Biomechanical Evaluation of Osseous Fixation Pathways in Associated Both-Column Acetabulum Fractures

Samuel Hailu MD*; Richard Jenkinson MD; Markku Nousiainen MD; Hans J Kreder MD; David J Stephen MD; Stewart McLachlin PhD; Cari Whyne PhD*
University of Toronto, Sunnybrook HSC, Toronto, ON, Canada

Purpose: Various configurations of screws and plates are utilized for associated both-column (ABC) acetabulum fracture fixation. However, there are limited biomechanical data that identify the ideal construct based on a clinical goal of maintaining intra-articular congruency of the acetabulum under load. This study examined the relative differences between ABC fracture fixation techniques.

Methods: Six composite right hemipelvises, with a fused right sacroiliac joint, with standardized high variety ABC fractures with each column in a single fragment (AO/OTA 62-C1.1) were used. Fractures were initially reduced and stabilized using 3.5-mm screws, which included: iliac crest screw, supra-acetabular (lateral compression type II [LC2] screws, posterior column screws, retroacetabular screws (RAS), infra-acetabular Letournel screws (LS), as well as a 3.5-mm 12-hole J-plate. This fully fixed construct was then tested in a single-leg stance model under 6 cycles of independent axial load tests of 150, 400, and 800 N (representing 25, 50, and 100% weight-bearing loads). The final cycle for each load was held for 60 sec to record the acetabular fracture gap displacement. These landmarks identified 4 fracture gap locations. Changes in acetabular stability were then compared between the (1) fully fixed configuration and following sequential removal of the (2) plate, (3) LS, and (4) RAS. An initial pilot test identified instability that was corrected with a change in the LC2 screw direction. As such, both configurations of the LC2 screws, Trajectory A (anterior inferior iliac spine [AIIS] to posterior inferior iliac spine [PIIS]) and Trajectory B (from AIIS to posterior superior iliac spine [PSIS]), were examined in all specimens. This required duplication of the testing protocol with the trajectory order randomized. Post hoc data analysis of the fracture gap displacement was evaluated using a repeated-measures analysis of variance in R ($\alpha = 0.05$).

Results: With Trajectory A, no differences were found between any of the 4 fixation configurations at the 4 fracture exit sites. With Trajectory B large increases at the sciatic notch fracture exit gap (>1 mm) were found at 400 N following removal of the LS ($P < 0.05$). At 800 N, only in the initial fully fixed configuration did the Trajectory B specimens remain below the clinical failure target of 2 mm at the greater sciatic notch fracture exit location.

Conclusion: This study identified that the ABC acetabulum fracture pattern was effectively stabilized at the articular fracture site by all fixation configurations tested in quasistatic loading. When the LC2 screw was directed towards the PIIS, no plate was required to maintain stability at all fracture sites. Fracture stability identified at simulated 100% body weight loads may suggest patients with an inferiorly directed supra-acetabular screw could withstand earlier weight-bearing provided they have good bone quality but should be examined in future fatigue testing.