

THE BEST DURATION OF LOW INTENSITY PULSED ULTRASOUND FOR ACCELERATING FRACTURED-RADIAL BONE REPAIR

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ABSTRACT

We have already shown that low intensity pulsed ultrasonic treatment increases rabbit radial fracture healing. The present experiment was undertaken to find out the best duration for treatment. A complete transverse fracture was made in the right radial bones of 21 adult male rabbits by a Stanley knife. The animals were divided into 4 groups: group 1, control; groups 2, 3, and 4, experimental groups, which received ultrasound (0.5 W/cm², 1MHz, 2 msec on-8 msec off) for durations of 5, 10, and 15 min/day, respectively, from the day after surgery until complete fusion was observed. Radiological studies indicated that mean duration of healing was longer and rate of healing was lower in the control compared with those of the experimental groups ($p < 0.05$). However, group 3 showed the least mean healing duration and group 2 and 3 showed the highest healing rate. Our results revealed no deleterious effects of ultrasound on treated and untreated ipsilateral and contralateral bones during the experiment or one month after complete fusion of the bones, at which time ultrasound treatment was terminated.

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Keywords: Ultrasound, Different duration, Healing, Fractured bone.

INTRODUCTION

Ultrasound is used as a therapeutic agent primarily because it stimulates the repair of soft tissues.¹ The repair of bone and soft tissues has many aspects in common. These processes show similar overlapping phases on inflammation, proliferation and remodeling in both types of tissues.² Furthermore, similar cells are actively involved in the early stages of repair in both tissues.^{3,4} These and other similarities suggest that it could be possible to use therapeutic levels of ultrasound in order to stimulate bone repair.^{5,6} We have already shown that low intensity pulsed ultrasound accelerates healing of fractured radial bones in rabbits, which was examined histologically and radiologically as well as through evaluation of mineral composition of the bones, using a stereoelectron microscope.⁷ Mortimer and Dyson⁸ also studied the effect of

therapeutic ultrasound on calcium uptake by embryonic chick fibroblasts using calcium-45 radiotracer techniques, and found that Ca uptake was elevated with increasing exposure time. The main object of the present study was to determine the optimum exposure time of therapeutic ultrasound for accelerated healing of fractured bone. Another aim was to study the possible side effects of ultrasound treatment with different exposure times on the ipsilateral and contralateral bones during ultrasonic treatment and one month after its termination and complete bone healing.

MATERIAL AND METHODS

White rabbits, weighing between 1.5-2.2 kg, were obtained from the animal center of Shiraz Medical School. Each rabbit was caged individually and given free access to food and water. A total of 21 rabbits were

ulnar bones. Our results are in good agreement with other reports which demonstrated that ultrasonic treatment at a frequency of 0.5-1.5 MHz was completely safe.¹³⁻¹⁵

In the present experiment ipsilateral fractured and intact bones and contralateral intact bones were examined radiologically one month after termination of ultrasound treatment (complete healing). However there was no sign of abnormality in the above mentioned bones and they were completely normal. In group 3, histological examination was also done and confirmed our radiological results.

In summary, it seems that ultrasound at an intensity of 0.5 W/cm², repeating at 1 MHz, pulsed 2 msec on and 8 msec off, for durations of 5, 10 and 15 min/day, can all accelerate bone healing without having any deleterious effect on the treated fractured and intact bones during healing and even one month after complete healing. Thus ultrasound treatment can be recommended for direct stimulation of the fracture site and have a possible application in clinical therapy.

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REFERENCES

1. Fufe MC, Chahl LA: The effect of ultrasound on experimental edema in rats. *Ultrasound Med Biol* 6: 107-110, 1980.
2. Dyson M: Therapeutic applications of ultrasound. In: Nyborg WL, Ziskia MC. (eds.), *Biological Effect of Ultrasound*. New York: Churchill Livingstone, pp. 121-133, 1985.
3. Young SR, Dyson M: Macrophage responsiveness to therapeutic ultrasound. *Ultrasound Med Biol* 16: 809-816, 1990.
4. Ingel BM, Hay SM, Eastell R: Change in bone turnover following distal forearm fracture. *Osteoporos Int* 10(5): 399-407, 1999.
5. Mayr E, Frankel V, Ruter A: Ultrasound-an alternative healing method for nonunion? *Arch Orthop Trauma Surg* 120 (1-2): 1-8, 2000.
6. Warden SJ, Bennell KL, McMeeken JM, Wark JD: Acceleration of fresh fracture repair using the sonic accelerated fracture healing system (SAFHS). *Calcif Tissue Int* 66 (2): 157-163, 2000.
7. Nayeri Kaman GD, Keshtgar S: Low intensity pulsed ultrasound treatment increases rabbit radial fracture healing. *MJIRI* 13 (1): 43-50, 1999.
8. Mortimer AJ, Dyson M: The effect of therapeutic ultrasound on calcium uptake in fibroblasts. *Ultrasound Med Biol* 14: 499-506, 1988.
9. Tsai CL, Change WH, Liu TK, Song GM: Ultrasound can affect bone healing both locally and systemically. *Chinese J Physiol* 34 (2): 213-222, 1991.
10. Klug W, Franke WG, Knoch HG: Scintigraphic control of bone-fracture healing under ultrasonic stimulation: an animal experimental study. *Eur J Nucl Med* 11: 494-497, 1986.
11. Pilla AA, Mont MA, Nasser PR, Khan SA, Figueiredo M, Kaufman JJ, Siffert RS: Non-invasive low intensity pulsed ultrasound accelerates bone healing in the rabbit. *J Orthopaedic Trauma* 4 (3): 246-253, 1990.
12. Tsai CL, Change WH, Liu TK, Song GM: Ultrasonic effect on fracture repair and prostaglandin E₂ production. *Chinese J Physiol* 35 (1): 27-34, 1992.
13. Wang SJ, Lewallen DG, Bolander ME, Chao EYS, Ilstrup DM, Greenleaf JF: Low intensity ultrasound treatment increases strength in a rat femoral fracture model. *J of Orthopaedic Research* 12: 40-47, 1994.
14. Mayr E, Wagner S, Ecker M, Rutter A: Ultrasound therapy for nonunion. Three case reports. *Ullfallchirurg* 102 (3): 191-6, 1999.
15. Hadjiargyrous M, McLeod K, Ryaby JP, Rubin C: Enhancement of fracture healing by low intensity ultrasound. *Clin Orthop* 355 (Suppl): S216-29, 1998.