Treatment and Complications of Patients With Ipsilateral Acetabular and Femur Fractures: A Multicenter Retrospective Analysis

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Objectives: The purpose of this study was to review the treatment of patients with ipsilateral acetabular and femur fractures to provide descriptive demographic data, injury pattern classification, treatment, and evaluate the complication profile reflective of current practices.

Study Design: Multicenter retrospective cohort.

Setting: Eight Level 1 Trauma Centers.

Patients/Participants: One hundred one patients met inclusion criteria.

Intervention: Surgical treatment of both the acetabular and femur fractures.

Main Outcome Measurements: The complications evaluated include avascular necrosis, heterotopic ossification, posttraumatic arthritis, deep venous thrombosis, pulmonary embolism and superficial/deep infection, fracture union, and secondary surgeries.

Results: Forty-three patients had 31 type fractures (29A; 11B, and 3C), 60 had 32 type (37A, 8B; 15C), and 8 had 33 type (1A, 4B, 3C) femur fractures; 10 patients had combinations involving more than 1 femur fracture pattern. There were 35 62A type fractures, 47 62B, and 19 62C acetabular fractures. Age of 45 or older was associated with marginal impaction ($P = 0.001$). The aggregate infection rate was 17%. More than 30% of patients required secondary surgeries. The rate of avascular necrosis was higher in acetabular fractures combined with proximal femur fractures ($P < 0.05$). The rate of deep venous thrombosis was associated with increased age and time to surgical fixation ($P < 0.05$).

Conclusions: We report the largest review of the surgical treatment and complications of ipsilateral acetabular and femoral fractures. This study provides useful information regarding the complications and provides some treatment recommendations regarding these injuries.

Key Words: acetabulum, femur, ipsilateral, fractures

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

The current literature is comprehensive in the diagnosis and treatment of acetabular and femur fractures in patients with polytrauma. Case reports have been published in literature with this unusual pattern of injury.[1–11] A few studies have reviewed results and complications of ipsilateral acetabular and femur fractures to establish treatment protocols. These studies have been limited, thus establishing that current practice patterns and the incidence of complications, such as avascular necrosis (AVN), heterotopic ossification (HO), posttraumatic arthritis (PTA), deep venous thrombosis (DVT), pulmonary embolism (PE), superficial and deep infection are not well known.[12–17] The purpose of this study was to review the experience of this injury at multiple Level 1 trauma centers to provide descriptive data, injury classification, treatment, and evaluate the complication profile reflective of current practices.

PATIENTS AND METHODS

A retrospective review from 8 Level 1 trauma centers was completed: Saint Louis University, Wake Forest Baptist Medical Center, Vanderbilt University, Indiana University, University of Missouri, Palmetto Health Richland, Mercer University, and Carolinas Medical Center. Institutional review board approval was obtained. The study included patients admitted between January 2007 and December 2013. Inclusion criteria were as follows: age 18–85 years, ipsilateral acetabular fracture and femoral fractures (at/below the neck), surgical intervention for both fractures, and follow-up radiographs and clinical notes. Demographic data, injury, surgical, and postoperative details were collected. All fractures were classified according to the OTA/AO classification. Further grouping of acetabular fractures was completed according

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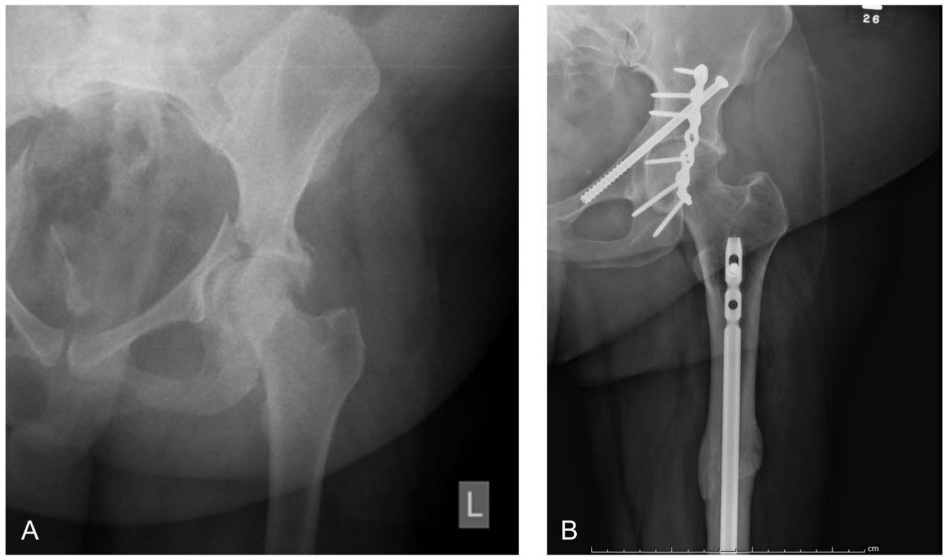

FIGURE 1. A and B, Plain anteroposterior pelvic radiographs of a patient with an acetabular fracture and associated femoral shaft fracture preoperatively and postoperatively.

to Letournel.[19] Femur fractures were also grouped by location: proximal, diaphyseal, or distal. Complications recorded were DVT, PE, infection (superficial and deep), PTA, HO, AVN, fracture union, and need for additional surgery.

Statistical analysis was performed using SPSS version 23 (IBM). Nominal data were analyzed using χ^2 analysis or Fisher exact test as appropriate. Categorical data were analyzed using Mann–Whitney *U* test. Analysis of variance (ANOVA) was performed to model combinations of variables. Comparisons on binomial variables—such as presence or absence of PE, DVT, and infection—were performed using χ^2, 2 group comparisons of continuous variables were performed using independent *t* tests, and variables with greater than 2 groups with continuous variables were compared using ANOVA. Some demographic variables such as sex or age were also modeled with other variables using stepwise ANOVA.

RESULTS

Demographics

After the initial collection, 20 patients were excluded for insufficient follow-up data. That left 101 patients. The mean age of patients was 37 (range: 17–78). Sixty-four (63%) were men and 37 (37%) were women. Of the records in which employment status was noted (72%), 44 patients were employed, 24 were unemployed, and 4 were disabled at the time of injury. Of the 44 who were employed before injury, 18 returned to work, 6 were unemployed, and 2 disabled. Fifty-two percent of patients were smokers, 49% used alcohol, and 21% indicated illicit drug use. At the latest follow-up, 29.7% were still using narcotic pain medication.

Injury Details

The majority of patients were injured in either a motor vehicle or motorcycle collision (86%). The remaining patients were injured by pedestrian struck (7%), fall (4%), crush (2%), and assault (1%). The average Glasgow Coma Score (GCS) score was 13 (range: 3–15), and the average Injury Severity Score (ISS) was 21 (range: 9–59). Ninety-one percent of patients sustained additional orthopaedic injuries: 48% extremity fractures, 9% pelvis, 2% spine, and 32% in multiple areas. Figure 1 is a case example.

Fracture Characteristics

The fractures were classified according to the OTA/AO Classification.[18] Table 1 delineates the fracture types. Acetabular fractures were also classified according to the Letournel classification[19]: 54 elementary (53%) and 47 (47%) associated fractures. Twenty-four percent of patients had marginal impaction. Age >45 was significantly associated with marginal impaction ($P < 0.05$).

Operative Details

Eighty-two percent of patients were placed in traction initially and 12 patients had an external fixator for their

TABLE 1. Fracture Patterns

Femur*		Acetabular	
31A	29	62A1	20
31B	11	62A2	12
31C	3	62A3	3
32A	37	62B1	43
32B	8	62B2	1
32C	15	62B3	3
33A	1	62C1	3
33B	4	62C2	9
33C	3	62C3	7

*Ten patients had combinations involving more than 1 area of the femur and are outlines in the text.

TABLE 2. Acetabular Fixation-Operative Details

Positioning	
	Prone 38%
	Supine 32%
	Lateral decubitus 30%
Approach	
	Kocher 71%
	Ilioinguinal 13%
	Pfannesnstiel 7%
	Stoppa 4%
	Percutaneous 4%
	Gibson 1%

femur. One hundred patients (99%) underwent fixation of the femur first. The average time from admission to definitive fixation of the femur was 2 days (range: 0–14). The average time between surgical procedures was 3 days (range 0–20). The average time to fixation of the acetabular fracture was 5 days (range 0–24 days). There were 77 patients with head trauma. There was no significant difference in time to fixation of the femur fracture or acetabular fracture in those patients with and without head trauma. There were 52 patients with chest trauma. There was a significant difference ($P = 0.01$) in time to fixation of femur fractures in those patients with chest trauma: 2.5 versus 1.3 days in those without chest trauma, but no significant difference in time to fixation of acetabular fractures.

Operative fixation for the femur included antegrade nail 30%, retrograde nail 35%, and plate 35%. The positioning for acetabular fixation was prone 38%, supine 32%, and lateral 30%. Table 2 describes acetabular fixation approach.

Thirty-one percent of patients underwent fixation of the acetabulum and the femur during the same procedure. This was at an average of 2.4 days from admission. The positioning was supine for fixation of the both fractures in 16 patients. The remainder used more than 1 position. There was no significant difference in complications for single versus 2 surgeries.

For 12 patients (12%), the same incision was used for fixation of both fractures. These 12 patients had a Kocher approach with plate fixation of proximal femur and acetabular fractures.

Hospital Details

The average length of hospital stay was 21 days (median: 14 days; range: 3–206). During hospitalization, patients underwent an average of 2 additional surgeries. Twenty-one patients received radiation after acetabular fixation. Of those who received radiation, 16 (76%) had acetabular fixation through a Kocher approach. Patients were discharged home (42%), rehab (56%), or prison (2%). At discharge, 60% of patients were non–weight bearing, 38% were toe touch, and 2% were weight bearing as tolerated.

Complications

The overall complication rate included DVT 10 (10%), PE 4 (4%), infection (superficial/deep) 17 (17%), PTA 18 (18%), HO 29 (29%), and AVN 7 (7%). We considered major complications as AVN (7/101), HO (29/101), deep infection (8/101), PE (4/101) for a total of 48 or a rate of 0.475/patient. Minor complications were considered PTA (18/101), superficial infection (9/101), and DVT (7/101) for a total of 34 or a rate of 0.376/patient.

Multiple associations were shown to be statistically significant in data analysis. Age was evaluated as a continuous variable with *t* tests. There were significant differences ($P < 0.05$) noted in the following complications: DVT (48 vs. 36 years); PE (54 vs. 37 years); infection (45 vs. 37 years); marginal impaction was associated with higher age (48 vs. 34) and development of PTA (44 vs. 36). The time from admission to fixation of the acetabular fracture (13 vs. 5 days) and femur fracture (8 vs. 2 days) was significant ($P < 0.02$). In the older patients with multiple trauma, there could be many factors leading to delay as our average ISS was 21. Because of the retrospective nature of this study, we cannot determine reasons for delay. The superficial infection rate was associated with longer time from admission to fixation for both the acetabulum (8 vs. 4 days) and femur (4 vs. 2) ($P = 0.019$ and $P = 0.030$).

There were 29 patients who developed HO. Their average GCS was 11 (range: 3–15). Twenty-one of 29 patients who developed HO had acetabular fixation through a Kocher approach (Fig. 2). Only 1/29 patient had post-op radiation. HO was associated with a lower GCS score on admission ($P = 0.001$).

Complication rates were further stratified by fracture classifications. Several specific fracture classification combinations demonstrated significant associations with complication rates. Femoral shaft fractures (OTA/AO 32 type) combined with any ipsilateral acetabular fracture; the rate of DVT (20%) was significantly higher than any other femur

FIGURE 2. An example of a patient who developed HO.

fracture classification ($P = 0.023$). Associated-type acetabular fractures in combination with a proximal femur fracture (OTA/AO 31) had a significantly higher rate of AVN when compared with distal femur fractures ($P = 0.018$) and a significantly higher rate of having additional surgeries during hospitalization (50%).

Other complications were not found to be significantly higher in any particular fracture pattern combination. However, although not statistically significant, several comparisons were notable regarding complications and fracture classification. (see **Table**, **Supplemental Digital Content 1**, http://links.lww.com/JOT/A61 and **Table**, **Supplemental Digital Content 2**, http://links.lww.com/JOT/A62). After initial fixation, 33 percent of patients required additional surgeries to the acetabulum (15), femur (12), or both (6) (Table 3). This includes, but is not limited to, implant removals for infection or failure, nonunion, and total hip arthroplasty (THA). Of the 6 who required additional surgeries to both locations, 5/6 were in patients with proximal femur fractures.

Follow-up

The median follow-up time was 11 months (range: 3–80). Thirty percent of patients still required the use of assistive devices for ambulation, and 30% of patients were still using narcotic pain medication at their latest follow-up appointment.

DISCUSSION

The demographic data of our patient population included 101 patients with 64 men (63%) and 37 (37%) women with an average age of 37 years (range 17–78), which is similar to a review of 57 patients including types A, B, and C injury patterns extracted from the Orthopaedic Trauma Service Database between 1992 and 2005 as published by Burd et al.[13] The injury classification of the acetabular fractures was fairly equally split between elementary (53%) and associated (47%) patterns.[19] This was a much higher associated fracture pattern compared with 23% found by Müller et al[16] in a review of 30 type A and type C injury patterns.

In this relatively large patient cohort, approach and implant type for fracture fixation had no impact on complication rate. In general, surgeons were guided by their training and trauma principles established for the individual fracture patterns when confronted with these associated ipsilateral injuries. Aside from numerous individual case reports, there are limited surgical techniques available in the literature for this injury pattern.[12,20,21,] Bishop et al[12] provided the only significant series of 16 patients treated with a specific surgical technique by describing antegrade femoral nailing while allowing for a Kocher-Langenbeck approach for the acetabular fracture. This may be performed under 1 anesthetic or in a staged manner pending the medical status of the patient.[22,23] They described an increased risk of HO.

HO occurred at a rate of 34% according to Burd et al,[13] which was similar to this study at 29%. During subset analysis, HO was significantly increased for combined acetabular and ipsilateral proximal femur fractures ($P < 0.05$). The increased energy dissipated to the bones and soft tissue at a focal location is a possible explanation for this occurrence.[24] The use of HO prophylaxis was at the discretion of the treating surgeon in this study. There was only 1/29 patient who received prophylactic radiation who developed HO. These results suggest consideration for prophylactic radiation. The authors of this study did find a decreased GCS in patients with HO, which is consistent with thoughts of head-injured patients having an increased risk for HO.[25]

An infection rate was reported at 8% by Bishop et al[12] and 0% according the database review by Burd et al.[13] We reported a combined infection rate at 17% which is higher than isolated acetabular fractures with a range of 1.27%–6.15%.[12,26–28] Delaying surgical fixation of the acetabular or femoral fracture was found to lead to an increased rate of superficial infection in this patient cohort. We would have expected a higher rate of infection when the same incision was used for both procedures. However, we could not find that to be significant.

The rate of DVT was 12% by Burd et al[13] with no reported incidence of PE. For acetabular and pelvic fractures, the rate of DVT ranges from 35% to 60%.[29,30] Ten percent of patients in this study developed DVT with a significantly increased rate of DVT (20%) for combined acetabular (elementary or associated) and ipsilateral femoral shaft fractures, as well as for older patients and delayed fracture fixation for both the acetabulum and femoral fracture ($P < 0.05$). Harvin et al[31] reviewed 1376 patients with diaphyseal femur fractures and found a reduced rate of PE of 2% versus 4% with early fixation (<24 hours) compared with delayed fixation (≥24 hours). Four patients in this review developed PE and were associated with older age and delayed fixation of the fracture ($P < 0.05$). This is similar to the findings of Harvin et al,[31] but with a different time frame for what was considered early fixation. Older patients (age ≥40 years) also fared worse in a review of 60 patients with isolated acetabular fractures according to Harris hip scores with greater than 2 years of follow-up.[32] Perhaps, older patients were slower to mobilize which may explain the increased complications with age. Although more aggressive early treatment may decrease complication rate, these early interventions in patients with multitrauma must be balanced with their additional injuries and physiologic status. The use of thromboembolic prophylaxis in these patients is highly advised and must be indicated on an individual patient basis.[33,34]

The rate of AVN was nearly double for acetabular fractures with ipsilateral proximal femur fractures compared with diaphyseal and distal femur fractures reflecting a higher disruption rate of the blood supply to the femoral head.[35,36] These patients also experienced a higher reoperation rate which may be indicative of higher complexity of soft tissue injury and more than 1 fracture in the same location.

Wei et al[17] reviewed 8 cases between 1990 and 2008 with combined acetabular and ipsilateral femoral neck fractures. Five of 8 patients who had associated dislocations had a 100% incidence of AVN, whereas the other 3 did not. These authors argue that an acute THA should be "worthy of consideration" for this injury with associated dislocation. The acute treatment of acetabular fractures in elderly patients with early primary THA has overall positive results on small patient populations, but these authors found no reports of primary THA on ipsilateral acetabulum and femur

TABLE 3. Additional Procedures After Fixation

Age, y	Acetabular Classification	Femoral Fracture Classification	Acetabular Approach	Femoral Approach	Additional Procedure(s) Performed	Reason for Additional Procedure(s), If Documented	Time From Initial Fixation to Add. Procedure (If Documented)
58	Simple	Shaft	Posterior	Proximal plate	Closed reduction of hip dislocation	Hip dislocation and femoral head fracture-likely AVN related.	1 mo
					I&D	Post-op wound skin break.	
44	Simple	Proximal	Posterior	Proximal plate	HO excision and neuroplasty sciatic nerve	HO	11 mo
33	Simple	Proximal	Posterior	Undocumented	Hardware removal.	Infection	
					THA		
43	Complex	Proximal	Posterior	Proximal plate	THA*	DJD	
49	Complex	Proximal	Posterior	Distal retrograde nail	Debridement of hip infection	Infection	
27	Simple	Proximal	Posterior	Proximal nail	Debridement and superficial excision, hardware removal.	Infection	
30	Complex	Shaft	Posterior	Proximal plate	Femur fracture de-rotation.	Malunion	
28	Complex	Proximal	Ilioinguinal	Proximal plate	Removal of hardware	Infection	
28	Complex	Shaft	Posterior	Proximal plate	Femur fixation revision.	Malrotation and HO	
					HO excision		
55	Complex	Proximal	Posterior	Away from the acetabulum	HO excision	HO	
32	Complex	Shaft	Posterior	Distal nail	Acetabular fixation revision.	Noncompliance	
					HO excision		
38	Complex	Shaft	Posterior	Proximal nail	I&D ×3.	Infection (location not specified)	4 mo
					Removal of hardware		
51	Complex	Shaft	Posterior	Proximal nail	THA with removal of hardware.		7 y
					I&D with hip capsule arthrotomy.		
44	Simple	Shaft	Posterior	Proximal nail	Removal of hardware, hip.	Infection of hip, femoral head AVN, PTA	
					Girdlestone resection of femoral head, saucerization of acetabulum, Insertion of nonbiodegradable drug-delivery implants, I&D.		
					THA*		
49	Simple	Shaft	Posterior	Away from the acetabulum.	Revision of acetabulum fixation	Malreduction of the patient's anterior column and subluxation of femoral head medially under acetabular dome.	
52	Simple	Shaft	AIP	Away from the acetabulum	I&D ×3	Infection of hip	
23	Complex	Distal	AIP	Away from acetabulum	Revision nailing of femoral nail.	Femur originally fixed in shortened position	
37	Simple	Proximal	Posterior	Proximal plate	HO excision.	PTA and HO	
					Complex conversion THA.		

TABLE 3. (*Continued*) Additional Procedures After Fixation

Age, y	Acetabular Classification	Femoral Fracture Classification	Acetabular Approach	Femoral Approach	Additional Procedure(s) Performed	Reason for Additional Procedure(s), If Documented	Time From Initial Fixation to Add. Procedure (If Documented)
29	Complex	Distal	Posterior	Proximal plate	THA		
51	Simple	Shaft	Posterior	Proximal plate	Removal of hardware for nonunion.	Nonunion	13 mo
					Exchange nailing.		19 mo
29	Simple	Proximal	Posterior	Proximal plate	I&D	Infection of hip	
33	Simple	Proximal	Posterior	Proximal plate	THA*		
53	Simple	Proximal	Posterior	Proximal plate	THA	Failure of fixation with repeat posterior hip dislocation	2.5 mo

*THA indicates that the patient was referred for THA, but had not yet undergone the procedure at the time of data collection.

fractures.[37,38] No patient in this review received an acute THA at the index procedure, indicating that orthopaedic traumatologists prefer anatomical fixation with ORIF as the mainstay of treatment in this young patient demographic. In isolated acetabular fracture ORIF, this treatment practice is well supported with 79% survivorship with 20 years of follow-up shown by Tannast et al.[39]

Our study found a significantly higher rate of marginal impaction in older patients. We did not have any information on bone quality, and there was no one with an underlying known diagnosis of osteoporosis, but the increased rate of marginal impaction may be reflective of there being more injury to the joint with the marginal impaction.

Studies have discussed benefits of stratifying orthopaedic fracture care depending on the presence of multiorgan system trauma and resuscitation when choosing between "Damage-control orthopaedic" (DCO) techniques and what is called "Early total care" in multiply injured patients with femoral shaft fractures.[40,41] DCO involves temporizing the orthopaedic injuries versus definitive stabilization. Tuttle et al[40] found no significant differences between the 2 techniques in 2009, but concluded that DCO may be a safer, initial alternative. A more recent article comparing the 2 techniques in patients with multiple trauma included femur, acetabular/pelvic fractures, and spine fractures.[41] They concluded that in resuscitated patients, definitive fixation of multiple injuries in the same setting did not increase the frequency of complications.[41] There seemed to be only a small group of patients in our study undergoing DCO with external fixation to the femur. However, we indicated that 82% of patients were placed in traction initially and this is acceptable treatment and may be considered a form of DCO.[42] However, as 31/101 had treatment of both fractures in the same setting, the patients' physiologic status must have permitted this to occur and they must have been adequately resuscitated. We had no deaths, despite this high energy injury combination in a multitrauma patient.

The limitations to this study include its retrospective nature. There were multiple surgeons involved across the 8 Level 1 trauma centers and there were no protocols at any institution in place for this injury combination as this is a rare injury combination. Functional outcome scores were not assessed. The study had 11 months of median follow-up, which is appropriate for the described complication profile and goals of the study; however, it would be reasonable to speculate that longer follow-up would demonstrate an increasing rate of AVN and secondary procedures.

The strengths of the study include describing the largest patient cohort and would be expected to include a larger variation of treatment patterns than smaller studies. All surgeries were supervised by trauma fellowship-trained orthopaedic surgeons.

CONCLUSIONS

This study reports the largest patient cohort from multiple Level 1 trauma centers with ipsilateral acetabular and femur fractures reporting patient demographics, injury patterns, treatments, and complications. Patients sustaining this injury pattern are predominately young men involved in high-energy motor vehicle collisions with this injury pattern sustaining a fairly equal amount of elementary and associated acetabular fractures with 52% proximal, 40% diaphyseal, and 8% distal femur fractures. There are multiple lessons learned from this review of patients. With this injury combination, in all cases but 1, the femur was stabilized first. We believe this is important to continue with fixation of the femur fracture, as there is then a stable platform for manipulation and reconstruction of the joint surface. The complication profile was significantly worse for AVN for associated acetabular type and ipsilateral proximal femur fractures compared with the rest of the patient cohort ($P < 0.05$). It is not surprising that there were more complications with older patients. Our infection rates are slightly higher than previously reported for treatment of either injury separately. However with this combination of injuries, the infection rate we found could be due to the high-energy nature of this injury and subsequent soft tissue damage and due to the fact that the patient group had multiple trauma with an average ISS of 21. Because delaying surgery was noted to be associated with multiple complications, consideration for early definitive fixation of these fractures may be associated with fewer complications.

The authors advocate for appropriate prophylaxis for HO and DVT/PE, which must be individualized for each patient. These data guide discussions concerning the prognosis and complications for this injury and provide treatment suggestions based on our results.

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