energy density values.

Khadra M, Kassem N, Haanaes HR, Ellingsen JE, Lyngstadaas S P.

Improvement of bone formation in skull bone defects in rats using low energy laser therapy.

Oral Surgical Operation Oral Med Oral Pathol Oral Endod. 2004; 97: 693-700.

The aim of Khadra's study was to investigate the effect of laser therapy with GaAlAs on the healing and fixation of titanium implants in the bone. This study was conducted as an 8-week animal experiment with a blinded, placebo-controlled design. Two coin-shaped titanium implants 6.25 mm in diameter and 1.95 mm in height were implanted in the cortical bone in each proximal tibia of twelve New Zealand rabbits (n = 48). The animals were randomly divided into irradiated and control groups. The laser was used immediately after the operation and performed daily for 10 consecutive days. The animals were sacrificed after 8 weeks of healing. The mechanical strength of the connection between the bone and 44 titanium implants was evaluated using a pull-out test. A histomorphometric analysis of the four remaining implants from four rabbits was then carried out. An energy-dispersive X-ray microanalysis was carried out to analyze the calcium and phosphorus on the implant test surface after the tensile test. The mean tensile forces of the irradiated implants and controls measured in Newtons were 14.35 (SD ± 4.98) and 10.27 (SD ± 4.38), respectively, indicating a gain in functional attachment after 8 weeks after laser irradiation suggests. An energy-dispersive X-ray microanalysis was carried out to analyze the calcium and phosphorus on the implant test surface after the tensile test. The mean tensile forces measured in Newtons of the irradiated implants and controls were 14.35 (SD ± 4.98) and 10.27 (SD ± 4.38), respectively, indicating a gain in functional attachment after 8 weeks after laser irradiation suggests. An energy-dispersive X-ray microanalysis was carried out to analyze the calcium and phosphorus on the implant test surface after the tensile test. The mean tensile forces of the irradiated implants and controls measured in Newtons were 14.35 (SD ± 4.98) and 10.27 (SD ± 4.38), respectively, indicating a gain in functional attachment after 8 weeks after laser irradiation suggests.

The histomorphometric evaluation indicated that the irradiated group had more bone-to-implant contact than the controls. The weight percentages of calcium and phosphorus were significantly higher in the irradiated group compared to the controls, suggesting that bone maturation was faster in the irradiated group.

Effect of the low power Gaalas laser (660 Nm) on bone structure and cell activity: an animal study

Nicola RA, Jorgetti V, Rigau J, Pacheco MT, dos Reis LM, Zangaro RA. Vale of Paraiba University, Sao Jose dos Campos, SP, Brazil. renatanicolau@hotmail.com , Lasers Med Sci. 2003; 18 (2): 89-94.

Low-level laser therapy (LLLT) is increasingly used in the regeneration of soft tissue. In the regeneration of hard tissue, it has already been shown that the biomodulation effect of lasers repairs bones more quickly. We examined the activity in bone cells after LLLT near the site of the bone injury. The thighbones of 48 rats were perforated (24 in the irradiated group and 24 in the control group), and the irradiated group was treated with a GaAlAs laser on the 2nd, 4th, 6th and 8th days after surgery (DAS) 660 nm, 10 J / cm2 irradiated. We performed a histomorphometric analysis of the bone. We found that the activity was higher in the irradiated group than in the control group: (a) bone volume at 5 DAS (p = 0.035); (b) osteoblastic surface at 15 DAS (p = 0.0002); (c) Mineral deposition rate at 15 and 25 DAS (p = 0.0008 and 0.006); (d) osteoclastic surface at 5 DAS and 25 DAS (p = 0.049 and p = 0.0028); and (e) eroded surface (p = 0.0032).

We came to the conclusion that the LLLT increases the activity in the bone cells (resorption and formation) around the repair site without changing the bone structure.

Osseointegration of endosseous ceramic implants after postoperative low-power laser

Stimulation: An In Vivo Comparative Study
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Clinical Oral Implants Res. 2003 Apr; 14 (2): 226-32.

Stimulation with a low power laser (LPL) can improve bone repair, as reported in experimental studies of bone defects and fracture healing. There is little data available on the use of postoperative LPL stimulation to improve osseointegration of endosseous implants in orthopedic and dental surgery. For the present study, an in vivo model was used to assess whether LPL stimulation with Ga-Al-As (780 nm) can improve the osseointegration of biomaterials. After drilling holes, cylindrical hydroxyapatite (HA) implants were placed in the two distal femur bones of 12 rabbits. From the first postoperative day and for 5 consecutive days, the left femur bones of all rabbits were subjected to LPL treatment (LPL group) with the following parameters: 300 J / cm2, 1 W, 300 Hz, pulsing emission, 10 min. The right thigh bones were sham treated (control group). Histomorphometric and microhardness measurements were taken three and 6 weeks after implantation. A higher affinity index was observed at the HA-bone interface in the LPL group after 3 (P <0.0005) and 6 weeks (P <0.001); a significant difference in bone microhardness was found in the LPL group versus the control group (P <0.01). These results suggest that postoperative LPL treatment improves the bone-implant interface. 1 W, 300 Hz, pulsating emission, 10 min. The right thigh bones were sham treated (control group). Histomorphometric and microhardness measurements were taken three and 6 weeks after implantation. A higher affinity index was observed at the HA-bone interface in the LPL group after 3 (P <0.0005) and 6 weeks (P <0.001); a significant difference in bone microhardness was found in the LPL group versus the control group (P <0.01). These results suggest that postoperative LPL treatment improves the bone-implant interface. 1 W, 300 Hz, pulsating emission, 10 min. The right thigh bones were sham treated (control group). Histomorphometric and microhardness measurements were taken three and 6 weeks after implantation. A higher affinity index was observed at the HA-bone interface in the LPL group after 3 (P <0.0005) and 6 weeks (P <0.001); a significant difference in bone microhardness was found in the LPL group versus the control group (P <0.01). These results suggest that postoperative LPL treatment improves the bone-implant interface. A higher affinity index was observed at the HA-bone interface in the LPL group after 3 (P <0.0005) and 6 weeks (P <0.001); a significant difference in bone microhardness was found in the LPL group versus the control group (P <0.01). These results suggest that postoperative LPL treatment improves the bone-implant interface. A higher affinity index was observed at the HA-bone interface in the LPL group after 3 (P <0.0005) and 6 weeks (P <0.001); a significant difference in bone microhardness was found in the LPL group versus the control group (P <0.01). These results suggest that postoperative LPL treatment improves the bone-implant interface.

Titanium implants

Clinical Oral Implants Res. 2004; 15 (3): 325-332.
Khadra M, Ronold HJ, Lyngstadaas SP, Ellingsen JE, Haanaes H R.

This study was conducted as an 8-week animal experiment with a blinded, placebo-controlled design. Two coin-shaped titanium implants 6.25 mm in diameter and 1.95 mm in height were implanted in the cortical bone in each proximal tibia of twelve white New Zealand female rabbits (n = 48). The animals were randomly divided into irradiated and control groups. The LLLT was used immediately after the operation and performed daily for 10 consecutive days. The animals were sacrificed after 8 weeks of healing. The mechanical strength of the attachment between the bone and 44 titanium implants was evaluated using a pull-out test. A histomorphometric analysis of the four remaining implants from four rabbits was then carried out. An energy-dispersive X-ray microanalysis was carried out to analyze the calcium and phosphorus on the implant test surface after the tensile test. The mean tensile forces of the irradiated implants and controls measured in Newtons were 14.35 (SD +/- 4.98) and 10.27 (SD +/- 4.38), which indicates a gain in functional attachment after 8 weeks after LLLT close (P = 0.013).

The histomorphometric evaluation indicated that the irradiated group had more bone-to-implant contact than the controls. The weight percentages of calcium and phosphorus were significantly higher in the irradiated group compared to the controls (P = 0.037) and (P = 0.034), respectively, suggesting that bone maturation in the irradiated bone is progressing faster. These results suggest that LLLT may have a beneficial effect on the healing and fixation of titanium implants.

Laser therapy plays a role in bone healing
Laser Surgery Med. 1998; 22: 97-102.
Luger et al. studied the effect of the HeNe laser on the healing of tibial bone fractures in rats.

63 J (35mW) were administered daily transcutaneously over the fracture area. After 4 weeks, the tibia was removed and tested under tension until failure. It was found that the maximum stress at failure and the structural rigidity of the tibia were significantly increased in the irradiated group, while the maximum tensile stress was reduced. In addition, gross non-connection was found in four fractures in the control group, while none was found in the irradiated group.

Computer-aided morphometric assessment of the effect of low-level laser therapy on bone repair **: an animal study** Silva JÃºnior AN, Pinheiro AL, Oliveira MG, Weismann R, Ramalho LM, Nicolau RA. J Clin Laser Med Surg. 2002; 20: 83-87

The aim of this study was the morphometric assessment of the amount of newly formed bone after GaAlAs laser irradiation of surgical wounds that had developed in the thigh bone of rats. Low-level laser therapy (LLLT) has been used in various medical fields due to its biomodulatory effects on various biological tissues. However, due to conflicting reports, the LLLT remains controversial.
This is a direct consequence of the different methods used in this work. In this study, 40 Wistar rats were divided into four groups of 10 animals each: Group A (12 sessions, 4.8 J / cm2 per session, observation time of 28 days); Group C (three sessions, 4.8 J / cm2 per session, observation time of 7 days). Groups B and D acted as non-irradiated controls. The samples were routinely waxed, cut to a thickness of 6 microns, and stained with H&E. The software Imagelab was used for the computer-aided morphometry.

RESULTS: Computerized morphometry showed a significant difference between the areas of mineralized bone in groups C and D (p = 0.017). There was no difference between groups A and B (28 days; p = 0.383).

Effects of the Visible NIR Low Intensity
Laser **on Implant Osseointegration In Vivo** Laser Med Surg Abstract Edition, 2002: 11.
Blay A, Blay CC, Groth EB et al.

The effects of 680 and 830 nm lasers on osseointegration were studied by Blay. 30 adult rats were divided into three groups; two laser groups and a control group. The rats in the two laser groups were implanted with Frialit-2 implants made of pure titanium in each proximal metaphysis of their respective tibia, which were inserted with a torque of 40 Ncm. The initial stability was monitored using a resonance frequency analyzer. Ten irradiations were carried out 48 hours apart at 4 J / cm2 at two points that began immediately after the operation. The resonance frequency analysis showed a significant difference between the frequency values after 3 and 6 weeks compared to the control.

Bone repair of periapical lesions treated or not treated with low intensity laser (wavelength = 904 nm)
Laser surgery Med. Abstract Edition 2002. Abstract 303.
Sousa GR, Ribeiro MS, Groth E B.

The effect of bone repair on periapical lesions was 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 of the other group were subjected to the same procedure and in addition the lesions were irradiated with a GaAs laser, 11 mW, 9 J / cm2. This therapy was carried out in 10 sessions with an interval of 72 hours. The bone regeneration was assessed by an X-ray examination. The results showed a significant difference between the laser and control group in favor of the laser group.

Low-power laser irradiation improves histomorphometric parameters and the organization of the bone matrix in tibial wound healing in rats

Garavello-Freitas I, Baranauskas V, Joazeiro PP, Padovani CR, Dal Pai-Silva M, da Cruz-Hofling MA. Faculdade de Engenharia Eletrica e Computacao, Departamento de Semicondutores Instrumentos e Fotonica, Universidade Estadual de Campinas, Av. Albert Einstein N.400, 13 083- 970 Campinas, SP, Brazil. J Photochem Photobiol B. 2003 May-June; 70 (2): 81-9.

The influence of daily energy doses of 0.03, 0.3 and 0.9 J He-Ne laser irradiation on the repair of surgically produced tibia damage was investigated in Wistar rats. Laser treatment was initiated 24 hours after the trauma and continued daily for 7 or 14 days in two groups of nine rats (n = 3 per laser dose and period). Two control groups (n = 9 each) with injured tibiae were used. The healing process was monitored by means of morphometric analysis of the trabecular area. The organization of the collagen fibers in the bone matrix and the histology of the tissue were evaluated using the Picrosirius polarization method and the Masson trichrome. After 7 days there was a significant increase in the area of the neoformable trabeculae in the tibiae irradiated with 0.3 and 0.9 J compared to the controls. At a daily dose of 0.9 J (15 minutes of irradiation per day), the 7-day group showed a significant increase in trabecular bone growth compared to the 14-day group. However, laser irradiation at the daily dose of 0.3 J did not cause a significant decrease in the trabecular area of the 14-day group compared to the 7-day group, but there was a significant increase in the trabecular area of the 15-day controls compared to the other to the 8-day controls. The irradiation increased the number of hypertrophic osteoclasts compared to the non-irradiated injured tibiae (controls) on days 8 and 15. However, 3J did not cause a significant decrease in the trabecular area of the 14-day group compared to the 7-day group, but there was a significant increase in the trabecular area of the 15-day controls compared to the 8-day controls. The irradiation increased the number of hypertrophic osteoclasts compared to the non-irradiated injured tibiae (controls) on days 8 and 15. However, 3J did not cause a significant decrease in the trabecular area of the 14-day group compared to the 7-day group, but there was a significant increase in the trabecular area of the 15-day controls compared to the 8-day controls. The irradiation increased the number of hypertrophic osteoclasts compared to the non-irradiated injured tibiae (controls) on days 8 and 15.

The Picrosirius polarization method showed bands of parallel collagen fibers (parallel-fibrous bone) at the repair site of the tibiae that had been irradiated for 14 days, regardless of the dose. This organization improved compared to the 7-day irradiated tibiae and control tibiae. These results show that the low-level laser therapy stimulated the growth of the trabecular area and the simultaneous invasion of osteoclasts during the first week and accelerated the organization of the matrix collagen (parallel alignment of the fibers) in a second phase that in the non-irradiated ones Control tibiae was not observed during the same period. The active osteoclasts that invaded the regeneration site were likely responsible for the decrease in trabecular area by the fourteenth day of irradiation.

Effect of 830 nm laser light on the repair of bone defects transplanted with inorganic bovine bone and decalcified cortical bone membrane

Barbos Pinheiro AL, Limeira Junior Fde A, Marquez Gerbi ME, Pedreira Ramalho LM, Marzola C, Carneiro Ponzi EA, Oliveira Soares A, Bandeira De Carvalho LC, Vieira Lima HC, Oliveira Goncalves T.
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J Clin Laser Med Surg. 2003 Dec; 21 (6): 383-8.

OBJECTIVE: The aim of this study was to histological assessment of the effect of LLLT (lambda830 nm) on the repair of standardized bone defects on the femur of Wistar albinus rats transplanted into inorganic bovine bones and associated or not with decalcified bovine cortical bone membrane.

BACKGROUND DATA: Bone loss can be the result of various pathologies, trauma, or surgery. This led to extensive studies of the process of bone repair and the development of techniques to correct bone defects, including the use of different types of grafts, membranes and the combination of both techniques. There is evidence in the literature of the beneficial effects of LLLT on soft tissue wound healing. However, its effect on bones is not fully understood. MATERIALS AND METHODS: Five randomized groups were studied: Group I (control); Group IIA (Gen-ox); Group IIB (Gen-ox + LLLT); Group IIIA (Gen-ox + Gen-derm) and Group IIIB (Genox + Gen-derm + LLLT). Bone defects developed on the thigh bone of the animals and were treated according to the group. The animals in the irradiated groups were irradiated every 48 hours for 15 days; the first irradiation took place immediately after the surgery. The animals were transcutaneously irradiated at four points around the defect. A dose of 4 J / cm2 was administered at each point (phi approx. 0.6 mm, 40 mW), and the total dose per session was 16 J / cm2. The animals were sacrificed unconditionally 15, 21 and 30 days after the operation. The samples were routinely waxed, serially cut and stained with H&E and Picrosirius stains and analyzed by light microscopy. the first irradiation took place immediately after the surgery. The animals were transcutaneously irradiated at four points around the defect. A dose

of 4 J / cm2 was administered at each point (phi approx. 0.6 mm, 40 mW), and the total dose per session was 16 J / cm2. The animals were sacrificed unconditionally 15, 21 and 30 days after the operation. The samples were routinely waxed, serially cut and stained with H&E and Picrosirius stains and analyzed by light microscopy. the first irradiation took place immediately after the surgery. The animals were transcutaneously irradiated at four points around the defect. A dose of 4 J / cm2 was administered at each point (phi approx. 0.6 mm, 40 mW), and the total dose per session was 16 J / cm2. The animals were sacrificed unconditionally 15, 21 and 30 days after the operation. The samples were routinely waxed, serially cut and stained with H&E and Picrosirius stains and analyzed by light microscopy.

RESULTS: The results showed evidence of more advanced repair in the irradiated groups compared to the non-irradiated groups. The repair of the irradiated groups was characterized by both increased bone formation and an increased amount of collagen fibers around the graft within the cavity since the 15th day after the operation, namely by the analysis of the osteoconductive capacity of the Gen-ox and that Increment of cortical repair in specimens with gen derm membrane.

CONCLUSION: It is concluded that the LLLT had a beneficial effect on the repair of the bone defect when the application for implantation of the graft was made.

Effects of the pulse rate of low-level laser therapy (LLLT) on the formation of bone nodules in rat calvary cells

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Department of Orthodontics, Nihon University School of Dentistry in Matsudo Chiba, Japan. J Clin Laser Med Surg. 2003 Oct; 21 (5): 271-7.

OBJECTIVE: The aim of this study was to determine the effect of pulse rates of low-level laser therapy (LLLT) on bone nodule formation in rat calvary cells in vitro.

BACKGROUND DATA: Various photobiostimulatory effects of LLLT, including bone formation, were influenced by some radiation factors such as total energy dose, radiation phase, laser spectrum and power density. However, the effects of the pulse frequencies used during laser irradiation on bone formation have not been elucidated.

MATERIALS AND METHODS: Osteoblast-like cells isolated from fetal rat calvaries were exposed once with a low-energy Ga-Al-As laser (830 nm, 500 mW, 0.48-3.84 J / cm2) in four different radiation modes irradiated: continuous irradiation (CI) and pulsed 1, 2 and 8 Hz irradiation (PI-1, PI-2, PI-8). We then examined the effects on cell proliferation, bone nodule formation, alkaline phosphatase (ALP) activity, and ALP gene expression.

RESULTS: The laser irradiation in all four groups significantly stimulated cellular proliferation, bone nodule formation, ALP activity and ALP gene expression compared to the non-irradiation group. Notably, PI-1 and 2 exposure stimulated these factors significantly compared to the CI and PI-8 groups, and PI-2 exposure was the best approach to knot formation under the current experimental conditions .

CONCLUSION: Since low frequency pulsed laser irradiation significantly stimulates bone formation in vitro, it is very likely that the pulse rate of LLLT is an important factor influencing the biological responses in bone formation.

Effect of low-level laser irradiation on osteoglycine gene expression in osteoblasts

Hamajima S, Hiratsuka K, Kiyama-Kishikawa M, Tagawa T, Kawahara M, Ohta M, Sasahara H, Abiko Y.
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Lasers Med Sci. 2003; 18 (2): 78-82.

Many studies have attempted to elucidate the mechanism of the biostimulatory effects of low intensity laser irradiation (LLLI), but the molecular basis of these effects remains unclear. We investigated the stimulatory effect of LLLI on bone formation during the early proliferation phase of cultured osteoblastic cells. A mouse calvary osteoblastic cell line, MC3T3-E1, was used to perform cDNA-microarray hybridization to identify genes that induced early-stage expression by LLLI. Among the genes that showed at least a two-fold increased expression, the osteoglycine / mimecan gene was upregulated 2.3-fold by 2 h after the LLLI. Osteoglycine is a small leucine-rich proteoglycan (SLRP) of the extracellular matrix, which was formerly known as the osteoinductive factor. SLRPs are abundant in the bone matrix, cartilage cells and connective tissue and are believed to regulate cell proliferation, differentiation and adhesion in close association with collagen and many other growth factors. We investigated the time-related expression of this gene by LLLI using a reverse transcription polymerase chain reaction (RTPCR) method, more precisely using a real-time PCR method, and found increases of 1.5-2-fold at 2-4 h LLLI compared to the non-irradiated controls. These results suggest

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Effect of low-power laser irradiation on bony implant areas

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This study was designed to investigate the effects of low energy laser irradiation on osteocytes and bone resorption at bone implantation sites. Five male baboons, mean age 6.5 years, were used in the study. Four holes were drilled in each iliac crest to accommodate implants. Immediately after drilling and inserting four sand-blasted and etched (Frialit-2 Synchro) implants, the sites on the left were irradiated for 1 minute (6 joules) with a low-energy 100 mW laser (690 nm). Five days later, the bone was removed en bloc and evaluated histomorphometrically. The average osteocyte count per unit area was 109.8 cells in the irradiated group compared to 94.8 cells in the control group. Since the intra-individual cell numbers varied greatly, the osteocyte viability was used for the evaluation. In the irradiated group, viable osteocytes were found in 41.7% of the gap compared to 34.4% in the non-irradiated group. This difference was statistically significant at $P < 0.027$. The total resorption area, eroded surface, was 24.9% in the control group compared to 24.6% in the irradiated group. This difference was not statistically significant. This study showed that the osteocyte vitality in the samples that were laser-irradiated immediately after the drilling of the implantation site and the implant placement was significantly higher compared to the control sites. This can have positive effects on the integration of the implants.

Laser technology in orthopedics: preliminary study for low-power laser therapy to improve the bone-biomaterial interface

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Low Power Laser (LPL) appears to promote healing of bone defects and fractures. The effect of LPL in other orthopedic areas such as the osteointegration of implanted bone prostheses is still unclear. In the present study, 12 rabbits were used to examine whether LPL stimulation with Ga-Al-As (780 nm) had positive effects on osteointegration. Cylindrical hydroxyapatite (HA) nails were drilled into both distal rabbit femur bones. From postoperative day 1 and on 5 consecutive days, the left femur of all rabbits was subjected to LPL treatment (Laser Group-LG) with the following parameters: 300 joules / cm2, 1 watt, 300 hertz, pulsating emission, 10 minutes. The right femur was sham treated (control group CG). After 4 and 8 weeks after the implantation, the bone-biomaterial contact was evaluated by means of histological and histomorphometric examinations. Histomorphometry showed a higher degree of osteointegration at the HA-bone interface in the LG group after 4 ($p < 0.0005$) and 8 weeks ($p < 0.001$). These preliminary positive results seem to support the hypothesis that LPL treatment can be considered a good means of improving the bone-implant interface in orthopedic surgery.

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Low-Level Laser Therapy Stimulates Bone-Implant Interaction: An Experimental Study in Rabbits

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The aim of the present study was to investigate the effect of low-level laser therapy (LLLT) with a gallium-aluminum-arsenide (GaAlAs) diode laser device on the healing and fixation of titanium implants in the bone. This study was conducted as an 8-week animal experiment with a blinded, placebo-controlled design. Two coin-shaped titanium implants 6.25 mm in diameter and 1.95 mm in height were implanted in the cortical bone in each proximal tibia of twelve white New Zealand female rabbits (n = 48). The animals were randomly divided into irradiated and control groups. The LLLT was used immediately after the operation and performed daily for 10 consecutive days. The animals were sacrificed after 8 weeks of healing. The mechanical strength of the attachment between the bone and 44 titanium implants was evaluated using a pull-out test. A histomorphometric analysis of the four remaining implants from four rabbits was then carried out. An energy-dispersive X-ray microanalysis was carried out to analyze the calcium and phosphorus on the implant test surface after the tensile test. The mean tensile forces of the irradiated implants and controls measured in Newtons were 14.35 (SD +/- 4.98) and 10.27 (SD +/- 4.38), which indicates a gain in functional attachment after 8 weeks after LLLT close ($P = 0.013$). The histomorphometric evaluation indicated that the irradiated group had more bone-to-implant contact than the controls. The weight percentages of calcium and phosphorus were significantly higher in the irradiated group compared to the controls ($P = 0.037$) and ($P = 0.034$), respectively, suggesting that bone maturation in the irradiated bone is progressing faster. These results suggest that LLLT may have a beneficial effect on the healing and fixation of titanium implants.
