Paper - Basic Science

Paper Session: Biomechanics

Reverse Dynamization Accelerated Bone Healing in a Goat Osteotomy Model

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Purpose: Reverse dynamization (RD) is a method developed to accelerate bone healing and remodeling. Using RD, the fracture is initially fixed with a more flexible fixation, and is then followed by a rigid fixation. The hypothesis is that a fracture initially stabilized less rigidly will allow micromotion and encourage cartilaginous callus formation, and once a substantial callus has formed, the stabilization is converted to a rigid configuration to prevent the disruption of vascularization, thereby accelerating the remodeling process. Therefore, the aim of this study was to investigate if bone healing can be accelerated using RD in a large-animal osteotomy model.

Methods: 18 goats had a circular external fixator applied to their right hind limbs, and a transverse 2-mm midshaft tibial osteotomy was created. The goats were then divided into 3 groups: static fixation group (SF, n = 6; rigid fixation), dynamic fixation group (DF, n = 6; rods containing the dynamizers providing continuous micromotion-flexible fixation), and reverse dynamization group (RD, n = 6; the dynamizers were removed converting to rigid fixation at 3 weeks after surgery). At the end of week 8 the goats were euthanized, and both limbs of each goat were evaluated using radiographs, microCT, and mechanical testing.

Results: Weekly radiographs showed earlier, bigger callus along with more bone formation in the DF and RD groups compared to the SF group, but significance was only reached between the SF and DF groups ($P = 0.04$). Bone volume fraction was also significantly different between the SF and DF groups ($P = 0.05$) but was not different between the SF and RD groups. Bone mineral density was higher in the RD group compared to the SF and DF groups, which reached nearly significant difference ($P = 0.06$). Moreover, the tibial osteotomies that healed under conditions of RD were considerably stronger in torsion than the osteotomies stabilized with SF and DF regimens ($P = 0.02$ and $P = 0.01$, respectively). Furthermore, torsional strength of tibias in the DF and RD groups was also significantly different from the intact bone (for both, $P = 0.001$).

Conclusion: These preliminary data confirm the influence of modulating the mechanical environment in the healing of osteotomies in a goat model. The best results were achieved using reverse dynamization as was demonstrated by torsional testing, radiographs, and microCT. The bones that healed under the RD regimen were significantly stronger, had smaller callus size, and higher bone mineral density, suggesting an accelerated remodeling process. These data agreed with previous small animal studies demonstrating that the axial stiffness of the fixator can be modulated to maximize the regenerative capacity of bone healing.