

Impact of Finite Element Analysis Studies on Reducing Mechanical Failure in Surgical Fixation of Pelvic Ring Injuries: A Retrospective Analysis

Jose M. Rojas, Orthopaedic surgeon; Tania L. Rojas, MD; Claudio Rojas, MD

Purpose: Finite element analysis (FEA) simulates the mechanical behavior of different fixation strategies, guiding surgical decisions for anterior and posterior pelvic arches. However, clinical validation of FEA recommendations remains limited. Our purpose was to evaluate whether adequate fixation based on FEA can reduce mechanical failure in patients with AO type B and C pelvic ring injuries (PRI).

Methods: A retrospective study of patients treated for PRI at a Level I trauma center between December 2022 and March 2024 was performed. Exclusion criteria included AO type A fractures, acetabular fractures, surgery at another center, less than 6 months of follow up, delayed surgery, or paraplegia from spinal cord injury. Adequate fixation was defined based on FEA findings and categorized by pelvic arch: for ligamentous injuries in the posterior arch, one iliosacral screw (ISS) in S1 for type B injuries and two ISS for type C injuries; in sacral ala fractures, one transiliac-transsacral screw (TITS) in S1 for type B injuries, and two TITS or lumbopelvic fixation for type C injuries; for the anterior arch, a four-hole plate for ligamentous type B injuries, and a double plate or a combination device (a plate with a supra-acetabular external fixator) for type C injuries. Mechanical failure was defined as pubic symphysis diastasis, pubic plate breakage, internal rotation of the hemipelvis, or nonunion of the fracture, with screw loosening also evaluated.

Results: Of 155 patients with PRI, 98 met inclusion criteria (median age: 44.5 years [range, 32–60 years], female: 20%, high-energy trauma: 96%); 62% of fractures were AO type B and 38% were type C. Overall, mechanical failure occurred in 56.1% of patients (27.6% when excluding screw loosening). Notably, no posterior arch failures were observed. Adequate fixation was associated with a significantly lower failure rate (10.3% vs 39% in patients with inadequate fixation; $p = 0.004$).

Conclusion: Integrating FEA insights into surgical planning can reduce mechanical failures by nearly 50%. These results underscore the importance of optimal fixation in both arches to improve outcomes in the management of pelvic ring injuries.