Biomechanical Analysis of Mechanically Unstable Pelvic Fractures: Retrograde Superior Pubic Ramus Screw Versus Anterior External Fixation

Justin A. Krajca, MD*; Hyunchul Kim, MS; Jason W. Nascone, MD; Theodore T. Manson, MD; Christina L. Boulton, MD; Adam H. Hsieh, PhD; Robert V. O'Toole, MD;*
R Adams Cowley Shock Trauma Center, Department of Orthopaedics,
University of Maryland School of Medicine, Baltimore, Maryland, USA

Purpose: Little is known about the biomechanical properties of the superior pubic ramus (SPR) screw, which has been proposed as a percutaneous alternative to traditional anterior external fixation for pelvic ring disruptions. We hypothesize that the retrograde SPR screw will have no biomechanical advantage over traditional anterior external fixators in an unstable pelvic fracture model with posterior fixation in place that is typical in common clinical practice.

Methods: Using five commercially available fourth-generation composite pelvis bone models (Pacific Research Laboratories, Vashon Island, WA) for each test case, an unstable pelvic ring injury (OTA 61-B2.1, LCI) was simulated. We excised 1 cm from the left sacrum and ipsilateral superior and inferior pubic rami to represent a complete, comminuted sacral fracture with comminuted pubic rami fractures in Nakatani Zone II (mid-ramus). All five composite models had the posterior ring stabilized with two stainless steel, fully threaded, 7.3-mm cannulated iliosacral screws into the vertebral bodies of S1 and S2, as is done in clinical practice. External fixators were applied using single 5-mm Schanz pins in the supra-acetabular bone bilaterally, connected to a single 11-mm curved carbon fiber rod with standard pin-bar clamps. Retrograde SPR screws placed were 32-mm partially threaded, 7.3-mm cannulated screws (Synthes, West Chester, PA) extending to the lateral iliac cortex cephalad to the acetabulum. Four constructs were tested sequentially in a randomized order: (1) control with posterior fixation and no anterior fixation, (2) external fixation with clamps placed at 8 cm above the bone, (3) external fixation with clamps placed at 12 cm above the bone (simulating an obese patient), and (4) partially threaded retrograde SPR screw. An axial load through the hip joint of 250 N was cycled 30 times in an anatomically neutral position with a simulated single-legged stance and floating pelvis test configuration as previously described. Outcome measure was construct stiffness (N/mm). Analysis of variance was performed with significance at $P = 0.05$.

Results: In contrast to our hypothesis, the retrograde SPR screw (mean axial stiffness 118.9 N/mm ± 12.9 SD) had significantly improved biomechanics compared to the control with posterior fixation alone (36.0 N/mm ± 12.4 SD, $P < 0.001$). No significant difference was noted between the 8 cm or 12 cm external fixator constructs and the control (45.0 N/mm ± 12.9 SD, $P = 0.83$; 41.5 N/mm ± 12.9 SD, $P = 0.98$, respectively). The SPR screw was 164% ($P < 0.001$) and 186% ($P < 0.001$) stiffer than 8 cm and 12 cm external fixators.

Conclusion: In contrast to our hypothesis, the retrograde superior pubic ramus screw provides significantly improved biomechanical performance over external fixator constructs in an unstable pelvic fracture model. Despite the mechanical advantage of being closer to bone, the external fixator at 8 cm was not stiffer than when placed at 12 cm above the

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bone. Neither external fixator construct had an axial stiffness significantly different from the control model with no anterior fixation. The clinical importance of this large difference is unknown, but SPR screws appear to confer a significant mechanical advantage over anterior external fixation in this loading scenario.

See pages 99 - 147 for financial disclosure information.