On the Horizon From the ORS

Reverse Dynamization: A Novel Approach to Bone Healing

Julius Wolff (1836-1902) demonstrated the remarkable ability of the long bones to adapt to their mechanical environment. This property underlies the strategy of dynamization as a way to improve bone healing. Introduced by De Bastiani et al1 in the 1980s, dynamization requires initial rigid stabilization of an osseous defect to allow the soft tissues to recover and bone healing to begin. With the first radiologic signs of mineral deposition within the defect. Epari et al2 confirmed this phenomenon and began to define the stiffness parameters and BMP-2 dose requirements.

Experimental Evidence

First experiments used a rat femoral critical-size diaphyseal defect stabilized with an external fixator. The fixator was designed to allow the axial stiffness to be modulated while attached to a living animal.5 Recombinant human bone morphogenetic protein-2 (BMP-2) was used to initiate healing. These studies confirmed that healing was accelerated and improved by reverse dynamization using initial low stiffness (114 N/mm) fixation, followed by reverse dynamization to a high stiffness fixator (254 N/mm) after 2 weeks of healing2 (Figure 1).

In a subsequent publication,6 we confirmed this phenomenon and began to define the stiffness parameters and BMP-2 dose requirements.

Reverse Dynamization Concept

The concept of reverse dynamization arose as a means of stimulating endochondral bone formation. We predicted that early exposure of the defect to loading would enhance the differentiation of mesenchymal progenitor cells into chondrocytes, a process accelerated by mechanical stimulation.3 Such loading, however, threatens to impair endochondral ossification by disrupting the formation of blood vessels within the ossifying structure. For this reason, we proposed to increase the rigidity of fixation at the first radiologic signs of mineral deposition within the defect. Epari et al4 subsequently published a theoretical paper supporting our postulates.

Next Steps

We are about to start exploring the effectiveness of reverse dynamization in a sheep tibial defect model7 as a prelude to possible human clinical trials and veterinary applications. Meanwhile, the mechanism of action of reverse dynamization requires elucidation. As noted, it was originally proposed as a means of stimulating the endochondral process. However, in our first study,2 we could detect no evidence of early chondrogenesis. Nevertheless, the subsequent study,6 using a lower dose of BMP-2 and a wider range of stiffnesses, identified cartilage at the defect site. The mechanism may thus be subtle, possibly involving an effect on the production of inflammatory proteins.

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mediators and the activation of the transcription factor nuclear factor kappa-B (NF-κB).\textsuperscript{8}

Experiments so far have used a large segmental defect model. The question is whether reverse dynamization will be effective in subcritical size defects and fractures. Pioneering studies by Hente et al\textsuperscript{9} suggest effectiveness in the former. These investigators noted a dramatic increase in bone formation at the site of a 2-mm diaphyseal osteotomy in sheep under cyclic compression, but not distraction.

There are no preclinical data concerning the effectiveness of reverse dynamization in fracture healing, but Howard et al\textsuperscript{10} recently published a pilot study in which a type of reverse dynamization was used to treat tibial fractures in humans. The outcomes were superior to those normally achieved using standard dynamization.

So far, the empirical evidence concerning reverse dynamization has come from studies using external fixators. Although it is possible to envision the use of sophisticated internal fixation devices for this purpose, external fixation has advantages of simplicity, affordability, and the possibility of removing the fixator once weight bearing is indicated, thus promoting maturation of the regenerate while preventing subsequent stress shielding.

\section*{References}

References printed in \textbf{bold type} are those published within the past 5 years.


