

Half Pin Instability in the Modern Circular External Fixator

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What was the question?

Stable fixation with half pins and K-wires is an important goal of modern external fixation. However, clinical and laboratory observations suggest that standard of care fixation still allows substantive bone-bone movement. Therefore we asked, what is the source of this observed movement?

How did you answer the question?

We mounted TSFs on PVC pipe bone model and used a camera motion tracking system to monitor the movements of various frame components while applying axial loads to simulate walking. In our construct rings were fixed to bones with three half pins and one K-wire per ring block. We varied two aspects of frame design: [1] the ring-ring connection (TSF struts, vs. traditional threaded rods, vs. rods with struts); and [2] bone segment relationship (compressed vs. neutral vs. distracted against a 250N vs. a 500N spring). We tracked the changes in bone-bone gap, ring-ring gap, proximal ring-bone gap and distal ring-bone gap between 0N and 700N.

What are the results?

Because compressed bone configurations had minimal bone end movement ($M = -.153$ mm 95% CI $[-.196, -.109]$) we excluded these cases from further analysis; otherwise, bone-bone movement was not predicted by ring-ring connection or bone segment relationship. The movement between bone ends ($M = -3.77$ mm 95% CI $[-3.96, -3.57]$) under walking loads originates as follows: ring-ring gap movement from ring connectors ($M = .37$ mm, 95% CI $[-.44, -.31]$); sum of proximal and distal ring-bone gap movement from ring-bone fixation ($M = 3.38$ mm, 95% CI $[3.20, 3.57]$).

What are your conclusions?

Using modern circular external fixation walking loads are sufficient to displace bone segment ends by 3-4 mm. The majority (90%) of this movement is attributable to the ring-bone connection. This effect was consistent across a range of construct setups ($\{250\text{N distraction, } 500\text{N distraction neutral}\} * \{\text{struts, rods, rods and struts}\}$). This result implicates the fixation of ring to bone as the primary source of bone end instability with external fixation.