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CORR Insights

CORR Insights®: What Are the Biomechanical Effects of Half-pin and Fine-wire Configurations on Fracture Site Movement in Circular Frames?

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Where Are We Now?

At first glance, this study evaluates the relative merits of Schanz pins and tensioned wires with respect to the stability achieved at a simulated fracture site in a synthetic long bone model. But on a deeper level, the current study addresses larger issues of interest with respect to both fracture healing and the mechanics of external fixation. Although both of these topics have been explored over the past several decades, important controversies remain. Goodship and Kenwright [7, 9] have demonstrated that limited axial micromotion is beneficial and transverse shear is detrimental, but the ideal mechanical environment to promote fracture healing has not yet been identified.

Only recently have we begun to fully appreciate the relationship between mechanical conditions and biological processes; it appears the mechanics determine, in large part, how the biology of fracture healing proceeds. This is a complex relationship [5], yet without stability the biology can never drive the fracture towards solid union. The mechanical conditions therefore are paramount, and ultimately play the leading role in the biology of fracture healing [5].

Substantial research has gone into the development of orthobiologics in an effort to artificially control, enhance, or otherwise hasten fracture healing. However, almost certainly, the most-expeditious approach will instead involve indirect modulation of fracture healing by varying the mechanical conditions locally. External fixators at this point allow us the most facile control of the mechanical environment of a fracture site [3], and will prove instrumental in determining how best to modulate conditions locally. Circular fixators, such as the Ilizarov device, allow control of the mechanical conditions at the fracture site better than most other devices currently available [2, 11]. But conventional wisdom may be completely wrong, and the principles of fracture fixation we have adhered to for the past 60 years may not be the most-efficient approach. Early rigid fixation and late dynamization may in fact be the opposite tactic to achieve the most

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rapid and predictable progression to union. The process of "reverse dynamization"—with an initial period of less stability followed by a short period of greatly increased stability—appears to have certain advantages [6], and pays greater respect to the biology of fracture healing.

Where Do We Need To Go?

The nonlinear response and self-stiffening effect of wires may be influential when lengthening bone [8], but fracture fixation is relatively static [2]. Yet some surgeons remain steadfastly devoted to the use of tensioned wires, despite the absence of any data that demonstrates an improvement in clinical results with their use [4]. Perhaps this is due to the fact that fracture reduction is an overwhelmingly more significant factor. Regardless, there is a continued controversy between the use of either tensioned wires or Schanz pins. Studies have convincingly demonstrated that cantilever loaded external fixation frames are deleterious to fracture healing [12, 14], but are cantilevered pins themselves detrimental? Almost certainly not, as this study again shows [10]. Many surgeons who use circular fixators insert wires when they are most advantageous, in metaphyseal and juxta-articular locations where they are less likely to cut through. Similarly, Schanz pins are used when they are most advantageous, in diaphyseal bone where they provide excellent purchase with less risk of infection. Ilizarov demonstrated two levels of fixation in each skeletal segment are important to achieve mechanical stability, and that this is necessary for reliable and predictable bone regeneration [8]. The spread of fixation is critically important to recognize, and surgeons should be aware of the concept of working length as it applies to fracture stabilization [1]. The focus of much prior research may have been misdirected, and the issue of whether we use pins or wires may not even be important. This study demonstrates half pins are not worse in axial load or torsion, but are better than wires at resisting any transverse translation associated with bending loads. Unfortunately, the focus remains on what may be considered a peripheral issue, somewhat analogous to many studies regarding internal fixation [13]. The spread of fixation is perhaps one of the most important factors [1], but this has still never been systematically evaluated. These topics are central to fracture healing and fracture fixation mechanics independent of the means used for stabilization, and apply equally to both external fixation and internal fixation with plates, including fixed-angle designs.

How Do We Get There?

Instead, future studies will look more closely at the pin/implant/screw geometry as a function of the spread of fixation on each side of the fracture site. Locked plating has certainly influenced the current philosophy with respect to fracture stabilization, but the ideal screw configuration also remains unknown [13]. Studies that comprehensively evaluate fracture site stability with regard to the mechanical control of the two intact skeletal segments adjacent to the fracture site clearly are required. Although Ilizarov obviously considered this important [8], the relative position of any device used for skeletal stabilization has never been adequately investigated. Unfortunately, this is not generally appreciated, but may be one of the most critical factors. External fixators allow us to improve stability as much as possible [2, 11] by spreading fixation maximally within anatomical constraints. The same is true for minimally invasive locked plates, but surgeons must understand how fracture site stability is influenced and affected by the length of the two major intact segments proximal and distal to the fracture. Mechanical conditions need to be evaluated relative to the moment arms involved, to determine how fixation controls each side of the fracture site individually. To adequately

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control the mechanical conditions within the fracture site itself, control must first be achieved in each of the two major intact segments adjacent to the fracture site. Studies to investigate this will therefore need to assess the working length of fixation relative to the length of the intact segments. More importantly, it will also need to consider the location of the fixation achieved in both of the adjacent intact skeletal segments. Only then can we hope to fully understand the mechanics of fracture stabilization, and perhaps by "bringing balance to the force" we can influence the biology to maximally enhance or accelerate rates of fracture healing.

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