



Analysis of Predictors of Results after Surgical Treatment of Acetabular Fractures

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Purpose: The aim of this study was to analyze the factors affecting the outcomes after surgical treatment of acetabular fractures.

Materials and Methods: Between January 2000 and December 2012, 106 patients with acetabular fractures were treated with open reduction and internal fixation. We performed a retrospective cohort study to analyze the factors which may influence a patient's prognosis after surgical treatment of an acetabular fracture. The factors examined included age, femoral head injury, fracture type, dislocation, initial displacement, delay to injury-related surgery (in days), and quality of reduction. Additionally, we investigated clinical and radiological outcomes, as well as the development of osteoarthritis.

Results: Patients included 85 males (80.2%) and 21 females (18.8%) with a mean age of 50.4 (17-78) years. The mean follow-up period was 2.6 (1-10) years. In a univariable regression analysis, quality of reduction, age, and initial displacement were significantly associated with radiological and clinical outcomes. In a multivariable regression analysis, quality of reduction ($P<0.001$) and initial displacement ($P=0.001$) were found to be factors predictive of clinical and radiological outcomes. Additionally, the quality of reduction ($P=0.005$) was found to be predictive of osteoarthritis development.

Conclusion: Study results indicated that the quality of reduction was the most important factor influencing the prognosis of patients with acetabular fractures.

Key Words: Acetabular fracture, Quality of reduction, Predictive factor

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INTRODUCTION

Acetabular fractures, typically attributable to high-energy trauma associated with upper or lower extremity fractures, as well as brain, chest, or abdominal injuries, are difficult to treat surgically and more prone to postoperative complications¹⁻⁶. Since Letournel⁷ proposed that surgical treatment was associated with a better prognosis than conservative management in patients with acetabular fractures and dislocations, open reduction with internal fixation and early ambulation

have been recommended as basic management. Patient's age, delay to injury-related surgery (in days), the presence of hip dislocations, fracture types, the preoperative degree of displacement, the degree of postoperative reduction, and femoral head and associated injuries have been identified as factors that may influence the outcomes of surgical management for acetabular fractures⁷⁻¹⁴). However, a limited number of domestic studies have been conducted in order to explore factors affecting the treatment outcomes of acetabular fractures. Therefore, this study aimed to identify the factors that may influence postoperative clinical and radiological outcomes in acetabular fractures treated surgically.

MATERIALS AND METHODS

1. Patients

This study included 106 patients who underwent open reduction and internal fixation due to acetabular fracture by nine surgeons in Pusan National University Hospital (Busan, Korea) from January 2000 to December 2012. Factors examined included age, gender, injury mechanism, associated injuries, fracture type, the presence of dislocation, nerve injury, the preoperative degree of displacement, and delay to injury-related surgery (in days). Based on data from operation records, surgical approaches, surgical methods, femoral head injuries, and the degree of reduction were also examined. Clinical and radiological outcomes in acetabular fractures were evaluated at the end of the first postoperative year, and the outcomes were evaluated according to the Matta scoring system. After evaluating joint space, sclerosis severity, and the degree of osteophyte formation, radiological outcomes were classified into excellent, good, fair, and poor. Clinical outcomes were graded into excellent, good, fair and poor by evaluating pain, gait, and range of motion according to the modified Merle d'Aubigne and Postel clinical grading system¹¹).

2. Predictors of Treatment Outcomes

Based on results from previous studies^{3-5,7,15,16}), we determined that possible prognostic factors included the degree of postoperative dislocation, patient's age, associated injury (head, chest, abdomen, genitourinary

system, spine, and extremities), femoral head injury, fracture type according to Letournel classification, the presence of hip dislocation, the preoperative degree of displacement, surgical approaches, and surgical methods. According to the Matta scoring system, the degree of postoperative displacement was classified into three categories by marking a maximum displacement on the anteroposterior and oblique radiographs in mm¹¹). To evaluate the effect of the degree of initial displacement on postoperative radiological and clinical outcomes, patients were divided into two groups (>20 mm and ≤20 mm) according to the initial degree of displacement on radiographs of the articular surface. Fractures were classified according to the Letournel-Judet classification system¹⁷). Fracture types were divided into simple and associated fractures, which were then re-classified into five sub-categories.

3. Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 21.0 software (IBM Co., Armonk, NY, USA). *P*-values <0.05 were considered to be statistically significant. A univariable regression analysis was performed in order to determine factors associated with radiological and clinical outcomes, and a multivariable regression analysis was conducted in order to identify significantly associated factors. Additionally, a logistic regression analysis was conducted in order to analyze the incidence of osteoarthritis.

RESULTS

1. Baseline Characteristics

Patients included 85 men (80.2%) and 21 women (19.8%) with a mean age of 50.4 years (range, 17-78 years). The most common injury types were attributable to car accidents in 54 cases (50.9%), followed by falls in 29 cases (27.4%), other causes in 23 cases (21.7%). According to the Letournel fracture classification system, 56 cases were considered to be simple types (52.8%) and associated types in 50 cases (47.2%). There were 67 patients (63.2%) with an initial degree of displacement <20 mm and 39 patients (36.8%) with a degree of displacement >20 mm. Surgical procedures were carried out using a Kocher-Langenbeck approach in 56 cases (52.8%), an ilioinguinal approach in 21 cases

(19.8%), and a combined ilioinguinal and Kocher-Langenbeck approach in 21 cases (19.8%; Table 1).

2. Clinical and Radiological Results

Clinical outcomes were evaluated according to the modified Merle d'Aubigne and Postel clinical grading system. Scores were excellent (18 points) in 37 cases (34.9%), good (15-17 points) in 46 cases (43.4%), fair (13-14 points) in 15 cases (14.2%), and poor (<13 points) in eight cases (7.5%). Radiological evaluation was conducted using the Matta scoring system. Scores

were excellent in 59 cases (55.7%), good in 28 cases (26.4%), fair in 11 cases (10.4%), and poor in eight cases (7.5%; Table 2). According to the results of a Spearman correlation analysis, the clinical and radiological classification scores showed a statistically significant and strongly positive correlation ($P<0.001$).

In a univariate regression analysis, the degree of postoperative reduction ($P<0.001$), age ($P=0.020$), and the preoperative degree of displacement ($P<0.001$) showed significant associations with radiological results. Moreover, the degree of postoperative reduction ($P<0.001$), age ($P=0.005$), and the preoperative degree of displacement ($P<0.001$) were identified as factors significantly affecting clinical outcomes ($P<0.001$; Table 3). Through a multivariate regression analysis, the degree of postoperative reduction ($P<0.001$) and the preoperative degree of displacement ($P=0.001$) were found to be prognostic factors for postoperative radiological and clinical outcomes (Table 4).

Regarding patients belonging to the fair and poor groups according to the Matta scoring system, those complaining of hip pain and movement limitations were classified into the arthritis group. Osteoarthritis of the

Table 1. Study Patients' Baseline Characteristics (n=106)

Variable	Data
Age (yr)	
≤55	68 (64.2)
>55	38 (35.8)
Sex	
Male	85 (80.2)
Female	21 (19.8)
Acetabular fracture type	
Simple	56 (52.8)
Anterior wall	4 (3.8)
Posterior wall	33 (31.1)
Posterior column	10 (9.4)
Transverse	2 (1.9)
Anterior column	7 (6.6)
Associated	50 (47.2)
Posterior column+posterior wall	5 (4.7)
Transverse+posterior wall	4 (3.8)
T-type	3 (2.8)
Anterior column+posterior hemitransverse	5 (4.7)
Both column	33 (31.1)
Associated injury	
Head	12 (11.3)
Abdomen	11 (10.4)
Chest	16 (15.1)
Genitourinary	0 (0.0)
Extremity	59 (55.7)
Spine	10 (9.4)
Pelvic ring	23 (21.7)
Dislocation	18 (17.0)
Femoral head injury	17 (16.0)
Surgical approach	
Ilioinguinal	21 (19.8)
Kocher-Langenbeck	56 (52.8)
Ilioinguinal+Kocher-Langenbeck	21 (19.8)
Limited iliofemoral	2 (1.9)
Initial displacement (mm)	
≤20	67 (63.2)
>20	39 (36.8)

Values are presented as number [%].

Table 2. Radiological and Clinical Outcomes

Variable	Data
Quality of reduction (mm)	
Anatomical (0-1)	81 (76.4)
Imperfect (2-3)	16 (15.1)
Poor (>3)	9 (8.5)
Radiological grade	
Excellent	59 (55.7)
Good	28 (26.4)
Fair	11 (10.4)
Poor	8 (7.5)
Clinical grading system	
Excellent (score=18)	37 (34.9)
Good (score 15-17)	46 (43.4)
Fair (score 13-14)	15 (14.2)
Poor (score <13)	8 (7.5)
Complication	
PE, DVT	1 (0.9)
Loss to reduction	4 (3.8)
Infection	8 (7.5)
Wound hematoma	0 (0.0)
AVN	6 (5.7)
Arthritis	9 (8.5)
Heterotopic bone	6 (5.7)

Values are presented as number [%].

PE: pulmonary embolism, DVT: deep vein thrombosis, AVN: avascular necrosis.

hip joint occurred in a total of nine patients (8.4%) with anatomical reductions in three cases, incomplete reduction in one case, and poor reductions in five cases. There were three patients with a preoperative degree of displacement <20 mm and six patients with a degree of dislocation >20 mm. By performing a logistic regression analysis, the postoperative degree of reduction was identified as a prognostic factor for the development of osteoarthritis ($P=0.005$).

DISCUSSION

Of the 106 patients with acetabular fractures treated surgically, 76.4% achieved anatomical reductions, 78.3% had excellent or good clinical outcomes, and 82.1% had excellent or good radiological outcomes. Statistical analyses revealed that the postoperative degree of reduction and the initial displacement were

critical factors for predicting patient clinical and radiological outcomes, and the postoperative degree of reduction was found to be a predictive factor for the occurrence of arthritis.

Matta¹¹⁾ reported that preoperative displacements had a insignificant effect on prognosis in 262 acetabular fracture patients with a mean initial displacement of 20 mm. Conversely, Meena et al.¹⁸⁾ demonstrated significantly poorer results in patients with an initial displacement of >20 mm. The results from the current study were comparable with those of the latter study, showing significantly ($P=0.001$) poorer radiological and clinical outcomes in the group with an initial displacement of >20 mm.

A large number of studies have addressed the importance of anatomical reductions in the management of acetabular fractures^{11,12,19)}. Bhandari et al.²⁰⁾ evaluated the clinical outcomes of 109 patients with acetabular

Table 3. Factors Associated with Radiological and Clinical Grades from the Univariable Regression Model and Presence of Arthritis from the Logistic Regression Model

Variable	Radiological grade CI (95% CI)	Clinical grade CI (95% CI)	Presence of arthritis OR (95% CI)
Quality of reduction	1.27 (1.11-1.42) $P<0.001$	1.09 (0.91-1.27) $P<0.001$	7.06 (2.66-18.77) $P<0.001$
Age (>55 yr vs. ≤55 yr)	0.43 (0.06-0.79) $P=0.023$	0.49 (0.15-0.84) $P=0.005$	4.06 (0.95-17.30) $P=0.058$
Damage to the femoral head (yes vs. no)	0.36 (-0.13-0.84) $P=0.148$	0.06 (-0.40-0.53) $P=0.777$	1.56 (0.29-8.25) $P=0.600$
Fracture type (associated vs. simple)	0.30 (-0.05-0.66) $P=0.093$	0.22 (-0.12-0.56) $P=0.205$	1.44 (0.36-5.70) $P=0.600$
Dislocation (yes vs. no)	0.29 (-0.18-0.77) $P=0.223$	0.13 (-0.32-0.59) $P=0.561$	0.58 (0.06-5.01) $P=0.628$
Initial displacement (>20 mm vs. ≤20 mm)	1.12 (0.82-1.43) $P<0.001$	1.06 (0.77-1.35) $P<0.001$	3.87 (0.91-16.50) $P=0.067$
Delay to injury related surgery (days)	0.000 (-0.009-0.010) $P=0.936$	-0.003 (-0.012-0.007) $P=0.587$	1.011 (0.983-1.039) $P=0.445$

CI: confidence interval, OR: odds ratio.

Table 4. Factors of Radiological and Clinical Grades from the Multivariable Regression Model

Variable	Radiological grade CI (95% CI)	Clinical grade CI (95% CI)
Quality of reduction	1.12 (0.95-1.30) $P<0.001$	0.89 (0.68-1.09) $P<0.001$
Age (>55 yr vs. ≤55 yr)	-0.04 (-0.24-0.15) $P=0.686$	0.11 (-0.12-0.35) $P=0.378$
Initial displacement (>20 mm vs. ≤20 mm)	0.37 (0.15-0.60) $P=0.001$	0.45 (0.19-0.70) $P=0.001$

CI: confidence interval.

fractures according to the modified Merle d' Aubigne and Postel score. Of these, 84% had excellent or good outcomes, and the study authors suggested that the postoperative degree of reduction was the most important factor for prognosis. In the current study, near-anatomical reductions were associated with satisfactory clinical and radiological outcomes ($P < 0.001$).

In order to achieve precise reductions, it is important to choose a surgical approach appropriate for each fracture type according to the AO fracture and dislocation classification²¹. In both-column acetabular fractures in particular, an extensile approach is considered as a better option for more precise reductions; however, the results of a previous study found satisfactory outcomes from indirect reductions of the posterior column using an ilioinguinal approach²². Isaacson et al.²³ obtained satisfactory outcomes in anterior-column and both-column acetabular fractures using the Stoppa approach. However, that study was not designed to verify the effects of surgical approaches on treatment outcomes.

The results of a few studies have suggested that fracture types according to the Letournel classification showed significant effects on prognosis^{16,24}. Furthermore, the results from previous studies revealed an unfavorable prognosis for patients with posterior column, posterior column + posterior wall, and T-shaped fractures^{12-14,19}. Since the Letournel system classifies fracture types according to fractures of the column or wall of the acetabulum, Meena et al.¹⁸ proposed that fracture types were helpful in guiding decisions regarding surgical approaches, but were not predictive of prognosis. Similarly, fracture type was not found to be a significant factor for predicting clinical and radiological outcomes or arthritis incidence in the current study.

In a study conducted by Moed et al.²⁵, a poor prognosis was observed in 100 patients with posterior wall fractures and an age > 55 years. In contrast, Matta¹¹ suggested that postoperative reductions were significant factors affecting treatment outcomes, as compared to age, which had an insignificant effect. Although age was associated with clinical and radiological outcomes in the current study, age was not found to be a prognostic factor for treatment outcomes or arthritis occurrence.

Osteoarthritis occurred in nine patients (8.4%). Of these, the outcomes of postoperative reductions were

anatomical in three cases, incomplete in one case, and poor in five cases. In a study conducted by Chiu et al.¹¹, osteoarthritis occurred in 13.2% of all satisfactory reductions and in 43.5% of unsatisfactory reductions. The likelihood of reduction achievement tended to reduce the risk of post-traumatic osteoarthritis. In the current study, postoperative reductions were found to be predictive of the risk of developing osteoarthritis after the surgical management of acetabular fractures, and the likelihood of reduction achievement significantly decreased the incidence of osteoarthritis.

The current study analyzed acetabular fractures by dividing them into simple and associated fractures due to the relatively small sample size. Therefore, further large-scale studies are warranted in order to analyze detailed fracture types according to the Letournel classification.

CONCLUSION

The results of the current study revealed that the initial degree of displacement and the quality of reductions were important factors affecting the prognosis of patients with acetabular fractures, and that the achievement of anatomical reductions was more likely to reduce the risk of osteoarthritis.

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