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High- Versus Low-Energy Acetabular Fracture Outcomes in the Geriatric Population

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Abstract

Introduction: High-energy mechanisms of acetabular fracture in the geriatric population are becoming increasingly common as older adults remain active later in life. This study compared outcomes for high- versus low-energy acetabular fractures in older adults. **Materials and Methods:** We studied outcomes of 22 older adults with acetabular fracture who were treated at a level-I trauma center over a 4-year period. Fourteen patients were categorized as low-energy mechanism of injury, and 8 were identified as a high-energy mechanism. We analyzed patient demographics with univariate logistic regressions performed to assess differences in high- and low-energy group as well as patient characteristics compared with surgical outcomes. **Results:** Most high-energy mechanisms were caused by motor vehicle collision (n = 4, 50.0%), with most having posterior wall fractures (50.0%). Among patient characteristics, the mechanism of injury, hip dislocation, fracture types, and fracture gap had the largest differences between energy groups effect size (ES: 2.45, 1.43, 1.36, and 0.83, respectively). The high-energy group was more likely to require surgery (odds ratio [OR] = 2.80, 95% CI: 0.26-30.70), develop heterotopic bone (OR = 4.33, 95% CI: 0.33-57.65), develop arthritis (OR = 3.60, 95% CI: 0.45-28.56), and had longer time to surgery (mean = 4.8 days, standard deviation [SD] = 5.8 days) compared to low-energy group (mean = 2.5 days, SD = 2.3 days). **Discussion:** The results of this case series confirm previous findings that patients with high-energy acetabular fractures are predominantly male, younger, and have fewer comorbidities than those who sustained low-energy fractures. Our results demonstrate that the majority of the high-energy fracture patients also suffered a concurrent hip dislocation with posterior wall fracture and experienced a longer time to surgery than the low-energy group. **Conclusion:** Geriatric patients who sustained high-energy acetabular fractures tend to have higher overall rates of complications, including infection, traumatic arthritis, and heterotopic bone formation when compared with patients with a low-energy fracture mechanism.

Keywords

high energy, geriatric trauma, elderly trauma, ground-level fall, geriatric acetabular fracture

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Introduction

Acetabular fractures are uncommon yet serious injuries (yearly incidence of approximately 37 fractures per 100 000) with historically less than perfect surgical outcomes.[1] As our population ages, the average age of individuals who suffer acetabular fractures is also increasing.[2,3] Many of these fractures are caused by ground-level falls, but an increasing proportion of them are the result of high-energy mechanisms such as motor vehicle collisions.[4] Older adults are living longer more active lives. They live independently and drive cars well into their 80s. As a result, orthopedic surgeons are faced with more geriatric acetabular trauma. With increased numbers of fractures and subsequent necessary surgeries, this raises the question: what are the outcomes of surgical management in the geriatric population?

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Although the research indicates that surgical fixation of acetabular fractures leads to better outcomes than nonoperative management, treatment guidelines indicate that nonoperative management should be considered in an acetabular fracture with an intact weight-bearing dome.[5,6] Low-energy mechanisms of fracture such as ground-level fall often leave the weight-bearing dome intact and thus are managed nonoperatively. Historically, nonoperative treatment included bed rest; however, this often led to poor outcomes. However, high-energy mechanisms of fracture, such as motor vehicle collisions, often lead to more serious injury with femoral head involvement and posterior wall fractures. Researchers continue to debate if operative management will deliver the best outcome for the patient.[7,8]

Increased age is also associated with heterotopic bone formation, hip avascular necrosis, and post-traumatic arthritis, which may ultimately require total hip arthroplasty.[8,9] Additionally, researchers found presurgical factors such as surgical delay to be significant predictors for patient outcome and major systemic complications.[10,11] With an increasing incidence of geriatric acetabular fractures and limited research on high-energy geriatric acetabular trauma, identifying predictors of poor outcome is essential to inform treatment and management of an older adult with an acetabular fracture.[8,12]

To this end, we reviewed 4 years of acetabular fracture data from a busy level-I trauma center. We collected patient demographics, comorbidities, and treatment outcomes for high- and low-energy acetabular fracture mechanisms in patients older than 65 years.

Materials and Methods

We studied all patients ≥65 years of age with acetabular fracture admitted to our level-I trauma center over a 4-year period (2013-2016) by chart review. Twenty-three patients met study inclusion criteria; one patient died prior to surgery and was removed from the analysis leaving 22 patients. Seventeen patients were treated operatively and 5 patients were treated nonoperatively. Additionally, there was some missing information in patients transferred to us from other hospitals (n = 1), fracture gap (n = 1), and time to surgery (n = 2). We included patients with a high- or low-energy mechanism acetabular fracture. Low-energy fractures are defined by low levels of force such as ground-level falls, and high-energy fractures are caused by high levels of force such as fall from height, car accident, or crush injuries. We excluded patients with incomplete data and those younger than age 65. We also excluded patients with pathological fractures.

We collected outcomes relating to acetabular fracture, including type of surgery, need for total hip replacement (both acute and salvage procedures), sepsis, infection, arthritis, avascular necrosis, heterotopic bone formation, postoperative nerve palsy, and 30- or 90-day readmission to the hospital status. Predetermined preexisting comorbidities such as alcoholism, diabetes, mechanism of injury, fracture pattern (anterior column, posterior column/posterior wall, associated both columns (ABCs), posterior wall, transverse, and T-type), fracture gap measurement (mm), traumatic brain injury, treatment method, prophylactic radiation therapy (XRT), dislocation of hip, surgical procedure, and transfer from other hospital were other parameters collected in addition to descriptive patient demographics (age, gender, body mass index [BMI], race) and time to surgery (calculated as number of days from admission to surgery). The fracture gap was measured with a digital ruler with the best X-ray view. It was measured to correlate fracture gap with outcome as a consideration.

Overall patient characteristics and operation-related factors were summarized as frequencies and percentages or means and standard deviations (SDs). The summaries were further broken down by energy levels (high and low). Absolute standardized effect sizes were calculated for continuous and dichotomous categorical patient characteristics and surgical outcomes.[13] The standardized effect size measures the strength of the relationship between patient characteristics and energy. According to Cohen, (absolute) effect sizes up to 0.5 were considered small, between 0.5 and 0.8 medium and above 0.8 large.[14] Finally, univariate logistic regression was performed to assess differences in energy groups as well as other patient characteristics against those surgical outcomes that were noted in at least 2 patients after acetabular fracture. Surgical procedure was not assessed with open reduction and internal fixation (ORIF) due to the direct relationship of ORIF coming from surgical procedures. Odds ratios (ORs) and their associated 95% CIs were reported. All statistical analyses were conducted using R (Version 3.4.4, R Foundation for Statistical Computing) and SAS statistical software version 9.4, at a significance level of .05. IRB: This study was approved by the University Institutional Review Board.

Results

Overall, 77% of the patients were Caucasian, with an equal distribution of males to females, and the average age was 75.5 years (SD: 9.9 years), and average BMI was 26.7 kg/m^2 (SD: 6.0 kg/m^2; Table 1). With respect to the mechanism of injury, ground-level fall was the only mechanism of injury for the low-energy group, whereas the high-energy group mechanisms included motor vehicle crash, crush injury, and fall from height (Table 1). Most common fracture types in order of frequency were anterior column, posterior wall, transverse, T-type and ABC (Table 1). Among patient characteristics, the mechanism of injury, hip dislocation, fracture types, injury severity score (ISS), and fracture gap had the largest differences between energy groups effect size (ES: 2.45, 1.43, 1.36, 1.29, and 0.83, respectively). Medium ES were found among age and time to surgery characteristics between the energy groups.

There were more posterior wall fractures in the high-energy group (50.0%) than the low-energy group (14.3%). The high-energy groups only had posterior surgical approach, whereas low-energy groups had a mix of posterior and Stoppa/anterior intrapelvic (Table 1). There was one case of extensile exposure for the patient who died and was excluded from the analysis. Traumatic hip dislocation was more prevalent in the

Table 1. Descriptive Statistics of Acetabular Fracture Patient Characteristics by Energy Groups (Low vs High).

Patient characteristics, n (%)	Overall[a]	Low-Energy Patients N = 14	High-Energy Patients N = 8	Effect Size,[b] (95% CI)
Age (years)[c]	75.5 ± 9.9	77.4 ± 11.4	72.0 ± 5.2	0.61 (−0.28 to 1.50)
Gender				0.40 (−0.48 to 1.28)
Male	11 (50.0%)	6 (42.9%)	5 (62.5%)	
Female	11 (50.0%)	8 (57.1%)	3 (37.5%)	
Race				0.08 (−0.79 to 0.95)
Caucasian or white	17 (77.3%)	11 (78.6%)	6 (75.0%)	
African American or Black	5 (22.7%)	3 (21.4%)	2 (25.0%)	
BMI[c]	26.7 (6.0)	26.6 ± 5.3	27.0 ± 7.6	0.07 (−0.80 to 0.94)
Diabetes				0.41 (−0.47 to 1.29)
Yes	5 (22.7%)	4 (28.6%)	1 (12.5%)	
No	17 (77.3%)	10 (71.4%)	7 (87.5%)	
Alcoholism				0.18 (−0.69 to 1.05)
Yes	2 (9.1%)	1 (7.1%)	1 (12.5%)	
No	20 (90.9%)	13 (92.9%)	7 (87.5%)	
Transferred[d]				0.36 (−0.52 to 1.24)
Yes	16 (76.2%)	11 (78.6%)	5 (71.4%)	
No	5 (23.8%)	3 (21.4%)	2 (28.6%)	
Fracture types				1.36 (0.40 to 2.32)
Anterior column	7 (31.8%)	6 (42.9%)	1 (12.5%)	
Associated both columns	1 (4.5%)	1 (7.1%)	0 (0.0%)	
Posterior column/posterior wall	1 (4.5%)	1 (7.1%)	0 (0.0%)	
Posterior wall	5 (22.7%)	1 (7.1%)	4 (50.0%)	
Transverse	5 (22.7%)	3 (21.4%)	2 (25.0%)	
T-type	3 (13.6%)	2 (14.3%)	1 (12.5%)	
Mechanism of injury				
Crush	2 (9.1%)	0 (0.0%)	2 (25.0%)	2.45 (1.32 to 3.58)
Fall	16 (72.7%)	14 (100.0%)	2 (25.0%)	
MVC	5 (18.2%)	0 (0.0%)	4 (50.0%)	
Dislocated				1.43 (0.46 to 2.40)
Yes	6 (27.3%)	1 (7.1%)	5 (62.5%)	
No	16 (72.7%)	13 (92.9%)	3 (37.5%)	
Treatment				0.41 (−0.47 to 1.29)
Closed/percutaneous	5 (22.7%)	4 (28.6%)	1 (12.5%)	
Open	17 (77.3%)	10 (71.4%	7 (87.5%)	
Surgical approach[f]				0.72 (−0.17 to 1.61)
Stoppa/Anterior	4 (23.5%)	4 (40.0%)	0 (0.0%)	
Posterior	13 (76.5%)	6 (60.0%)	7 (100.0%)	
Open/closed				0.39 (−0.49 to 1.27)
Open	1 (4.5%)	1 (7.1%)	0 (0.0%)	
Closed	21 (95.5%)	13 (92.9%)	8 (100.0%)	
Injury severity score[c]	7.2 ± 4.9	5.0 ± 2.0	11.0 ± 6.3	1.29 (0.34 to 2.24)
Gap (mm)[c,d]	8.4 ± 5.7	9.8 ± 6.2	5.6 ± 3.4	0.83 (−0.07 to 1.73)
Time to surgery (days)[c,e]	3.4 ± 4.1	2.5 ± 2.3	4.8 ± 5.8	0.51 (−0.37 to 1.39)

Abbreviations: BMI, body mass index; SD, standard deviation.
[a]Exclusion: n = 1 (patient died).
[b]Absolute effect size = difference in means or proportions divided by standard deviation where a higher the effect size implies stronger association with energy group levels.
[c]Continuous variables presented as mean (SD).
[d]Missing: n = 1.
[e]Missing: n = 2.
[f]Missing: n = 5.

high-energy group than the low-energy group. Finally, the high-energy group had longer time to surgery with a mean of 4.8 days versus 2.5 days in the low-energy group (Table 1).

Patients in the high-energy group were more likely to develop a complication after acetabular fracture surgery (Table 2). For outcomes of patients who underwent surgical fixation, 2 developed postoperative infection, 3 patients developed heterotopic bone (no prior XRT), 2 developed avascular necrosis, 5 developed post traumatic arthritis, and 3 developed postoperative nerve palsy (Table 2). Finally, the odds were higher to develop posttraumatic arthritis

Table 2. Descriptive Statistics of Surgical Outcomes in Acetabular Fracture Patients by Energy Groups (Low vs High).

Outcomes, n (%)	Overall[a]	Low-energy patients N = 14	High-energy patients N = 8	Effect size,[b] (95% CI)
Open reduction and internal fixation (ORIF)				0.41 (−0.47 to 1.29)
Yes	17 (77.3%)	10 (71.4%)	7 (87.5%)	
No	5 (22.7%)	4 (28.6%)	1 (12.5%)	
Total hip				0.53 (−0.35 to 1.41)
Yes	1 (4.5%)	0 (0.0%)	1 (12.5%)	
No	21 (95.5%)	14 (100.0%)	7 (87.5%)	
Sepsis				0.00 (−0.87 to 0.87)
No	22 (100.0%)	14 (100.0%)	8 (100.0%)	
Deep infection				0.53 (−0.35 to 1.41)
Yes	1 (4.5%)	0 (0.0%)	1 (12.5%)	
No	21 (95.5%)	14 (100.0%)	7 (87.5%)	
Heterotopic bone				0.50 (−0.38 to 1.38)
Yes	3 (13.6%)	1 (7.1%)	2 (25.0%)	
No	19 (86.4%)	13 (92.9%)	6 (75.0%)	
Avascular necrosis				0.18 (−0.69 to 1.05)
Yes	2 (9.1%)	1 (7.1%)	1 (12.5%)	
No	20 (90.9%)	13 (92.9%)	7 (87.5%)	
Arthritis				0.55 (−0.33 to 1.43)
Yes	5 (22.7%)	2 (14.3%)	3 (37.5%)	
No	17 (77.3%)	12 (85.7%)	5 (62.5%)	
Nerve palsy postoperation				0.50 (−0.38 to 1.38)
Yes	3 (13.6%)	1 (7.1%)	2 (25.0%)	
No	19 (86.4%)	13 (92.9%)	6 (75.0%)	
30-day readmission[c]				0.53 (−0.35 to 1.41)
Yes	1 (4.8%)	0 (0.0%)	1 (12.5%)	
No	20 (95.2%)	13 (100.0%)	7 (87.5%)	
90-day readmission[c]				0.53 (−0.35 to 1.41)
Yes	1 (4.8%)	0 (0.0%)	1 (12.5%)	
No	20 (95.2%)	13 (100.0%)	7 (87.5%)	

[a]Exclusion: n = 1 (patient died).
[b]Absolute effect size = difference in means or proportions divided by standard deviation where the higher the effect size implies stronger association with energy group levels.
[c]Missing: n = 1.

Table 3. Unadjusted Odds Ratios and 95% CIs for Acetabular Fracture–Related Outcomes on Patient Characteristics.[a]

Characteristics	ORIF	Heterotopic bone	Arthritis	Nerve palsy postoperation
High vs low energy	2.80 (0.26-30.70)	4.33 (0.33-57.65)	3.60 (0.45-28.56)	4.33 (0.33-57.65)
Age (years)	1.00 (0.90-1.11)	0.90 (0.73-1.11)	1.01 (0.91-1.12)	0.88 (0.69-1.12)
Gender, male vs female	0.59 (0.08-4.50)	2.22 (0.17-28.86)	5.71 (0.52-62.66)	2.22 (0.17-28.86)
Race, Caucasian vs African American	0.81 (0.07-9.52)	0.53 (0.04-7.49)	1.23 (0.11-14.42)	-
BMI	1.21 (0.95-1.54)	0.98 (0.79-1.21)	1.08 (0.91-1.28)	1.43 (0.99-2.05)
Diabetes	1.23 (0.11-14.42)	1.88 (0.13-26.32)	-	1.88 (0.13-26.32)
Transferred	2.89 (0.33-25.70)	0.27 (0.01-5.27)	-	0.57 (0.04-8.05)
Dislocated	-	7.50 (0.53-105.25)	2.17 (0.26-17.89)	1.40 (0.10-19.01)
Injury severity score	1.24 (0.83-1.87)	1.05 (0.84-1.32)	0.92 (0.71-1.20)	1.27 (0.99-1.64)
Time to surgery (days)	-	1.10 (0.85-1.41)	0.99 (0.74-1.31)	1.27 (0.93-1.76)
Surgical approach, anterior vs posterior[b]		-	1.11 (0.08-15.04)	-

Abbreviations: BMI, body mass index; OR, odds ratio; ORIF, open reduction and internal fixation.
[a]Cells with "-" were cases extreme OR.
[b]No calculation was done with ORIF due to relationship between surgical approach and ORIF.

(OR = 1.11, 95% CI: 0.08, 15.04) when comparing Stoppa/anterior intrapelvic to posterior approach (Table 3).

The odds ratios for the different acetabular fracture–related outcomes based on patient characteristics are reported in Table 3. We noted that with increasing time to surgery, the odds are higher for heterotopic bone (OR = 1.10, 95% CI: 0.85, 1.41) and postoperative nerve palsy (OR = 1.27, 95% CI: 0.93, 1.76). Although modeling these characteristics tends to trend in a certain direction, we are limited by a low sample size.

Discussion

Motor vehicle collision causes the majority of cases of acetabular fractures in the general population.[15] According to the Department of Transportation, approximately 20% of America's drivers are 65 and older, with that number expected to increase 77% by 2045.[16] With increasing numbers of individuals driving at advanced age, we expect to see an increase in motor vehicle collisions that lead to pelvic and acetabular trauma.

High-energy geriatric acetabular fractures are an uncommon injury yet represent a growing subset of pelvic fractures in the United States, especially those related to motor vehicle collisions.[4] Geriatric acetabular fractures represent an area of orthopedic trauma surgery without clear guidelines of care. Due to the aging population, orthopedic surgeons will treat increasing numbers of active older adults. Letournel's original unwillingness to operate on patients older than 60 years is no longer the standard of care to be followed.[17] Research has shown that nonoperative management demonstrated significantly higher mortality rates than those who underwent operative treatment.[4,18] Nonoperative treatment includes bed rest, traction, crutches, and bed to chair management. Older adults who present with concentric fractures of the acetabulum that are stable with mobilization and those medically unfit are managed nonoperatively.[19] If the patient is not fully resuscitated for surgery and cannot be made stable surgery should be delayed or the patient should be managed nonoperatively. The decision to operate varies both hospital-to-hospital and by surgeons within the health system.[20] It is important to identify and investigate factors that are associated with a poor outcome to better guide and inform surgeons and patients on the decisions for treatment.

A literature search revealed few publications on both high- and low-energy geriatric acetabular fracture outcomes.[4,8,20-22] Two of these studies found high-energy fracture patterns to follow similar fracture patterns as the low-energy group, resulting in a majority anterior wall or both column fractures.[8,21] Also, prior studies demonstrate that posterior wall fracture patterns are found to be associated with poorer outcomes.[21,23]

Our study found that high- and low-energy mechanisms of fracture resulted in differing fracture patterns, with 50% of the high-energy fractures demonstrating a posterior wall pattern, while the low-energy mechanisms primarily demonstrated an anterior wall fracture. The data demonstrate that the majority of acetabular fractures at our level-I trauma center were treated with surgical fixation in both the high- and low-energy groups. Others have reported that surgery leads to more complications in the geriatric population when compared with younger patients, but continues to be the standard of care.[24,25] The results of this case series confirm previous findings indicating that patients in the high-energy fracture group are predominantly male, younger, and have fewer comorbidities than those who sustain low-energy fractures.[8] Higher BMI in our study was associated with surgical intervention, arthritis, and postoperative nerve palsy.

The strength of the association with energy-level grouping can be seen by the magnitude of the effect size where higher associations include mechanism of injury, hip dislocation, fracture types, ISS, and gap. The data showed that the majority of the high-energy fracture patients were associated with a concurrent hip dislocation.

Time to surgery is an important prognostic feature of poor outcomes. Mears et al found that a delay of greater than 11 days was associated with significantly worse clinical outcomes.[7] We found that the time to surgery was approximately twice as long in the high-energy fracture group. However, this is likely due to larger proportion of high-energy patients who were transferred to our hospital with higher ISS requiring additional time for preoperative optimization. An increased time to surgery was associated with nerve palsy and heterotopic bone formation (Table 3). None of our patients developing post-traumatic arthritis required salvage total hip arthroplasty (THA). Clearly, there are some patients with femoral head damage, weight-bearing dome destruction, and nonconcentric reduction who would benefit from acute total hip replacement along with surgical fixation of their acetabular fracture. We did not perform any of these procedures during our study period.

Limitations of this study are intrinsic to the retrospective design and small sample size. The single-center patient data and limited sample size lead to decreased generalizability to other hospitals. Additionally, the small cohort size makes it difficult to find precise associations between patient characteristics and fracture mechanism. Therefore, additional studies in this geriatric population are required.

Conclusion

In this case series, older adults who sustained high-energy acetabular fractures were noted to show higher overall rates of poor outcomes, such as infection, arthritis, and heterotopic bone formation, when compared with low-energy mechanism group. The majority of high-energy acetabular fractures were due to motor vehicle collisions, which were more likely to undergo surgery and demonstrate a posterior wall fracture pattern. Based on this study, additional study of surgical outcomes in older adults undergoing acetabular fracture surgery is needed.

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