IS THE APPLICATION OF "LOW-MAGNITUDE HIGH-FREQUENCY VIBRATION" BENEFICIAL FOR FRACTURE REPAIR?

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Introduction

Fracture repair is regulated by the mechanical conditions present in the fracture healing area. One therapeutical approach to improve fracture healing might be the application of mechanical stimuli during the fracture healing period, e.g. low-magnitude high-frequency vibration" (LMHFV; [Rubin, 2004]). LMHFV showed an anabolic effect in intact and osteoporotic bone [Slatkovska, 2010]. However, inconsistent results were obtained in experimental fracture healing studies conducted so far [Leung, 2009; Stuermer, 2010] and the optimal LMHFV parameters are not known yet. Therefore, this study examined the effect of two different LMHFV protocols on fracture healing in C57BL/6 mice.

Methods

Female, 12 week old C57BL/6NCrl mice (n=30) received an osteotomy of the right femur, which was stabilized using an external fixator. Starting on the third postoperative day, all animals were placed on vibration platforms (20 min/d; 5d/week), and received either a mechanical intervention therapy (group 1: f=35 Hz, $a_{peak\text{-}to\text{-}peak}$=0.3 g; group 2: f=45 Hz, $a_{peak\text{-}to\text{-}peak}$=0.3 g; n=8) or no vibration (control group: n=14). Preoperatively and during the healing period on d4, d11 and d18 we measured the activity of the mice (number of steps during 12 h) using an infrared beam detection system (ActimotMot-System, TSE Systems GmbH, Germany) and the ground reaction force of the operated limb using a force plate (HE6x6, Watertown, MA, USA). The animals were sacrificed on d21 and the femora were analysed by biomechanical testing and µ-computed tomography. Statistics: Shapiro-Wilk-Normality-Test, Student T-Test, level of significance $p<0.05$.

Results

In all animal groups the activity and weight bearing was ≥ 70 % of the pre-operative values. There were no group differences in activity. In contrast, in the early post-operative phase group 2 (45 Hz) showed a significant reduction in the ground reaction force of the fractured limb compared to group 1 (35 Hz) and the non-vibrated control group. Vibration with 35 Hz did not significantly influence the bending stiffness and the relative amount of newly formed bone in the fracture callus. Vibration with 45 Hz significantly reduced the bending stiffness of the fractured femora by 34 % and BV/TV by 37 %.

Discussion

In this study we compared the effects of two LMHFV protocols, which were previously used in literature, on fracture healing in mice. We could not detect a significant improvement of fracture repair when applying LMHFV (f=35 Hz; a=0.3 g). The increase of the frequency from 35 Hz to 45 Hz even resulted in a significant impairment of fracture healing indicating that the vibration conditions might be a critical factor. Because we used young mice, optimal healing conditions could be assumed, possibly explaining that LMHFV did not improve fracture healing. In ongoing studies, we are currently investigating the effect of the vibration therapy in aged and osteoporotic bone with reduced healing capacity.

References

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