Low-Magnitude, High-Frequency Vibration Enhances Fracture Healing and Rehabilitation in Elderly with Intertrochanteric Fractures

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ABSTRACT INTRODUCTION:
Fractures are an important cause of morbidity in aged population and are the commonest problem related with osteoporosis. Osteoporotic hip fracture is common in elderly. As a result of aging population in Hong Kong, the total number of hip fracture cases is anticipated to increase substantially in the future, and therefore draw more resources in hospitals and healthcare cost. Hip fracture patients are frequently treated with surgery for treatment. Osteoporotic hip fracture usually causes severe pain and takes long time (4-8 months) to recover due to impaired healing capability in osteoporotic bones and limited mobility [1]. Consequently, the patients will recover very slowly as a result of low physical activities to provide inadequate mechanical stimulation. It is also known that mechanical, vascular and biological factors are the keys for fracture healing.

Low-magnitude, high-frequency vibration (LMHFV) treatment is a biophysical intervention to provide whole-body vibration signals for mechanical stimulation, which has been proven to be good in enhancing bone and muscle performance, as well as blood circulation[2,3,4]. Our previous pre-clinical studies also showed that LMHFV significantly accelerated normal and osteoporotic fracture healing in rats, with increased callus formation and up-regulation of endochondral ossification-related genes [5,6]. Our randomized controlled trial indicated an enhancement of muscle performance in elderly women after 3 months intervention as well [7]. Justified with these evidences, we therefore postulate LMHFV enhances osteoporotic hip fracture healing by enhancing fracture impaction, maintaining bone mineral density, enhancing muscle recovery, thus improving implant mechanical stability and better rehabilitation in elderly patients. Also, LMHFV has no adverse effect on hip fracture fixation in early post-operative period.

METHODS:
Forty elderly with unilateral trochanteric fracture and aged 65 years or above fixed with dynamic hip screw or Gamma nail were recruited. Patients were randomized into either vibration or control group, where vibration group was treated with LMHFV at 35Hz, 0.3g for 20 min/day and 7 days/week in addition to the standard post-fracture rehabilitation. The control group received standard rehabilitation programs only. The treatment was started from day 4 post-operation to 6 months and patients were followed up until 12 months. Radiographic examination on fracture healing was regularly taken immediately after surgery, before discharge from rehabilitation hospital and at each outpatient clinic follow up visits. Functional assessments including balancing ability, range of motion of hip joint, quality of life and daily activity performance were also measured at baseline, mid-term (2nd, 3rd, 6th months) and at end-point (12th months). Bone mineral density (BMD) of hip and spine, bone micro-architecture of distal tibia and radius were measured at day 2 post-operation, 6th month and 12th month. Bone remodelling in fracture healing was measured in terms of the level of bone biochemical markers of bone Receptor Activator for Nuclear Factor x B Ligand (RANKL) and Osteoprotegerin (OPG). The levels of RANKL and OPG in subjects’ serum were measured at day 2 and 10 as well as 24th months of post operation. Informed consent was obtained before patient enrolment and human ethics approval were obtained from the Clinical Research Ethics Committee of the Chinese University of Hong Kong (Reference number: CRE-2007.342-T). Data were analysed by Mann-Whitney U and Wilcoxon Signed Ranks Tests. P<0.05 was considered to be statistically significant.

RESULT SECTION:
There were 16 control cases aged 81.06±5.60 and 18 treatment cases aged 78.29±6.09, who have completed the 6th month assessment. The vibration compliance of the treatment group was 85% (5.95±1.4 days/week). There was no significant age difference between two groups. The functional assessments showed the vibration group with significant improvement in quality of life and early enhancement in range of motion of hip joint at 2nd month when compared with control group (p<0.05). For hip BMD on non-fracture side at 6th month, the vibration group showed a trend with higher BMD increase in wards triangle region (7.09±16.38 vs. 5.66±12.39) and less bone loss in femur neck(−2.53%±5.04 vs. −4.22%±3.15), as compared with control group. The radiographic examination also showed an earlier fracture impaction with sliding of lag screw and appearance of intra-medullary callus in vibration group. The RANKL/OPG ratio in vibration group at 2nd month post-operation was double of that in control group (16.26±13.22 vs. 8.97±5.76). There was no complications nor patients’ complaint on the pain or the use of LMHFV treatment in both groups.

DISCUSSION:
LMHFV accelerating normal and osteoporotic fracture healing in rats with increased callus formation was reported by our pre-clinical studies [5,6]. Our clinical radiographic examination in this study supported that LMHFV promoted early intra-medullary callus formation in fracture healing. The sliding of the lag screw in treatment group implies that fracture impaction during mobilization exercise is the most important factor that determines the successful outcomes of the LMHFV of inter-trochanteric fracture [8]. The retarded bone loss and BMD increase around the hip areas after the 6 months LMHFV therapy indicated an anabolic effect on bone tissues. These findings were substantiated by others reporting a relative benefit of 2.17% in hip BMD in post-menopausal women with a year of LMHFV treatment [2]. LMHFV enhanced quality of life, earlier regaining of hip joint functions and post operative activities may be explained by the effects of LMHFV on increasing blood circulation and muscle performance. LMHFV significantly enhanced peripheral and systemic blood flow and vasculature play an important role in supplying nutrients for better fracture healing [4,9]. Enhancement of muscle performance and postural control were also reported after treating LMHFV, which will be useful for rehabilitation and mobility after fracture healing [3]. The levels of RANKL/OPG ratio was double in vibration group, which implied that the bone resorption rate is faster than control group. Bone remodelling process might be enhanced by LMHFV. The good compliance (85%) in using LMHFV without complication in screw fixation nor complaint from patients also indicates that LMHFV is safe for application on elderly in the post-operative period.

REFERENCE:

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