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From Bench to Bedside

From Bench to Bedside: How Stiff is Too Stiff? Far-cortical Locking or Dynamic Locked Plating May Obviate the Question

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Plate-and-screw fracture fixation represents, at its core, perhaps the most basic and stereotypical of orthopaedic surgery procedures—the "bone broke, me fix" or "sterile carpentry" punchline of so many medical jokes. For many simple fracture patterns, compression plating, absolute stability, and primary bone healing work well. Achieving stable, rigid fixation represents a core principle of this approach. Over the last 15 years, the development of locking screws and locked-plating has allowed us to increase construct rigidity, improve purchase and stability in osteoporotic or otherwise compromised bone, and changed our approach to many comminuted fractures. These developments have enabled, and been accompanied by, greater interest in minimally invasive plate osteosynthesis, which better respects the soft-tissues and periosteal blood supply. This minimally invasive plate osteosynthesis seeks to preserve biology and improve the capacity for fracture healing. Far-cortical locking and active locked-plating of fractures represent, perhaps, the next revolution in fracture fixation.

Like most revolutions, locking screws have been accompanied by unintended consequences (beyond those of implant cost, which I won't even attempt to address here). Nowhere is this more evident than in the case of comminuted, osteoporotic distal femur fractures. These fractures are most commonly treated with

A Note from the Editor-In-Chief:
I am pleased to present the next installment of "From Bench to Bedside," *a quarterly column written by Benjamin K. Potter MD. Dr. Potter is a clinician-scientist in the Uniformed Services University-Walter Reed Department of Surgery. His column investigates important developments that are making—or are about to make—the transition from the laboratory to clinical practice, as well as technologies and approaches that have recently made that jump.*

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bridge plating, seeking to restore gross mechanical axes, rather than achieving anatomic fracture fragment reduction. The rigidity and stiffness achieved with this method of fixation has proved deleterious in many cases. The poor bone quality screams for more secure fixation in the form of locking screws, but the fracture requires relative stability and secondary bone healing via robust callus formation, rather than rigid fixation. Indeed, the frequency of nonunion ranges from 13% to more than 20%, and is as high as 41% for more rigid, stronger stainless-steel constructs [8, 11]. I am not a biomechanist, but it seems clear that at some point "rigid fixation" became too rigid.

The concept that interfragmentary strain and micromotion, in amounts approximately proportional to the size of fracture gap, are required for bone healing is not remotely new, of course [10]. In one experimental model [7], 1 mm of axial dynamization strengthened callus formation threefold and accelerated healing twofold. Simply put, motion predicts callus formation, but too much motion predicts nonunion. Recognition of these requirements and the poor outcomes of many patients treated with locked plating has led to a plethora of novel tweaks and approaches. Increased working length of bridge plating, favoring less-stiff titanium constructs, unicortical locking screws, and hybrid constructs have all been popularized in an effort to decrease construct rigidity while maintaining improved fixation strength and durability. But with regard to these nonunions, the unfortunate answer to the logical question "but what mistakes did the surgeon make in these cases?" is that plate length, screw density, and working length may not predict either healing or nonunion [11].

It gets even more complicated from here. While longitudinal motion promotes callus formation, shear inhibits it, and stiffness, in and of itself, may actually be a poor surrogate for fracture site motion [5]. Further, if a construct being too stiff and rigid is responsible for these distal femoral nonunions, how does making the construct even more stiff and rigid lead to healing? Holzman and colleagues [9] achieved healing in 20 of 21 distal femoral nonunions initially treated with lateral locked plating by adding an in situ medial plate combined with autogenous bone grafting.

Fortunately, new treatment options exist or will soon. The concept of far-cortical locking has recently gained popularity due to the recognition that the near cortex of fractures treated with locking constructs consistently demonstrates minimal to no callus due to greater rigidity at this site [4]. The far-cortical locking technique of controlled dynamization near the plate reduces the stiffness of the initial construct by as much as 80% while maintaining most of locked screw fixation strength in both osteoporotic and normal specimens, and it has been suggested that this results in controlled axial motion and progressive stiffness similar to an Ilizarov exernal fixator [1]. Early clinical results are promising, with one study demonstrating healing of 30 of 31 fractures treated with this technique [2].

Dynamic stabilization with active locking plates is another interesting development on the near horizon. This technique utilizes standard locking screws that lock into flexible, suspended sliding elements within the plate. A 1997 canine study [6] (which, interestingly, predated locking screws) demonstrated superior fracture healing in all four plating systems tested versus dynamic compression plating. More recently, a study [3] demonstrated the superiority of active locking plates versus standard locked plating in a 3 mm femoral osteotomy gap ovine model. At just 9 weeks postoperatively, the active locking plate cohort's simulated fractures had achieved 81% of native strength and were nearly 400% stronger than the standard locked plating specimens.

Further study of these techniques remains necessary. Far-cortical locking and active locking plates have not

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been compared to one another, for example, and what fractures besides bridge plated distal femur fractures might be optimally treated with either technique remains to be determined. Moreover, there are no clinically available active locking plate options at this point. However, far-cortical locking is available now, either by commercial design or by technique (overdrilling or slotting the near cortex). Both the far-cortical locking and active locking plate techniques may reduce complications and nonunions, while being technically simple to perform. In short, either, or perhaps both, of these techniques has potential to decrease reoperations and accelerate healing and improve patient outcomes as a result. Naturally, readers and early adopters of these techniques must continue to read (and write!) the pertinent subsequent studies in order to ensure that this revolution is not likewise accompanied by unintended consequences or unforeseen problems.

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