A Biomechanical Comparison of Intrapelvic and Extrapelvic Fixation for Associated Acetabular Fractures of the Quadrilateral Plate

Sharon Babcock, MD[1]*; Gregory Gillispie, BS*[2]*; Philip Brown, PhD*[2]*; Kyle McNamara, BS*[1]*; Arun Aneja, MD*[1]*; Joel Stitzel, PhD*[2]*; Eben Carroll, MD*[3]
[1]*Wake Forest School of Medicine, Winston Salem, North Carolina, USA;*
[2]*Virginia Tech - Wake Forest Center for Injury Biomechanics, Winston Salem, North Carolina, USA;*
[3]*Wake Forest Baptist Medical Center, Winston Salem, North Carolina, USA*

Purpose: Acetabular fractures resulting from low-energy trauma, such as direct fall from standing onto the greater trochanter, are common among elderly patients. This patient cohort represents the fastest-growing group sustaining acetabular fractures. Anterior column fracture patterns are one of the most common types of acetabular fractures seen in the elderly and have been associated with early failure after open reduction and internal fixation, necessitating arthroplasty. This fracture pattern can be treated with either extrapelvic or intrapelvic plating schemes. This study intends to quantify and compare the strength of intrapelvic and extrapelvic fixation through cadaveric biomechanical testing of a variant anterior column fracture pattern involving the quadrilateral plate.

Methods: Ten fresh-frozen cadaveric pelves were used. Quantitative CT scans were completed prior to intervention. Pelves were divided at the pubic symphysis and sacroiliac joints with one hemipelvis assigned to the extrapelvic and the other to the intrapelvic group. A standardized anterior column variant fracture was created using an oscillating saw. Fracture fixation was performed using randomization with one hemipelvis receiving fixation with a standardized extrapelvic construct, and the opposite hemipelvis with additional quadrilateral plate fixation (intrapelvic construct). Each hemipelvis was potted in polyurethane prior to testing. Appropriately sized acetabular trial cups were attached to the servohydraulic uniaxial loading system. Specimens were loaded at 50% of the donor's body weight (BW) for 3 axial loading cycles. The loading direction was chosen to model the most common fracture mechanism (falling on the hip), as well as that of a bedridden patient lying on their side. After the final cycle, destructive testing was conducted at a rate of 1 mm/s until the force dropped below 75% of the maximum or displacement reached 30 mm. Force and displacement were recorded for all tests and used to calculate stiffnesses and energies. For the 50% BW test, stiffness and displacement were calculated. For the destructive test, stiffness, elastic energy, and plastic energy were calculated. Yield point, force at clinical failure (defined at 2 mm of displacement), and maximum force were also identified.

Results: Specimens included 5 males and 5 females with a mean age of 76 years (range, 62-89) and mean body mass index (BMI) of 27 kg/m2 (range, 15-48). A Wilcoxon matched-pairs t test was used to analyze the data, and $t < 0.05$ signified statistical significance. When testing 50% BW, the intrapelvic group had a 28.3% decrease in fracture displacement, which was nearly significant ($t = 0.089$). No difference in stiffness for 50% BW testing was noted ($t = 0.216$). On average for destructive testing, the intrapelvic group performed better in all testing parameters (Table 1), with statistical significance being reached for yield force, maximum force, and plastic energy. All other parameters excluding yield displacement were nearly significant.

Destructive Testing	Stiffness (N/mm)	Clinical Failure Force* (N)	Elastic Energy (J)	Yield Disp. (mm)	Yield Force (N)	Plastic Energy (J)	Max Force (N)
Extrapelvic Avg.	326 (182)	640 (334)	3562 (2616)	4.9 (1.4)	1266 (787)	25894 (14338)	1608 (896)
Intrapelvic Avg.	404 (188)	787 (337)	4562 (2384)	5.1 (1.1)	1594 (688)	38147 (17352)	2128 (832)
% Difference	21.4%	20.6%	24.6%	4.0%	22.9%	38.3%	27.8%
t value	0.063	0.056	0.0749	0.366	0.011	<0.001	<0.001

Table 1. Summary of destructive test data *Clinical failure was defined as 2 mm of displacement

Conclusion: The addition of intrapelvic fixation significantly increases the ability of the fracture to resist catastrophic failure. Lower forces represented by 50% BW did not result in statistically significant differences. Intrapelvic plate contributes significant strength when higher loads are reached. This may have clinical correlation in preventing failure of fracture fixation or displacement in this common elderly fracture pattern.

See pages 49 - 106 for financial disclosure information.