

## Pelvic ring fractures: A biomechanical comparison of sacral and lumbopelvic fixation techniques

Ryan Jones, Sudharshan Tripathi, Sophia Soehnlen, Amey Kelkar, Yogesh Kumaran, Toshihiro Seki, Takashi Sakai, Vijay K. Goel, Norihiro Nishida  
The Engineering Center for Orthopedic Excellence (E-CORE)  
University of Toledo College of Medicine and Life Sciences and Engineering, Toledo, OH  
[ryan.jones9@rockets.utoledo.edu](mailto:ryan.jones9@rockets.utoledo.edu)

**Disclosures:** Ryan K. Jones (N), Sudharshan Tripathi (N), Sophia Soehnlen(N), Amey Kelkar(N), Yogesh Kumaran(N), Toshihiro Seki(N), Takashi Sakai(N), Vijay K. Goel (4; Spinal Balance, 4; OsteoNovus, 5; DePuy Synthes, 5; SI Bone, 5; NSF), Norihiro Nishida (N)

**INTRODUCTION:** The mechanical integrity of the pelvic ring is attributable to the pelvis' highly stable structure [1]. However, due to the aging population, fragility fractures are becoming more common. These fractures can be the result of low energy impact, or high-velocity injuries such as motor vehicle accidents, falls from large heights, and crush injuries [2]. Pelvic ring injuries can prove to be fatal and disrupt the associated vascular and neurologic structures, especially in geriatric patients as mortality rates range between 10% and 16% [3]. Stabilization of these fractures is challenging and often requires immediate internal fixation. Therefore, it is necessary to have a biomechanical understanding of the different fixation techniques for pelvic ring fractures.

**METHODS:** A previously validated three-dimensional finite element model of the lumbar spine, pelvis, and femur was used for this study. A unilateral pelvic ring fracture was simulated by resecting the left side of the sacrum and pelvis. Five different fixation techniques were used to stabilize the fracture. These fixation methods included L5-ilium posterior screw fixation without cross connectors (L5\_PF\_WO\_CC), L5-ilium posterior screw fixation without cross connectors (L5\_PF\_W\_CC), trans-ilium trans-sacral (TITS) fixation at S1 and S2 level (S1\_TITS\_S2\_TITS), Iliosacral screw fixation at S1 and TITS fixation at S2 (S1\_IS\_S2\_TITS), and double trans iliac rod and screw fixation (DTSF). See Figure 1 for models of fixation techniques. A compressive follower load and pure moment was applied to compare different biomechanical parameters including range of motion (contralateral sacroiliac joint, L1-S1 segment, L5-S1 segment), and stresses (L5-S1 nucleus stresses, instrument stresses) between different fixation techniques.

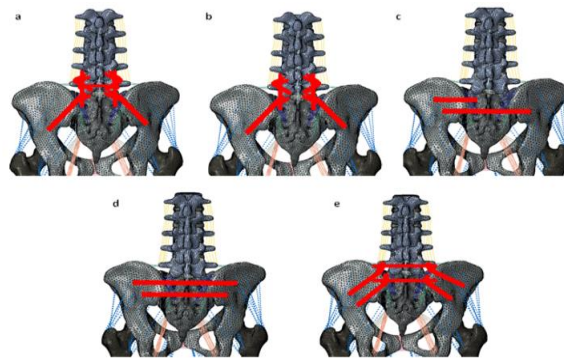
**RESULTS:** TITS at S1 and S2 showed the highest stabilization for horizontal and vertical displacement at the sacral fracture site and reduction of contralateral sacroiliac joint for bending and flexion range of motion by 165% and 121%, respectively (See Figure 2). DTSF model showed highest stabilization in horizontal displacement at the pubic rami fracture site, while the L5\_PF\_W\_CC and L5\_PF\_WO\_CC showed higher rod stresses, reduced L1-S1 (approximately 28%), and L5-S1 (approximately 90%) range of motion (See Figure 3).

**DISCUSSION:** Longer sacral screw fixations were superior in stabilizing sacral and contralateral sacroiliac joint range of motion. Lumbopelvic fixations displayed a higher degree of stabilization in the horizontal displacement compared to vertical displacement of pubic rami fracture, while also indicating the highest rod stresses. When determining the surgical approach for pelvic ring fractures, patient-specific factors should be accounted for to weigh the advantages and disadvantages for each technique.

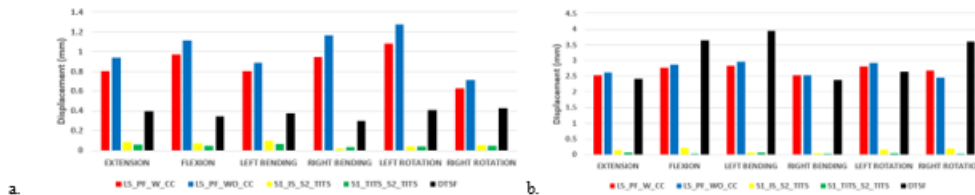
**CLINICAL RELEVANCE:** This study offers surgeons insight into the biomechanical effects of five different minimally invasive procedures for unstable fractures. This study can aid clinicians in understanding the characteristics, advantages, and disadvantages of each procedure.

**REFERENCES:** [1] Davis, D.D., et al., Pelvic Fracture, in StatPearls. 2021, StatPearls Publishing Copyright © 2021, StatPearls Publishing LLC.: Treasure Island (FL). [2] Rommens, P.M. and A. Hofmann, Comprehensive classification of fragility fractures of the pelvic ring: Recommendations for surgical treatment. Injury, 2013. 44(12): p. 1733-44. [3] Grotz, M.R., et al., Open pelvic fractures: epidemiology, current concepts of management and outcome. Injury, 2005. 36(1): p. 1-13.

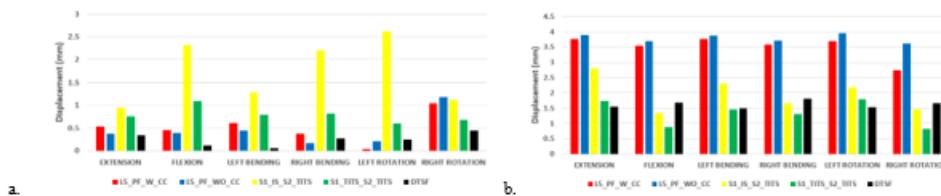
**IMAGES AND TABLES:**



**Figure 1** Stabilization of pelvic ring fracture with various fixation techniques: (a) L5\_PF\_WO\_CC, (b) L5\_PF\_WO\_CC, (c) S1\_IS\_S2\_TITS, (d) S1\_TITS\_S2\_TITS, (e) DTSF



**Figure 2:** Comparison of sacrum fracture (a.) horizontal and (b.) vertical displacement at 7.5 Nm moment with 400 N follower load



**Figure 2:** Comparison of pubic rami fracture (a.) horizontal and (b.) vertical displacement at 7.5 Nm moment with 400 N follower load