


A Survey of High- and Low-Energy Acetabular Fractures in Elderly Patients

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Abstract

Introduction: Geriatric patients represent 14% of acetabular fractures and are the fastest growing subset of patients affected by this injury in the US. Treatment outcomes have been reported as inferior to those achieved in younger patients after high-energy (HE) acetabular trauma. This study aimed to compare detailed demographic characteristics and clinical outcomes in elderly patients (≥ 65 years of age) treated in a tertiary North American trauma center for acetabular fractures after both high- and low-energy mechanisms of injury. **Methods:** Patients (≥ 65 years of age) diagnosed with an acetabular fracture were identified over a 7-year period. Patient and injury characteristics were extracted from our institutional trauma database. Length of stay, intervention, operative details, disposition, complications, readmissions, and mortality were analyzed. **Results:** One hundred nine patients were identified for inclusion. Low-energy mechanisms (simple falls) were found in 64 (58.7%) and HE mechanisms in 45 (41.3%) patients. The HE cohort was younger (74.6 vs 80.7 years; $P < .001$), had a higher male predominance (76% vs 56%; $P = .10$), a lower Charlson comorbidity index (1.29 ± 1.49 vs 2.16 ± 1.76 ; $P = .01$), and a higher injury severity score (19.90 ± 15.33 vs 6.46 ± 3.57 ; $P < .001$). Fracture patterns, described according to the Letournel-Judet classification, were similar between the 2 groups. Thirty-day mortality was significantly higher in the HE group (26.7% vs 3.1%; $P < .001$); however, the 1-year mortality rates were not statistically different (31.1% vs 25.0%; $P = .20$). **Discussion:** Patients with acetabular fractures sustained due to HE accidents demonstrate significantly higher 30-day mortality rate than patients with low-energy fractures, but similar mortality 1 year after the injury, despite having a much lower mean age and fewer comorbidities. **Conclusion:** Medical efforts made during initial hospital admission may have the biggest impact on survivorship following acetabular fracture.

Keywords

geriatric orthopedic trauma, acetabular fracture, high-energy mechanism, low-energy mechanism

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Introduction

While geriatric patients represent only 14% of acetabular fractures, it is the fastest growing subset of those affected by this injury in the United States.^{1,2} Outcomes of treatment have been reported to be inferior to those achieved in younger patients after high-energy (HE) acetabular trauma.³ These findings necessitate the need to learn about acetabular fractures among elderly patients to adequately meet their medical demands in the coming decades.⁴⁻⁸

Early research on geriatric acetabular trauma focused on descriptive epidemiological studies; however, publications that are more recent have concentrated on detailed, in-depth characterization of the injuries.⁹ Even though geriatric acetabular fractures were initially assumed to be a product of low-energy

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(LE) mechanism of impact (by analogy to periarticular and spinal fractures related to senile osteopenia), it became obvious that HE accidents could also involve elderly patients due to increased life expectancy and prolonged physical activity. Several authors have referenced the paucity of information on HE skeletal trauma in the elderly.^{8,10,11} Indeed, a recent review highlighted the lack of information on this increasingly important injury.^{1,12}

Indications for nonoperative versus operative treatment in geriatric patients are still poorly defined. Common consensus exists that fractures with posterior hip instability should be addressed surgically; however, more frequent patterns with anteromedial displacement may be amenable for nonoperative management.⁹ Nevertheless, nonoperative treatment often leads to inadequate reduction, and operative outcomes, even when improved techniques are used, are still worse than those of younger patients.^{3,9,13-22}

Therefore, the purpose of this study is to compare detailed demographic characteristics and clinical outcomes in elderly patients (≥ 65 years of age) treated in a tertiary North American trauma center for acetabular fractures after both HE and LE mechanisms of injury.

Methods

After institutional review board approval, all patients (≥ 65 years of age) who had been diagnosed with an acetabular fracture were identified from our institutional trauma database over a 7-year period. Periprosthetic acetabular fractures in patients with hip arthroplasties were excluded, as were pelvic ring injuries including pubic root fractures. Patient and injury characteristics were extracted from the database. These included age, sex, comorbidities, mechanism of injury, fracture classification, injury severity score (ISS), associated injuries, length of stay (LOS), intervention, type of fixation if applicable, ambulatory status, disposition, 1-year readmission rate, complications at 30 days and 6 months, and mortality at 6 months and 1 year. If the patient underwent operative treatment, time from injury to surgery, American Society of Anesthesiologists score, operative length, intraoperative blood loss, surgical approach, and type of fixation were all recorded. If the patient underwent nonoperative management, the reason for this decision was also extracted from the provider notes.

Patient comorbidities were classified according to the Charlson comorbidity index.²³ Preinjury habitation status was assigned as home or long-term care (LTC) facility. Mechanism of injury was classified as motor vehicle accident (MVA), low fall, high fall, assault, bicycle accident, pedestrian trauma, or crush injury. A low fall was defined to be any fall less than 6 ft, while a high fall was defined as any fall occurring from a height over 6 ft. If this was not distinguished from the provider notes, the injury was considered a low fall. Associated injuries were classified anatomically according to the methodology of the abbreviated injury scale.²⁴ The injury severity of each patient was calculated using the ISS.²⁵ Radiographs were evaluated to

classify fracture type according to the Letournel-Judet classification.^{26,27}

The postintervention ambulatory status of the patient was classified as nonambulatory, ambulatory with assistance, or no assistance necessary. The postintervention disposition was classified as LTC, transitional care unit, home, or rehabilitation. Patient mortality information was identified through the medical chart review, a search of the obituary index, and/or search of the social security index. The patient was believed to be living if there was no indication of death by any of these sources.

After all patient data were entered into a centralized database (Microsoft Excel, Redmond, Washington), patients were stratified into either HE or LE trauma categories. Statistical analysis was performed to compare the HE and LE patient populations. The Fisher exact test was used for all binary comparisons and the Mann-Whitney *U* test was used for all ordinal or continuous variables. Significance was set at $P < .05$.

Results

Patient Characteristics

One hundred nine patients were identified and included in the study. Low-energy mechanisms (simple falls) accounted for the acetabular fractures in 64 (58.7%) patients and HE mechanisms (eg, motor vehicle crash, high falls, motorcycle) were responsible for the fractures in 45 (41.3%) patients (Table 1). The majority of the patients in the LE group sustained injuries from low falls, 63 (98.4%), whereas mechanisms of injury in the HE group were more diverse including 19 (42.2%) MVAs, 12 (26.7%) high falls, and 6 (13.3%) pedestrian versus car accidents. The 2 groups were distinctly different with respect to the baseline demographics. The HE cohort was younger (74.6 vs 80.7 years; $P < .001$), had a higher male predominance (76% vs 56%; $P = .10$), had a lower Charlson comorbidity index (1.29 ± 1.49 vs 2.16 ± 1.76 ; $P = .01$), more patients lived at home (86.4% vs 69.8%; $P = .02$), and fewer walked with an assistive devices (4.5% vs 31.3%; $P < .001$) upon presentation when compared with the LE cohort.

Injury Characteristics and Radiographic Comparison

The majority of patients in the HE group presented with at least one associated injury (91.1% vs 50.0%) and a higher average number of associated injuries (4.6) compared with the LE group (0.8), $P < .001$. Injury severity scores were considerably higher, as well (19.9 ± 15.3 vs 6.5 ± 3.6 ; $P < .001$). In the HE group, abbreviated injury scores were highest for the pelvis followed by chest, head, abdomen, and extremities.

Interestingly, the fracture patterns, described according to the Letournel-Judet classification,^{26,27} were similar between the 2 groups (Table 2), with the preponderance of patients sustaining acetabular fractures including the anterior column (26.6%). Approximately half of patients in each group had fractures crossing both anterior and posterior columns.

Table 1. Patient Demographics.

Characteristic	Low Energy	High Energy	P Value
	n = 64	n = 45	
Age (mean ± SD)	80.7 ± 8.2	74.6 ± 8.1	<.001
Sex (M:F), N	36:28	34:11	.10
%	56%:44%	76%:24%	
Baseline habitation ^a			
Home, n (%)	44 (69.8%)	38 (86.4%)	.02
Long-term care, n (%)	19 (30.2%)	6 (13.6%)	.02
Ambulatory assistance required prefracture, n (%)	20 (31.3%)	2 (4.5%)	<.001
Mechanism of injury			
Low fall, n (%)	63 (98.5%)	0 (0%)	<.001
High fall, n (%)	0 (0%)	12 (26.7%)	<.001
Pedestrian vs vehicle, n (%)	0 (0%)	6 (13.3%)	<.001
Motor vehicle accident, n (%)	0 (0%)	19 (42.2%)	<.001
Motorcycle accident, n (%)	0 (0%)	2 (4.4%)	.07
Crush injury, n (%)	0 (0%)	2 (4.4%)	.07
Other, n (%)	1 (1.5%)	1 (2.2%)	.40
Charlson comorbidity index (mean ± SD)	2.16 ± 1.76	1.29 ± 1.49	.01
Injury Severity Score (mean ± SD)	6.5 ± 3.8	19.9 ± 15.3	<.001
Number of associated injuries (mean ± SD)	0.8 ± 1.1	4.6 ± 3.3	<.001
Patients with associated injuries, n (%)	32 (50.0%)	41 (91.1%)	<.001
Patients on thrombolytics, n (%)	59 (92.2%)	44 (97.8%)	.08

Abbreviations: F, female; M, male; SD, standard deviation.

^aMissing data, n = 2.

Table 2. Fracture Classifications.

Letournel-Judet Classification	Low Energy	High Energy	P Value
	n = 64	n = 45	
ABC	13 (20.3%)	6 (13.3%)	.16
PW	2 (3.1%)	6 (13.3%)	.03
Trans	8 (12.5%)	3 (6.7%)	.15
TransPW	1 (1.5%)	3 (6.7%)	.10
AC	15 (23.4%)	14 (31.1)	.20
PCPW	3 (4.7%)	1 (2.2%)	.20
PC	4 (6.3%)	2 (4.4%)	.34
AW	3 (4.7%)	2 (4.4%)	.50
T shaped	4 (6.3%)	5 (7.8%)	.20
ACPHT	11 (17.2%)	3 (6.7%)	.04

Abbreviations: ABC, Associated Both Column; ACPHT, anterior column/wall with Posterior Hemitransverse; AC, Anterior Column; AW, Anterior Wall; PW, Posterior Wall; PCPW, Posterior Column/Posterior Wall; PC, Posterior Column; Trans, transverse; TransPW, transverse posterior wall.

Management Comparison

A large number of patients in the entire cohort were treated nonoperatively (n = 66/109, 60.6%); however, in the HE group, a greater percentage of patients received an operative intervention (51.1% vs 31.3%; P = .02; Table 3). Treatment for the HE group consisted of open reduction and internal fixation (ORIF)

Table 3. Outcomes.

	Low Energy	High Energy	P Value
	n = 64	n = 45	
Nonoperative treatment, n (%)	44 (68.8%)	22 (48.9%)	.02
Died before stabilization, n (%)	0 (0%)	12 (26.7%)	<.001
Operative treatment, n (%)	20 (31.3%)	23 (51.1%)	.02
Type of intervention			
ORIF, n (%)	15 (23.4%)	18 (40.0%)	.04
ORIF with total hip arthroplasty, n (%)	1 (1.5%)	2 (4.4%)	.20
Minimally invasive osteosynthesis, n (%)	4 (6.3%)	3 (6.7%)	.50
Time to surgery (days), mean ± SD	5.6 ± 6.4	4.0 ± 3.0	.28
Operative time (minutes), mean ± SD	258.2 ± 103.5	272.3 ± 122.4	.07
Intraoperative blood loss (mL), mean ± SD	855.6 ± 928.1	771.0 ± 529.0	.72
Length of stay (days), mean ± SD	7.5 ± 7.1	10.7 ± 7.3	.03
Discharge disposition ^a			
TCU, n (%)	36 (57.1%)	20 (45.5%)	.10
Home, n (%)	8 (12.7%)	6 (13.6%)	.40
LTC, n (%)	17 (26.9%)	6 (13.6%)	.04
Hospice, n (%)	2 (3.2%)	0 (0%)	.08
Died, n (%)	0 (0%)	12 (26.7%)	<.001
30-day outcomes			
30-day complications, n (%)	13 (20.3%)	21 (46.7%)	.002
30-day mortality, n (%)	2 (3.1%)	12 (26.7%)	<.001
1-year outcomes			
6-month complications, n (%)	33 (51.5%)	26 (57.8%)	.30
1-year readmission, n (%)	15 (23.4%)	9 (20%)	.30
1-year mortality, n (%)	16 (25.0%)	14 (31.1%)	.20

Abbreviations: LTC, long-term care; ORIF, open reduction internal fixation; SD, standard deviation; TCU, transitional care unit.

^aMissing data, n = 1 high energy, 1 low energy.

in 18 (40.0%) patients, minimally invasive osteosynthesis (MIO) in 3 (6.7%) patients, combined ORIF with total hip arthroplasty (THA) in 2 (4.4%) patients, or nonoperative management in 22 (48.9%) patients, including those who died before treatment could be rendered (n = 12, 26.7%). For the HE patients treated nonoperatively, 10 (45.4%) of 22 patients were deemed to have a nondisplaced/stable fracture pattern and, therefore, treated with toe-touch weight bearing or weight bearing as tolerated. However, the remainder of the nonoperatively treated patients in this cohort (n = 12/22, 54.5%) were not taken to surgery because the surgeon did not feel that the patients could withstand the surgical insult related to preexisting medical comorbidities or due to the severity of their associated injuries.

For the LE group, the treatment consisted of ORIF in 15 (23.4%) patients, MIO in 4 (6.3%) patients, combined ORIF/THA in 1 (1.5%) patient, or nonoperative management in

44 (68.8%) patients. Patients treated nonoperatively because they were believed to be too fragile for surgery included 14 (31.8%) of the 44 in the LE cohort. Other reasons for nonoperative treatment included nondisplaced/stable fracture patterns in 22 (50%) patients and secondary congruence of the femoroacetabular articulation in 6 (13.6%) patients with associated both column fractures and they were allowed to bear weight as tolerated.

Very few patients ($n = 5$, 7.8%) required admission to the intensive care unit (ICU) in the LE cohort. The average total hospital LOS in the LE group was 7.5 days (standard deviation [SD]: 7.1). Conversely, 24 patients (53.3%) of the HE group were admitted to the ICU and the average total LOS extended to 10.7 days (SD: 7.3). This difference was significant ($P = .03$). Complications were significantly higher in the HE cohort within the first 30 days as well (46.7% vs 20.3%; $P = .002$).

Mortality

Thirty-day mortality (26.7% vs 3.1%; $P < .001$) was significantly higher in the HE group; however, the 1-year mortality rates (31.1% vs 25.0%; $P = .20$) were not found to be statistically different between the 2 groups. Of the 23 patients in the HE cohort who underwent operative management, the 1-year mortality rate was only 8.6% ($n = 2$ patients). In the LE cohort, patients who were not taken to surgery due to medical comorbidities or because they were not stable for surgery had an extremely high 1-year mortality rate. Forty-three percent ($N = 6/14$) of these patients died within 1 year.

Discussion

It is clear that HE geriatric acetabular fractures are a unique type of injury and pose a challenging conundrum in the field of orthopedic trauma. One potential source of improvement in the management of these injuries is a more specific and nuanced characterization of these fractures. Given that the literature indicates HE and LE geriatric acetabular fractures are distinct entities, medical and surgical management will be different in each case. Better characterization of the differences between HE and LE acetabular fractures in the elderly increases the chances of finding opportunities for improved management strategies and better outcomes. There is only one study to date that directly compared demographics and short-term clinical outcomes between geriatric patients with acetabular fractures after LE and HE mechanisms of trauma.²⁸ The authors demonstrated that patients with LE acetabular fractures were older, sicker, and thinner, were less likely to receive surgical treatment for their injuries, and had longer admission lengths than their counterparts with HE mechanisms. The authors confirmed dominance of anterior column involvement in geriatric patients regardless of the mechanism of injury. Even though general comparison of 2 groups was made, detailed characteristics of injury such as severity of the trauma, rehabilitation, ambulatory status, and long-term mortality were not provided. Applicability of the Korean patient population to the US population also remained

unclear due to possible differences in levels of activity and expectations in cultural and socioeconomic environments.²⁹

This study compared demographics and clinical outcomes between elderly patients with acetabular fractures due to HE and LE mechanisms of injuries. It was found that 1-year mortality rates among those patients were similar; however, HE fractures were associated with significantly higher 30-day mortality rate. The significance of these findings is that the biggest impact on survivorship after geriatric acetabular injuries can be made in the acute posttraumatic period of care. The majority of previously published studies has focused on relationship between outcomes of geriatric acetabular fractures and treatment algorithms, but not by force of impact; therefore, direct comparison of patients 65 years and older with acetabular fractures distinguished from each other by energy of injury, was justifiable to access, and compares clinical outcomes.

This study is the first attempt to compare long-term outcomes of treatment of geriatric acetabular fractures in the US population. Results of our study confirmed that patients with HE fractures are younger, more active, and healthier, with male predominance than those with LE fractures. A different level of activity between groups also resulted in dissimilar mechanisms of injury with ground-level falls and high-speed MVAs dominating correspondingly among patients with LE and HE injury patterns, respectively. This study confirmed that more than 50% of elderly patients required nonoperative treatment regardless of mechanism of injury; however, this statement should be approached with caution because in many cases, the decision-making was affected by subjective assessment of general medical fitness of the patients by an attending surgeon. In as much as 26.7% ($n = 12/45$) of patients with HE fractures and 21.8% ($n = 14/64$) of patients with LE fractures, nonoperative treatment was chosen because the patient was felt to be too fragile to withstand stress of surgery. Although there were different surgeons assessing fitness for surgery or not, the results are from the same institution and trauma service (and surgeons) throughout this period.

Fracture patterns in geriatric patients were well described in previous studies.^{1,2,5,30} This study confirmed that both HE and LE mechanisms also resulted in similar fracture pattern with involvement of the anterior column and a predominance of associated both column fracture patterns regardless of the mechanism of injury.

Mortality rates for the combined cohort of geriatric patients with acetabular fractures were reported to vary from as low as 16% to a soaring 79% 1 year after injury.^{1,14} Even though some authors thought that higher mortality was associated with surgical treatment of the fractures, recent studies proved that mortality is mostly influenced by general medical condition of the patients including medical comorbidities and magnitude of sustained injuries.^{14,17,20,21,31} Thirty-day mortality rate in this study was 9 times higher among patients with HE acetabular fractures (26.7% vs 3.1%, $P < .001$); however, 1-year mortality rates were not significantly different between groups ($P = .20$). These findings were opposite to the results, obtained among the Korean patients with LE and HE acetabular fractures by Kim

et al, where in-hospital mortality rates were similar between groups.²³ Even though demographics and comorbidity parameters were comparable between studies, the HE cohort in this study was characterized by significantly higher ISSs and magnitude of associated injuries, which echoed on higher mortality rates among HE patients. Longer hospital stays and higher rates of admission to the ICU among patients with HE fractures serve as a reflection of higher morbidity, associated with HE acetabular fractures. One-year mortality rates similar for patients, affected by LE and HE fracture mechanisms, confirm results of other studies, where once the patient makes it out of the hospital, further mortality was mostly influenced by general medical status of the patient due to preinjury comorbidities and results of impact of the injury.^{1,14,32} Given that the 30-day mortality rate was higher in the HE acetabular group, we want to make clear that this likely results from other factors besides the fracture itself, something implied by the 40% lower difference in associated injury rate and 13 point lower ISS score in the LE group.

Limitations of this study include retrospective design, relatively small cohort size, lack of patient-derived outcome measures included in the study, and allocation of all patients to a single major trauma US center, which can make extrapolation of the results difficult to smaller hospitals. Potential selection bias may also be introduced by the lack of formal treatment algorithms for geriatric acetabular fractures and subjective selection of a treatment approach by an attending orthopedic surgeon. In addition, we have not performed a detailed fracture analysis, beyond pattern. These fracture parameters would likely be useful assessment of variables affecting functional outcome, rather than 30-day or 1-year mortality measures. Further study into fracture characteristics and its impact on decision-making will make for a good future analytics.

Conclusion

In summary, geriatric patients with acetabular fractures, sustained due to HE accidents, demonstrate significantly higher 30-day mortality rate than patients with LE fractures, but similar mortality 1 year after the injury, despite having a much lower mean age (74.6 ± 8.1 vs 80.7 ± 8.2 years, $P < .001$) and health (Charlson comorbidity index 1.29 ± 1.49 vs 2.16 ± 1.76 , $P = .01$). Based on the findings of this study, medical efforts made during initial hospital admission after the injury may have the biggest impact on survivorship following acetabular fracture injuries.

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References

1. Firoozabadi R, Cross WW, Krieg JC, Routt MLC. Acetabular fractures in the senior population—epidemiology, mortality and treatments. *Arch Bone Jt Surg*. 2017;5(2):96-102.
2. Ferguson TA, Patel R, Bhandari M, Matta JM. Fractures of the acetabulum in patients aged 60 years and older: an epidemiological and radiological study. *J Bone Joint Surg Br*. 2010;92(2):250-257.
3. Capone A, Peri M, Mastio M. Surgical treatment of acetabular fractures in the elderly: a systematic review of the results. *EFORT Open Rev*. 2017;2(4):97-103.
4. Boudissa M, Francony F, Kerschbaumer G, et al. Epidemiology and treatment of acetabular fractures in a level-1 trauma centre: retrospective study of 414 patients over 10 years. *Orthop Traumatol Surg Res*. 2017;103(3):335-339.
5. Buller LT, Lawrie CM, Vilella FE. A growing problem: acetabular fractures in the elderly and the combined hip procedure. *Orthop Clin of North Am*. 2015;46(2):215-225.
6. Butterwick D, Papp S, Gofton W, Liew A, Beaulé PE. Acetabular fractures in the elderly: evaluation and management. *J Bone Joint Surg Am*. 2015;97(9):758-768.
7. Cornell CN. Hip fractures in the elderly: on the acetabular side. *Orthopedics*. 2004;27(9):931-932.
8. Daurka JS, Pastides PS, Lewis A, Rickman M, Bircher MD. Acetabular fractures in patients aged > 55 years: a systematic review of the literature. *Bone Joint J*. 2014;96-B(2):157-163.
9. Ryan SP, Manson TT, Sciadini MF, et al. Functional outcomes of elderly patients with nonoperatively treated acetabular fractures that meet operative criteria. *J Orthop Trauma*. 2017;31(12):644-649.
10. Hill BW, Switzer JA, Cole PA. Management of high-energy acetabular fractures in the elderly individuals a current review. *Geriatr Orthop Surg Rehabil*. 2012;3(3):95-106.
11. Ortega-Briones A, Smith S, Rickman M. Acetabular fractures in the elderly: midterm outcomes of column stabilisation and primary arthroplasty. *Biomed Res Int*. 2017;2017:4651518.
12. Switzer JA, Gammon SR. High-energy skeletal trauma in the elderly. *J Bone Joint Surg Am*. 2012;94(23):2195-2204.
13. Gary JL. Acetabular fractures in the elderly. *Clinical Medicine Insights. Trauma and Intensive Medicine*. 2015;6:9.
14. Gary JL, Paryavi E, Gibbons SD, et al. Effect of surgical treatment on mortality after acetabular fracture in the elderly: a multicenter study of 454 patients. *J Orthop Trauma*. 2015;29(4):202-208.
15. Hayes PJ, Carroll CM, Roberts CS, et al. Operative treatment of acetabular fractures in the Medicare population. *Orthopedics*. 2013;36(8):e1065-e1070.
16. Manson TT, Reider L, O'Toole RV, Scharfstein DO, Tornetta P III, Gary JL. Variation in treatment of displaced geriatric

- acetabular fractures among 15 level-I trauma centers. *J Orthop Trauma*. 2016;30(9):457-462.
17. O'Toole RV, Hui E, Chandra A, Nascone JW. How often does open reduction and internal fixation of geriatric acetabular fractures lead to hip arthroplasty? *J Orthop Trauma*. 2014;28(3):148-153.
 18. Ryan SP, Manson TT, Sciadini MF, et al. Functional outcomes of nonoperative treatment of geriatric acetabular fractures meeting operative criteria. *Proceedings of 27th Annual Meeting of the Orthopaedic Trauma Association*; October 12-15, 2011; San Antonio, TX.
 19. Tissingh EK, Johnson A, Queally JM, Carrothers AD. Fix and replace: an emerging paradigm for treating acetabular fractures in older patients. *World J Orthop*. 2017;8(3):218-220.
 20. Walley KC, Appleton PT, Rodriguez EK. Comparison of outcomes of operative versus non-operative treatment of acetabular fractures in the elderly and severely comorbid patient. *Eur J Orthop Surg Traumatol*. 2017;27(5):689-694.
 21. O'Toole R, Hui E, Chandra A. Does ORIF of geriatric acetabular fractures lead to hip arthroplasty and poor midterm outcomes? Paper Presented at: The Annual Meeting of the Orthopaedic Trauma Association; October 7-10, 2009; San Diego, CA.
 22. Ryan S, Manson TT, Sciadini MF, et al. Functional outcomes of nonoperative treatment of geriatric acetabular fractures meeting operative criteria. Paper presented at: 27th Annual Meeting of the Orthopaedic Trauma Association; 2011; San Antonio, TX.
 23. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373-383.
 24. Glerum KM, Zonfrillo MR. Validation of an ICD-9-CM and ICD-10-CM map to AIS 2005 Update 2008. *Inj Prev*. 2019;25(2):90-92.
 25. Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;14(3):187-196.
 26. Judet R, Judet J, Letournel E. Fractures of the acetabulum: classification and surgical approaches for open reduction. Preliminary report. *J Bone Joint Surg Am*. 1964;46:1615-1646.
 27. Letournel E. Acetabulum fractures: classification and management. *Orthopedic Trauma Direct*. 2007;5(5):27-33.
 28. Kim JW, Herbert B, Hao J, Min W, Ziran BH, Mauffrey C. Acetabular fractures in elderly patients: a comparative study of low-energy versus high-energy injuries. *Int Orthop*. 2015;39(6):1175-1179.
 29. Mauffrey C, Hao J, Cuellar DO III, et al. The epidemiology and injury patterns of acetabular fractures: are the USA and China comparable? *Clin Orthop Relat Res*. 2014;472(11):3332-3337.
 30. Rickman M, Young J, Trompeter A, Pearce R, Hamilton M. Managing acetabular fractures in the elderly with fixation and primary arthroplasty: aiming for early weightbearing. *Clin Orthop Relat Res*. 2014;472(11):3375-3382.
 31. Hanschen M, Pesch S, Huber-Wagner S, Biberthaler P. Management of acetabular fractures in the geriatric patient. *SICOT J*. 2017;3:37.
 32. Bible JE, Wegner A, McClure DJ, et al. One-year mortality after acetabular fractures in elderly patients presenting to a level-I trauma center. *J Orthop Trauma*. 2014;28(3):154-159.