Effects of different therapeutic ultrasound intensities on osteoporosis and bone defect in rats

Shuxin Sun[1], Liang Tang[2], Lijun Sun[2], Feng Xu[1], Xue Jiang[1], Dean Ta[1]
1 Department of Electronic Engineering, Fudan University, Shanghai 200433, China
2 Institute of Sports Biology, Shaanxi Normal University, Xi'an 710119, China

Background, Motivation and Objective

Low-intensity pulsed ultrasound (LIPUS) with the intensity (spatial average temporal average, ISATA) of 30mW/cm^2 has proved to be effective on bone fracture healing. Considering the strong attenuation of ultrasound in the intact cortical bone and the absence of an injury working as an entry point for the acoustic signal, we do not know if the intensity of LIPUS should be enhanced while treating osteoporosis to obtain better therapeutic effects. Thereby, we compared the effects of 30mW/cm^2 and 150mW/cm^2 LIPUS on the osteoporotic rat femur. Meanwhile, a drill hole at the femur mid-diaphysis was also treated as a comparison.

Statement of Contribution/Methods

Healthy 3-month-old female Sprague-Dawley rats received bilateral ovariectomy (OVX) or sham-operations. After twelve weeks, a drill hole, 1 mm in diameter, was created at mid-diaphysis of the left femur for all rats. Then, according to sham or OVX surgery, rats were randomly assigned to 4 groups: (1) sham-C (n = 32), (2) OVX-C (n = 32), (3) OVX+30mW/cm^2 (n = 24), (4) OVX+150mW/cm^2 (n = 24). LIPUS intervention was applied to bilateral femurs by a self-developed LIPUS system. Eight rats in the Sham-C and OVX-C group, respectively, were euthanized before LIPUS intervention. Thereafter, 8 rats from each group were sacrificed at day 10, 21, and 42 after LIPUS intervention, respectively. Right femurs were subjected to μCT scanning and subsequently mechanical testing, measuring the trabecular bone structural parameters and the femur biomechanical properties, respectively. Left femurs were used to evaluate bone defect healing by μCT analysis of the drill holes.

Results/Discussion

At day 10 after LIPUS intervention, no cortices was bridged in the defect region, so the healing rate was calculated from day 21. As shown in Fig. 1, 30 mW/cm^2 LIPUS indeed worked well for bone defect healing, but not for osteoporotic bone. With an entry point for LIPUS signals in cortical bones, LIPUS functioned faster. However, for ameliorating bone loss of osteoporosis, energy of the 30 mW/cm^2 is insufficient in consideration of the strong attenuation in the intact cortical bone. This may suggest that improving the LIPUS intensity may be a potential effective consideration in LIPUS mitigation of osteopenia and osteoporosis.

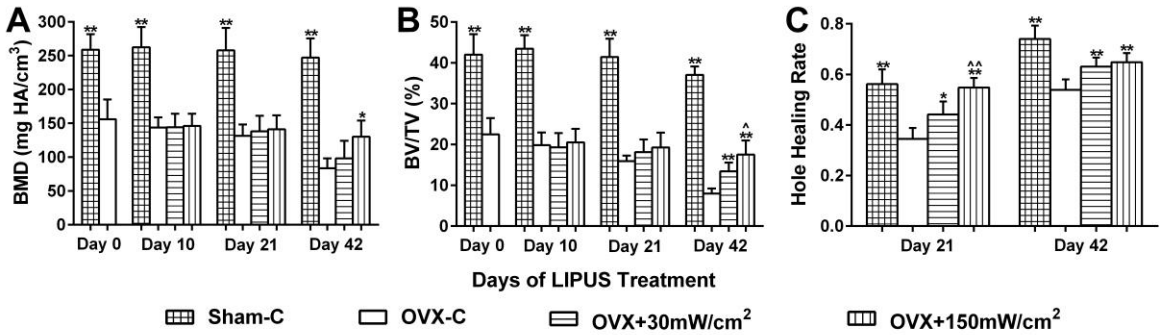

Fig. 1 Results of μCT analysis of trabecular bone in the distal femur (A and B) and bone defect healing rete of the drill hole (C). *, ** $p < 0.05, 0.001$, vs. OVX-C ; ^, ^^ $p < 0.05, 0.001$ vs. OVX+30mW/cm^2.