A Novel Fixative Needle Carried Mg Can Promote Fracture Healing In Ovx Rats

ZHANG Yifeng.
The Chinese University of Hong Kong, Hong Kong, China.

Disclosures: Z. Yifeng: None.

Introduction: Magnesium (Mg) can promote the new bone formation in the periosteum region after intramedullarily implanted into the rat femur canal. This osteogenic effect inspired us to apply it into the OVX rat fracture healing. Mg itself is too soft to fix the rat fracture bone directly, that puzzled clinicians without a resolution of enhancing Mg metal’s strength. Here we designed a novel fixative needle-encapsulated Mg intramedullary nail to fixate the fractured bone. We speculated Mg ions which released through the window at middle site of the needle can promoted the fracture healing. That will make Mg's orthopedic application into an applicable real.

Methods: Three kinds of needle designs were drafted in software SolidWorks. Finite elemental analysis (FEA) was used to screen design drawing with the best mechanical performance and broad window area. 18G spinal needles were machined as rough blank. Mg degradation captured in designed needle was evaluated in vitro. 48 3-month old rats were ovariectomized and raised to 9-month old to perform osteoporosis. Then rats were made to closed fracture on right femur and fixed separately by designed needle (n=24) and blank needle (n=24). Samples were harvested at week 2, 4, 8, 12 (all groups with 6 samples at each time point). Micro-CT scanning and X-ray photographs were applied to analyse fracture callus. Samples at week 12 were under mechanical test. Callus area and length in x-ray results, callus total volume and bone volume, callus bone density, mechanical strength and E-modulus were analysed.

Results: The window design was evolved from original semi-roundness shape to the cruciately interlacing holes. However semi-roundness shape needle was broken in the rat femur fracture fixation at week 4 to 6. The ideal design preserved enough window area and strong enough to fixate the fracture bone. The window area in 1/5 needle outer diameter design was about 3.6 square millimeters, just 0.8 times to that of ½ needle outer diameter design, but the strength was enforced significantly. The cruciately interlacing holes design was 18 holes interlacingly arranged in the middle site of the needle. Holes diameter was 0.5mm. 18 holes distributed at needle surface with length of 10 mm. So sum area of total 18 holes was 3.53 square millimeters, it was closed to 1/5 needle outer diameter design. FEA results showed that both middle site and lateral site bearing were largest in needle with ½ outer diameter design, the needle with 1/5 outer diameter design was less but still more than the intact needle. The needle with cruciately interlacing holes design had almost no difference with the intact needle, and this design was our first choice. In fracture, lateral X-ray radiographs showed that Mg treated group showed 1.89 times callus area than the control group, its callus width was 1.38 times than the control at week 2. At week 4, Mg treated group had 1.64 times callus area than the control group, and the callus width was still 1.38 times than the control. At week 8, Mg treated group still had 1.71 times callus area than the control group, and the callus width was 1.4 times than the control. All the differences were vanished at week 12. CT results of fracture callus showed that Mg treated fracture bone group performed significantly more total callus bone volume than the control group at week 2, 4 and 8. At week 2, the total callus bone volume of Mg treated group was 1.178 times than that of control group. At week 4, the total callus bone volume of Mg treated bone was 1.417 times than the control.
At week 8, the Mg treated group still had 1.318 times than the control. We observed that the callus total volume in Mg treated group was remarkably higher than the control group from beginning to the end, and the increasing range was achieved to the top at week 4, after week 4, the increasing amount was sloping to a low value at week 8. Also all the differences were disappeared at week 12. At week 12, we carried biomechanical test, the results showed that Mg treated fracture femur had better bending resisting strength than the control (about 27% improvement to the control).

**Discussion:** FEA analysis helped us choosing a most appropriate needle design to fixate rat fracture bone and carrying Mg. We successfully applied Mg to treat fracture healing by a novel needle. X-ray and micro-CT results suggested the Mg containing needle significantly enhanced fracture callus volume. Biomechanical testing results proved Mg containing needle had excellent performance in fracture healing. This work firstly designed a hollow needle which carried Mg in treatment of fracture repair, and made Mg’s orthopedic usage to be an applicable real in clinical field.

**Significance:** Data were presented as mean ± standard deviation. A two-sided, nonpaired t test was used to analyze all the data, differences were considered significant as p<0.05.
Figure 1. Needle designs

Figure 2. FEA analysis and results

Figure 3. Fracture results

ORS 2015 Annual Meeting
Poster No: 1151