

Ultrasound and Fracture Healing Reference Material

- 2000 – 2008 -

- (2002). "Pulsed ultrasound for fracture healing." *Bandolier* 9(5).
- Anglen, J. (2003). "The clinical use of bone stimulators." *J South Orthop Assoc* 12(2): 46-54.
- Aynaci, O. et al. (2002). "The effect of ultrasound on the healing of muscle-pediculated bone graft in spinal fusion." *Spine* 27(14): 1531-5.
- Azuma, Y. et al. (2001). "Low-intensity pulsed ultrasound accelerates rat femoral fracture healing by acting on the various cellular reactions in the fracture callus." *J Bone Miner Res* 16(4): 671-80.
- Bandow, K. et al. (2007). "Low-intensity pulsed ultrasound (LIPUS) induces RANKL, MCP-1, and MIP-1beta expression in osteoblasts through the angiotensin II type 1 receptor." *J Cell Physiol* 211(2): 392-8.
- Bennell, K. and P. Brukner (2005). "Preventing and managing stress fractures in athletes." *Physical Therapy in Sport* 6(4): 171-80.
- Bevilaqua-Grosso, D. et al. (2002). "A physiotherapeutic approach to craniomandibular disorders: a case report." *J Oral Rehabil* 29(3): 268-73.
- Busse, J. W. and M. Bhandari (2004). "Therapeutic ultrasound and fracture healing: a survey of beliefs and practices." *Archives of Physical Medicine and Rehabilitation* 85(10): 1653-6.
- Busse, J. W. et al. (2002). "The effect of low-intensity pulsed ultrasound therapy on time to fracture healing: a meta-analysis." *Can-Med-Assoc-J.* 166(4): 437-41.
- Busse, J. W. et al. (2005). "An economic analysis of management strategies for closed and open grade I tibial shaft fractures." *Acta Orthopaedica* 76(5): 705-12.
- Carvalho, D. C. and A. Clinquet (2004). "The action of low-intensity pulsed ultrasound in bones of osteopenic rats." *Artificial Organs* 28(1): 114-118.
- Carvalho, D. C. et al. (2002). "[Non-pharmacological treatments in the stimulation of osteogenesis]." *Rev Saude Publica* 36(5): 647-54.
- Chan, C. W. et al. (2006). "Low intensity pulsed ultrasound accelerated bone remodeling during consolidation stage of distraction osteogenesis." *J Orthop Res* 24(2): 263-70.
- Chang, W. H. et al. (2002). "Study of thermal effects of ultrasound stimulation on fracture healing." *Bioelectromagnetics* 23(4): 256-63.
- Childs, S. G. (2003). "Stimulators of bone healing. Biologic and biomechanical." *Orthop Nurs* 22(6): 421-8.
- Claes, L., A. et al (2005). "Low-intensity ultrasound enhances maturation of callus after segmental transport." *Clin Orthop Relat Res*(430): 189-94.

Claes, L. and B. Willie (2007). "The enhancement of bone regeneration by ultrasound." *Prog Biophys Mol Biol* 93(1-3): 384-98.

Cook, S. D. et al. (2001). "Low-intensity pulsed ultrasound improves spinal fusion." *The Spine Journal* 1: 246-254.

Divelbiss, B. J. and B. D. Adams (2001). "Electrical and ultrasound stimulation for scaphoid fractures." *Hand Clin* 17(4): 697-701, x-xi.

dos Santos, C. A. et al. (2005). "Influence of therapeutic ultrasound on rabbits bone growth plate [Portuguese]." *Fisioterapia e Pesquisa* 12(2): 13-9.

Dudda, M. et al. (2005). "[Application of low intensity, pulsed ultrasound on distraction osteogenesis of the humerus. Case report]." *Unfallchirurg* 108(1): 69-74.

Eberson, C. P. et al. (2003). "Effect of low-intensity ultrasound stimulation on consolidation of the regenerate zone in a rat model of distraction osteogenesis." *J Pediatr Orthop* 23(1): 46-51.

El-Bialy, T. et al (2003). "Growth modification of the rabbit mandible using therapeutic ultrasound: Is it possible to enhance functional appliance results?" *Angle Orthod.* 73(6): 631-639.

El-Bialy, T. H. et al. (2002). "The effect of pulsed ultrasound on mandibular distraction." *Ann Biomed Eng* 30(10): 1251-61.

El-Bialy, T. H. et al (2003). "Effect of ultrasound on rabbit mandibular incisor formation and eruption after mandibular osteodistraction." *Am. J. Orthod. Dentofac. Orthop.* 124(4): 427-434.

El-Mowafi, H. and M. Mohsen (2005). "The effect of low-intensity pulsed ultrasound on callus maturation in tibial distraction osteogenesis." *Int Orthop* 29(2): 121-4.

Erdogan, O. et al. (2006). "Effects of low-intensity pulsed ultrasound on healing of mandibular fractures: an experimental study in rabbits." *J Oral Maxillofac Surg* 64(2): 180-8.

Esenwein, S. A. et al. (2004). "[Efficiency of low-intensity pulsed ultrasound on distraction osteogenesis in case of delayed callotaxis -- clinical results]." *Zentralbl Chir* 129(5): 413-20.

Fujioka, H. et al. (2004). "Ultrasound treatment of nonunion of the hook of the hamate in sports activities." *Knee Surg Sports Traumatol Arthrosc* 12(2): 162-4.

Fujioka, H. et al. (2000). "Treatment of ununited fracture of the hook of hamate by low-intensity pulsed ultrasound: a case report." *J Hand Surg [Am]* 25(1): 77-9.

Fujishiro, T. et al. (2005). "Treatment of a bone defect in the femoral shaft after osteomyelitis using low-intensity pulsed ultrasound." *Eur J Orthop Surg Traumatol* 15: 244-246.

Gebauer, D. and J. Correll (2005). "Pulsed low-intensity ultrasound: a new salvage procedure for delayed unions and nonunions after leg lengthening in children." *J Pediatr Orthop* 25(6): 750-4.

Gebauer, D. et al. (2005). "Low-intensity pulsed ultrasound: effects on nonunions." *Ultrasound Med Biol* 31(10): 1391-402.

Gebauer, G. P. (2002). "Low-intensity pulsed ultrasound increases the fracture callus strength in diabetic BB Wistar rats but does not affect cellular proliferation." *J Orthop Res* 20: 587-592.

Giannini, S. et al. (2004). "Low-intensity pulsed ultrasound in the treatment of traumatic hand fracture in an elite athlete." *Am J Phys Med Rehabil* 83(12): 921-5.

Gold, S. M. and R. Wasserman (2005). "Preliminary results of tibial bone transports with pulsed low intensity ultrasound (Exogen)." *J Orthop Trauma* 19(1): 10-6.

Handolin, L. et al. (2005). "Effect of ultrasound therapy on bone healing of lateral malleolar fractures of the ankle joint fixed with bioabsorbable screws." *J Orthop Sci* 10(4): 391-5.

Handolin, L. et al. (2005). "The effect of low intensity ultrasound and bioabsorbable self-reinforced poly-L-lactide screw fixation on bone in lateral malleolar fractures." *Arch Orthop Trauma Surg* 125(5): 317-21.

Handoll, H. H. G. et al (2003). "A systematic review of rehabilitation for distal radial fractures in adults." *British Journal of Hand Therapy* 8(1): 16-23.

Hannouche, D. et al (2001). "Current trends in the enhancement of fracture healing." *J Bone Joint Surg Br* 83(2): 157-64.

Hantes, M. E. et al. (2004). "Low-intensity transosseous ultrasound accelerates osteotomy healing in a sheep fracture model." *J Bone Joint Surg Am* 86-A(10): 2275-82.

Harle, J. et al. (2001). "Effects of therapeutic ultrasound on osteoblast gene expression." *J. Mater. Sci.-Mater. Med.* 12(10-12): 1001-1004.

Hayton, M. J. et al. (2005). "Involvement of adenosine 5'-triphosphate in ultrasound-induced fracture repair." *Ultrasound Med Biol* 31(8): 1131-8.

Jingushi, S. et al. (2007). "Low-intensity pulsed ultrasound treatment for postoperative delayed union or nonunion of long bone fractures." *J Orthop Sci* 12(1): 35-41.

Korstjens, C. M. et al. (2004). "Stimulation of bone cell differentiation by low-intensity ultrasound - a histomorphometric in vitro study." *J. Orthop. Res.* 22(3): 495-500.

Korstjens, C. M. et al. (2002). "[Effects of low-intensity ultrasound on bone. Perspectives for dentistry?]." *Ned Tijdschr Tandheelkd* 109(12): 485-9.

Lerner, A. et al (2004). "Compound high-energy limb fractures with delayed union: our experience with adjuvant ultrasound stimulation (exogen)." *Ultrasonics* 42(1-9): 915-7.

Leung, K. S. et al. (2004). "Low intensity pulsed ultrasound stimulates osteogenic activity of human periosteal cells." *Clin. Orthop. Rel. Res.*(418): 253-259.

Leung, K. S. et al. (2004). "Lack of efficacy of low-intensity pulsed ultrasound on prevention of postmenopausal bone loss evaluated at the distal radius in older Chinese women." *Clin Orthop Relat Res*(427): 234-40.

- Leung, K. S. et al. (2004). "Complex tibial fracture outcomes following treatment with low-intensity pulsed ultrasound." *Ultrasound Med Biol* 30(3): 389-95.
- Li, J. G. R. et al. (2002). "Optimum intensities of ultrasound for PGE(2) secretion and growth of osteoblasts." *Ultrasound Med. Biol.* 28(5): 683-690.
- Li, J. K. et al. (2006). "Comparison of ultrasound and electromagnetic field effects on osteoblast growth." *Ultrasound Med Biol* 32(5): 769-75.
- Lind, M. et al. (2000). "Stimulated bone healing." *Critical Reviews in Physical and Rehabilitation Medicine* 12(4): 313-43.
- Lirani-Galvao, A. P. et al (2006). "Comparative study of how low-level laser therapy and low-intensity pulsed ultrasound affect bone repair in rats." *Photomed Laser Surg* 24(6): 735-40.
- Lu, H. et al. (2006). "Low-Intensity Pulsed Ultrasound Accelerates Bone-Tendon Junction Healing: A Partial Patellectomy Model in Rabbits." *Am J Sports Med* 34(8): 1287-1296.
- Luthje, P. and I. Nurmi-Luthje (2006). "Non-union of the clavicle and delayed union of the proximal fifth metatarsal treated with low-intensity pulsed ultrasound in two soccer players." *J Sports Med Phys Fitness* 46(3): 476-80.
- Lyon, R. et al (2003). "The effects of therapeutic vs. high-intensity ultrasound on the rabbit growth plate." *J Orthop Res* 21(5): 865-71.
- Maddi, A. et al. (2006). "Long wave ultrasound may enhance bone regeneration by altering OPG/RANKL ratio in human osteoblast-like cells." *Bone* 39(2): 283-8.
- Malizos, K. N. et al. (2006). "Low-intensity pulsed ultrasound for bone healing: an overview." *Injury* 37 Suppl 1: S56-62.
- Malizos, K. N. et al. (2006). "Transosseous application of low-intensity ultrasound for the enhancement and monitoring of fracture healing process in a sheep osteotomy model." *Bone* 38(4): 530-9.
- Mayr, E. (2000). "[More rapid recovery after fracture. When can ultrasound accelerate healing? Interview by Petra Eiden.]" *MMW Fortschr Med* 142(35): 10.
- Mayr, E. et al (2000). "Ultrasound--an alternative healing method for nonunions?" *Arch Orthop Trauma Surg* 120(1-2): 1-8.
- Mayr, E. et al. (2002). "[Is low intensity ultrasound effective in treatment of disorders of fracture healing?]" *Unfallchirurg* 105(2): 108-15.
- Mayr, E. et al. (2000). "[Does low intensity, pulsed ultrasound speed healing of scaphoid fractures?]" *Handchir Mikrochir Plast Chir* 32(2): 115-22.
- McAlinden, M. M. (2002). "Fracture healing using low-intensity pulsed ultrasound." *Cmaj* 167(2): 128; author reply 128.
- Miller, C. et al (2003). "Pelvic stress injuries in the athlete: management and prevention." *Sports*

Medicine 33(13): 1003-12.

Mitragotri, S. (2005). "Healing sound: the use of ultrasound in drug delivery and other therapeutic applications." *Nat Rev Drug Discov* 4(3): 255-60.

Miyamoto, K. et al. (2005). "Exposure to pulsed low intensity ultrasound stimulates extracellular matrix metabolism of bovine intervertebral disc cells cultured in alginate beads." *Spine* 30(21): 2398-405.

Mohtadi, N. (2003). "Sport medicine journal club. Low-intensity pulsed ultrasound therapy for fracture healing: a meta-analysis." *Clinical Journal of Sport Medicine* 13(2): 127.

Moros, E. G. et al. (2004). "Thermal contribution of compact bone to intervening tissue-like media exposed to planar ultrasound." *Phys Med Biol* 49(6): 869-86.

Mukai, S. et al. (2005). "Transforming growth factor-beta1 mediates the effects of low-intensity pulsed ultrasound in chondrocytes." *Ultrasound Med Biol* 31(12): 1713-21.

Naruse, K. et al. (2003). "Distinct anabolic response of osteoblast to low-intensity pulsed ultrasound." *J. Bone Miner. Res.* 18(2): 360-369.

Nelson, F. R. et al. (2003). "Use of physical forces in bone healing." *J Am Acad Orthop Surg* 11(5): 344-54.

Nishikori, T. et al. (2002). "Effects of low-intensity pulsed ultrasound on proliferation and chondroitin sulfate synthesis of cultured chondrocytes embedded in Atelocollagen gel." *J Biomed Mater Res* 59(2): 201-6.

Nolte, P. A. et al. (2001). "Low-intensity ultrasound stimulates endochondral ossification in vitro." *J. Orthop. Res.* 19(2): 301-307.

Nolte, P. A. et al. (2001). "Low-intensity pulsed ultrasound in the treatment of nonunions." *J Trauma* 51(4): 693-702; discussion 702-3.

Okada, K. et al. (2003). "Congenital pseudoarthrosis of the tibia treated with low-intensity pulsed ultrasound stimulation (LIPUS)." *Ultrasound Med Biol* 29(7): 1061-4.

Parvizi, J. et al. (2002). "Calcium signaling is required for ultrasound-stimulated aggrecan synthesis by rat chondrocytes." *J Orthop Res* 20: 51-57.

Phieffer, L. S. and J. A. Goulet (2006). "Delayed unions of the tibia." *J Bone Joint Surg Am* 88(1): 206-16.

Pigozzi, F. et al. (2004). "Low-intensity pulsed ultrasound in the conservative treatment of pseudoarthrosis." *J Sports Med Phys Fitness* 44(2): 173-8.

Pilla, A. A. (2002). "Low-intensity electromagnetic and mechanical modulation of bone growth and repair: are they equivalent?" *J Orthop Sci* 7(3): 420-8.

Pounder, N. M. and A. J. Harrison (2008). "Low intensity pulsed ultrasound for fracture healing: a

review of the clinical evidence and the associated biological mechanism of action." *Ultrasonics* 48(4): 330-8.

Protopappas, V. C. et al. (2005). "An ultrasound wearable system for the monitoring and acceleration of fracture healing in long bones." *IEEE Trans Biomed Eng* 52(9): 1597-608.

Qin, L. et al. (2006). "Low intensity pulsed ultrasound increases the matrix hardness of the healing tissues at bone-tendon insertion-a partial patellectomy model in rabbits." *Clin Biomech (Bristol, Avon)* 21(4): 387-94.

Qin, L. et al. (2006). "Low-intensity pulsed ultrasound accelerates osteogenesis at bone-tendon healing junction." *Ultrasound Med Biol* 32(12): 1905-11.

Raasch, W. G. and D. J. Hergan (2006). "Treatment of stress fractures: the fundamentals." *Clin Sports Med* 25(1): 29-36, vii.

Reher, P. et al. (2002). "Ultrasound stimulates nitric oxide and prostaglandin E-2 production by human osteoblasts." *Bone* 31(1): 236-241.

Ricardo, M. (2006). "The effect of ultrasound on the healing of muscle-pediculated bone graft in scaphoid non-union." *Int Orthop* 30(2): 123-7.

Robertson, V. J. (2003). "Therapeutic Ultrasound: Re-evaluating the Evidence." *Physiother-Singapore*. 6(2): 28-35.

Rubin, C. et al. (2001). "The use of low-intensity ultrasound to accelerate the healing of fractures." *J Bone Joint Surg Am* 83-A(2): 259-70.

Rue, J. P., D. W. Armstrong, 3rd, F. J. Frassica, et al. (2004). "The effect of pulsed ultrasound in the treatment of tibial stress fractures." *Orthopedics* 27(11): 1192-5.

Rutten, S. et al. (2007). "Use of low-intensity pulsed ultrasound for posttraumatic nonunions of the tibia: a review of patients treated in the Netherlands." *J Trauma* 62(4): 902-8.

Rutten, S. et al. (2008). "Low-intensity pulsed ultrasound increases bone volume, osteoid thickness and mineral apposition rate in the area of fracture healing in patients with a delayed union of the osteotomized fibula." *Bone* 43(2): 348-54.

Saito, M. et al. (2004). "Effect of low- and high-intensity pulsed ultrasound on collagen post-translational modifications in MC3T3-E1 osteoblasts." *Calcif Tissue Int* 75(5): 384-95.

Saito, M. et al. (2004). "Intensity-related differences in collagen post-translational modification in MCM-E1 osteoblasts after exposure to low- and high-intensity pulsed ultrasound." *Bone* 35(3): 644-655.

Sakurakichi, K. et al. (2004). "Effects of timing of low-intensity pulsed ultrasound on distraction osteogenesis." *J Orthop Res* 22: 395-403.

Sant'Anna, E. F. et al. (2005). "Effect of low intensity pulsed ultrasound and BMP-2 on rat bone marrow stromal cell gene expression." *J Orthop Res* 23(3): 646-52.

Santos, C. A. and H. S. A. Fialho (2003). "Influence of the therapeutic ultrasound on the rabbits's [sic] bone growth plate [Portuguese]." *Revista de Fisioterapia da USP* 10(1): 50-1.

Schortinghuis, J. et al. (2004). "Therapeutic ultrasound to stimulate osteoconduction; A placebo controlled single blind study using e-PTFE membranes in rats." *Arch Oral Biol* 49(5): 413-20.

Schortinghuis, J. et al. (2005). "Does ultrasound stimulate osteoconduction? A placebo-controlled single-blind study using collagen membranes in the rat mandible." *Int J Oral Maxillofac Implants* 20(2): 181-6.

Schortinghuis, J. et al. (2004). "Therapeutic ultrasound to stimulate osteoconduction A placebo controlled single blind study using e-PTFE membranes in rats." *Archives of Oral Biology* 49: 413-420.

Schortinghuis, J. et al. (2003). "Ultrasound stimulation of maxillofacial bone healing." *Crit Rev Oral Biol Med* 14(1): 63-74.

Sena, K. et al. (2005). "Early gene response to low-intensity pulsed ultrasound in rat osteoblastic cells." *Ultrasound Med Biol* 31(5): 703-8.

Shimazaki, A. et al. (2000). "Low-intensity pulsed ultrasound accelerates bone maturation in distraction osteogenesis in rabbits." *J Bone Joint Surg Br* 82(7): 1077-82.

Stein, H. and A. Lerner (2005). "How does pulsed low-intensity ultrasound enhance fracture healing?" *Orthopedics* 28(10): 1161-3.

Takayama, T. et al. (2007). "Low-intensity pulsed ultrasound stimulates osteogenic differentiation in ROS 17/2.8 cells." *Life Sci* 80(10): 965-71.

Takikawa, S. et al. (2001). "Low-intensity pulsed ultrasound initiates bone healing in rat nonunion fracture model." *J Ultrasound Med* 20(3): 197-205.

Tanzer, M. (2001). "Enhancement of bone growth into porous intramedullary implant using non-invasive low intensity ultrasound." *J Orthop Res* 19(2): 195-199.

ter Haar, G. (2007). "Therapeutic applications of ultrasound." *Prog Biophys Mol Biol* 93(1-3): 111-29.

Tis, J. E. et al. (2002). "The effect of low intensity pulsed ultrasound applied to rabbit tibiae during the consolidation phase of distraction osteogenesis." *J Orthop Res* 20(4): 793-800.

Tsumaki, N. et al. (2004). "Low-intensity pulsed ultrasound accelerates maturation of callus in patients treated with opening-wedge high tibial osteotomy by hemicallotasis." *J Bone Joint Surg Am* 86-A(11): 2399-405.

Wang, C. J. et al. (2003). "Shock wave therapy induces neovascularization at the tendon-bone

junction. A study in rabbits." *J Orthop Res* 21(6): 984-9.

Warden, S. J. (2003). "A new direction for ultrasound therapy in sports medicine." *Sports Med* 33(2): 95-107.

Warden, S. J. et al. (2001). "Skeletal effects of low-intensity pulsed ultrasound on the ovariectomized rodent." *Ultrasound Med Biol* 27(7): 989-98.

Warden, S. J. et al. (2001). "Efficacy of low-intensity pulsed ultrasound in the prevention of osteoporosis following spinal cord injury." *Bone* 29(5): 431-6.

Warden, S. J. et al. (2000). "Acceleration of fresh fracture repair using the sonic accelerated fracture healing system (SAFHS): a review." *Calcif Tissue Int* 66(2): 157-63.

Warden, S. J. et al. (2001). "Low-intensity pulsed ultrasound stimulates a bone-forming response in UMR-106 cells." *Biochem Biophys Res Commun* 286(3): 443-50.

Warden, S. J. et al. (2006). "Ultrasound produced by a conventional therapeutic ultrasound unit accelerates fracture repair." *Phys Ther* 86(8): 1118-27.

Yang, K. H. and S. J. Park (2001). "Stimulation of fracture healing in a canine ulna full-defect model by low-intensity pulsed ultrasound." *Yonsei Med J* 42(5): 503-8.

Yang, R. S. et al. (2005). "The effects of low-intensity ultrasound on growing bone after sciatic neurectomy." *Ultrasound Med Biol* 31(3): 431-7.

Yang, R. S. et al. (2005). "Regulation by ultrasound treatment on the integrin expression and differentiation of osteoblasts." *Bone* 36(2): 276-83.

Zhang, Z. J. et al. (2002). "The influence of pulsed low-intensity ultrasound on matrix production of chondrocytes at different stages of differentiation: an explant study." *Ultrasound Med Biol* 28(11-12): 1547-53.

Zura, R. D. et al. (2007). "A survey of orthopaedic traumatologists concerning the use of bone growth stimulators." *J Surg Orthop Adv* 16(1): 1-4.