A Biomechanical Study of Zone II Sacral Fractures: Which Approach Is Most Beneficial for Fixation and Lumbopelvic Stabilization?

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Introduction: A vertical zone II sacral fracture with anterior disruption is a highly unstable injury of the pelvic ring. The traditional surgical technique involves a 360° approach, where trans-sacral screws are inserted posteriorly, spanning the fracture zone through at least one SI joint, and a dynamic compression plate is implanted anteriorly to traverse the disrupted pubis symphysis. However, one clinical study found a 14% impairment in physical outcome with this traditional fixation [1]. Clearly, there is room for improvement in patient outcomes, which may be attributable to the configuration and need for 360° access for this fixation methodology. Therefore, this study investigated whether a posterior-only, less surgically invasive approach could accomplish improved fracture stability in hopes of reducing surgical complications often seen in a 360° surgery and improving patient outcomes.

Methods: Fresh-frozen cadaveric specimens (L4-pelvis, n=7) were carefully stripped of all soft tissues, leaving all ligaments and discs intact. Fixation (Bondo auto body filler) at L4 and the left ischium was performed. Unlike previous biomechanical studies [2-3], specimens were tested using a new “gliding hip model” (Figure 1). Placement of the specimen into this fixture allowed independent motion to be observed between left and right halves. Flexion-extension (FE), lateral bending (LB), and axial rotation (AR) were assessed after application of a pure moment at L4 (8.0N·m, 1.5°/second) by an external six degrees of freedom spine motion machine. Rigid body markers were placed at L4, the fixed half of the pelvis, and one on each side of the Zone II fracture within the sacrum. Optotrac Certus software (NDI, Inc., Waterloo, Canada) was then used to track the motion. Pelvic ring stability was assessed via relative angular motions observed between each iliac crest. Relative translations at the site of the fracture were captured during the maximum range of motion for FE (anterior-posterior translation, AP) and LB (cranial-caudal and medial-lateral, CC and ML translations).
Figure 1. The “gliding hip model” and specimen testing setup. A smooth interface allowed the ball-bearing to move freely, thus allowing 5 degrees of freedom (inset). The anterior dynamic compression plate and rigid body markers are shown on the specimen’s anterior.

After the intact state was tested, a vertical zone II fracture was created using an oscillating saw, and the pubic symphysis was transected using a #10 scalpel. Five instrumentation constructs were tested thereafter: 1) traditional fixation, using a dynamic compression symphyseal plate with trans-sacral screws placed at S1 and S2 (T), 2) a posterior-only, lumbo-pelvic fixation approach, using bilateral L5-Pelvis fixation with pedicle screws and cannulated iliac screws (P), 3) the same lumbo-pelvic fixation but with a cross-connector (P+C), and 4) a combined traditional/lumbo-pelvic approach without (T+P) and 5) with a cross-connector (T+P+C). A one-way ANOVA determined significant differences between constructs ($p<0.05$).

Results: The lumbopelvic fixation methods had significantly greater motion ($p\geq0.05$) between the iliac crests compared to traditional and intact specimen states (Figure 2a). The crosslink did restrict motion further, even though it was not significant in LB. However, within the fracture zone itself, only the traditional and combined traditional/lumbopelvic constructs were equivalent to the intact state in all of the considered translations (Figure 2b).
Figure 2. a) Relative angular motions were normalized to the intact state with respect to the motion between each iliac crest. b) Translations observed during FE (AP translation) and LB (CC and ML translation) within the fractured sacral bone.

**Discussion:** This study demonstrated that a posterior-only approach does not have a similar range of motion at the pelvic ring as compared to traditional fixation, and the amount of displacement observed at the fracture zone may be a contraindication for this posterior-only approach with respect to early osteogenesis. While the compressive forces from the surrounding soft tissues were not present, this “gliding hip model” can provide insight into the *in vivo* performance of each of these lumbopelvic fixation constructs.

**Significance:** This study adds biomechanical knowledge regarding a newly proposed surgical technique, and indicates that this technique may not be as mechanically stable as traditional stabilization for this trauma.

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