ACTA ORTHOPAEDICA et TRAUMATOLOGICA TURCICA
www.aott.org.tr

Research Article

Analysis of predictive factors for post-traumatic osteoarthritis and poor outcomes in acetabular fractures treated surgically

Mustafa Kavak[1], Aytek Hüseyin Çeliksöz[2], Büşra Tokmak[1], Ulukan Inan[1]

[1]Department of Orthopedics and Traumatology, Osmangazi University Faculty of Medicine, Eskişehir, Turkey
[2]Department of Orthopedics and Traumatology, Eskişehir State Hospital, Eskişehir, Turkey

ARTICLE INFO

Article history:
Submitted July 21, 2022
Received in revised form
January 3, 2023
Last revision received
May 11, 2023
Accepted June 2, 2023
Publication Date August 23, 2023

Keywords:
Acetabular fracture
Functional outcome
Post-traumatic osteoarthritis
Long-term results
Risk factors of poor outcome

ORCID iDs of the authors:
M.K. 0000-0002-0280-2088,
A.H.Ç. 0000-0003-4630-1856,
B.T. 0000-0002-0029-5860,
U.I. 0000-0002-1903-5516.

ABSTRACT

Objective: The aims of this study were (i) to assess the radiological and functional outcomes of surgically treated displaced acetabular fractures and (ii) to analyze the predictive factors of poor outcomes following surgery.

Methods: A total of 119 patients (24 female, 95 male) who were operated between 2009 and 2019 were included in the study. The mean age was 47.5 years (range=18-61). The mean follow-up was 92.3 months (range=24-120). Failure to preserve the biological hip joint, as treated with total hip replacement or the Girdlestone procedure, was defined as a poor outcome. Patients' demographic information, comorbidities, fracture types, surgical approach, concomitant injuries, reduction quality, and complications were analyzed. Computed tomography was utilized to evaluate the fracture type and quality of reduction. Factors affecting poor outcomes were analyzed by logistic regression analysis. The modified Harris Hip Score was also used to evaluate the functional status.

Results: The poor outcome rate was 10.1%. Multivariate logistic regression analysis revealed that dislocation (odds ratio: 44.87, confidence interval: 3.18-633.22, $P=.005$), wound site problems (odds ratio: 9.09, confidence interval: 1.01-81.12, $P=.04$), reduction quality (odds ratio: 77.88, confidence interval: 5.95-1019.07, $P=.001$), and diabetes (odds ratio: 7.29, confidence interval: 1.01-52.07, $P=.04$) were associated with poor outcomes. Eight of the 12 patients with poor outcomes had a fair Harris Hip Score, and 4 had a poor Harris Hip Score. The relationship between poor outcomes and Harris Hip Score was found to be significant ($P<.001$).

Conclusion: For a favorable functional outcome in acetabular fractures, preservation of the biological hip joint should be a top priority. The accompanying dislocation and the patient's diabetes appear to be uncontrollable factors for the poor prognosis. Good reduction quality and wound infection protection are modifiable factors.

Level of Evidence: Level IV, Therapeutic Study.

Introduction

Open reduction and internal fixation have been the gold standard treatment for displaced acetabular fractures since Judet et al[1] described it in 1964. Although the surgical method has much better results than conservative treatment, the rate of post-traumatic osteoarthritis reaching 25% and complications such as infection and neurologic deficit have required further research on this topic.[2-5] Therefore, numerous researchers have published studies that include the functional and radiological results of surgically treated patients.[2-9] These retrospective studies that report the most common long-term complication was osteoarthritis and other late complications were heterotopic ossification (HO) and avascular necrosis of the femoral head, focused on long-term survivorship of the hip.

A recent systematic review[10] reported that most of the studies on the surgical treatment of acetabular fractures have focused on radiographic outcomes, including the quality of the reduction and the degree of subsequent arthritis. It was also stated in the review that although radiological measurements are important, they do not define the functional outcomes of patients after surgery. In addition, it was emphasized that the results of surgical treatment of acetabular fractures lack scientific certainty and that more studies are needed to determine the functional outcomes and the risk factors for post-traumatic osteoarthritis.

The purpose of this study was to evaluate the radiological and functional outcomes of surgically treated displaced acetabular fractures and the factors associated with poor results.

Materials and Methods

A total of 131 patients who were surgically treated for displaced acetabular fractures between June 2009 and June 2019 were reviewed retrospectively. Patients aged 18 years or older and followed up for at least 24 months were included in the study. The patients without pre- and postoperative computed tomography (CT) were excluded from the study. After excluding 4 patients due to being lost to follow-up and 8 patients due to insufficient data, a total of 119 patients were included in the study. All patients were operated on by the senior author. After examining the patients' computerized data and hospital charts, data regarding age at admission, gender, body mass index (BMI),

Corresponding author:
Mustafa Kavak
kavak.m@gmail.com

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Cite this article as: *Kavak M, Çeliksöz AH, Tokmak B, Inan U. Analysis of predictive factors for post-traumatic osteoarthritis and poor outcomes in acetabular fractures treated surgically. Acta Orthop Traumatol Turc., 2023;57(4):141-147.*

DOI: 10.5152/j.aott.2023.22124

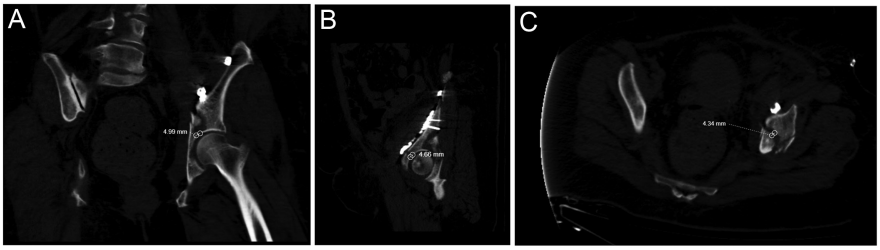

Figure 1. Evaluation of reduction quality with postoperative CT scan: (A) coronal plane, (B) sagittal plane, and (c) axial plane. CT, computed tomography.

smoking status, American Society of Anesthesiologists (ASA) score, additional traumas, traumatic nerve palsy, skeletal traction, iatrogenic nerve palsy, wound infection, postoperative intensive care need, deep vein thrombosis, and surgical approach were obtained. All patients included in the study had previous preoperative and postoperative CT scans. The preoperative conventional radiographs and CT scans of the patients were examined and their fractures were classified according to the Letournel classification.[11] Data regarding dislocation, femoral head fracture, and marginal impaction were recorded. The quality of the reduction was evaluated on the postoperative radiographs and CT scans (Figure 1A–C). Evaluation of reduction quality and fracture classification was done blindly by 2 investigators. Evaluation was made for inter-observer reliability and Cohen kappa value was found as 0.903 (0.831-0.975) with 95% confidence intervals for fracture classification and 0.924 (0.881-0.967) with 95% confidence intervals for reduction quality. Reduction of those with a 2 mm or smaller displacement was accepted as satisfactory.[12] During the follow-up period, radiographs of the patients were examined and the patients who underwent arthroplasty in which the biological hip joint could not be preserved and required a Girdlestone procedure were considered to have a poor outcome. In addition, data regarding avascular necrosis of the femoral head, the degree of osteoarthritis, and HO on the final radiograph were recorded. Brooker classification was used for the evaluation of HO.[13] The Matta classification, which was used in many previous studies, was used for osteoarthritis classification. Giannoudis et al[3] in their meta-analysis evaluated patients with Matta grade 3 and 4 arthrosis as severe OA. In this study, when evaluating OA, the division into 2 groups was made in accordance with this meta-analysis.[13] Both the 36-item Short-Form Health Survey (SF-36),[14] which evaluates the general health status of the patient, and the modified Harris Hip Score (mHHS),[8] which evaluates the functional status of the joint, were used to assess the functional outcomes. For functional results, patients were invited to the clinic and evaluated by 2 researchers at the same time. Ethics committee approval was obtained from Eskisehir Osmangazi University before the study (16.10.2020/24). Verbal informed consent was obtained from the patients who agreed to take part in the study.

HIGHLIGHTS

- Open reduction and internal fixation have been the treatment of choice for displaced acetabular fractures however, post-traumatic arthritis is a rather common complication following surgical treatment. This study aimed to assess the radiological and functional outcomes and analyze the predictive factors for poor outcomes of surgical treatment for displaced acetabular fractures.
- The results showed that satisfactory reduction was achieved in 89.9% of the patients, and 63.6% of these patients had excellent functional scores. Poor radiological outcome was seen in 10.1% of the patients, 66.6% had fair and 33.3% had poor functional results. Age, body-mass index, diabetes, dislocation, poor reduction quality and wound infection were associated with poor outcomes.
- The results indicate that favorable functional outcomes can be achieved with preservation of the hip joint which is possible with good reduction quality. Preventitive measures should be taken to avoid wound infections.

Statistical analyses

The continuous data (age and SF-36 score) are given as mean ± SD. The categorical data (gender, BMI, ASA score, smoking, additional trauma, diabetes, postoperative intensive care need, fracture type, dislocation, femoral head fracture, marginal impaction, avascular necrosis, nerve palsy, reduction quality, wound site infection, and surgical approach) are given as percentage (%). The Shapiro–Wilk test was used to investigate the normality of the data. In the comparison of the normally distributed groups, independent samples *t*-test was used in cases with 2 groups and 1-way analysis of variance in cases with 3 or more groups. Pearson's chi-square, Yates's chi-square, Fisher's exact chi-square, and Pearson's exact chi-square tests were employed in the analyses of the created cross tables. Logistic regression was used to determine the risk factors, while the Kaplan–Meier analysis was utilized to calculate the life span of the patients. All statistical analyses were performed using the IBM Statistical Package for the Social Sciences Statistics version 21.0 software (IBM SPSS Corp.; Armonk, NY, USA). The level of statistical significance was set at $P < .05$.

Results

Of the 119 patients included in the study, 95 were males and 24 were females, with a mean age of 47.5 ± 16.3 (18-61) years. The mean follow-up period was 92.3 ± 48.2 (24-120) months. The baseline characteristics of the patients are given in Table 1. Based on the Letournel classification, elementary fractures were seen in 42 (35.3%) patients, while associated fractures were seen in 77 (64.7%). The most common fracture pattern was posterior wall fracture (26.9%). A detailed distribution of the fracture types is given in Table 2. The hip dislocation was detected in 40 patients (33.6%) at the first admission. Femoral head fractures were observed in

Table 1. Baseline characteristics of the study population

Characteristics		Patients
Gender	Men	95 (79.8%)
	Women	24(20.2%)
Body mass index	Thin	2 (1.7%)
	Normal	58 (48.7%)
	Overweight	24 (20.2%)
	Obese	35 (29.4%)
Smoking	Yes	50 (42%)
	No	69 (58%)
Additional trauma	Abdominal injury	34 (28.6%)
	Lower extremity fracture	32 (26.9%)
	Chest injury	30 (25.2%)
	Upper extremity fracture	26 (21.8%)
	Vertebral fracture	19 (16%)
	Head trauma	19 (16%)
Diabetes	Yes	17 (14.3%)
	No	102 (85.7%)

Table 2. Distribution of the fracture types according to the Letournel classification

Fracture	n (%)
Elementary fractures	42 (35.3)
Anterior wall	0 (0)
Anterior column	0 (0)
Posterior wall	32 (26.9)
Posterior column	1 (0.8)
Transverse	9 (7.6)
Associated fractures	77 (64.7)
Posterior column+wall	17 (14.3)
Transverse+posterior wall	14 (11.8)
T-shaped	21 (17.6)
Anterior column+posterior hemitransverse	11 (9.2)
Both columns	14 (11.8)

9 patients (7.6%) while marginal impaction was noticed in 17 (14.3%). Avascular necrosis of the femoral head was observed in 8 patients (6.7%) (Figure 2A–D). Grade 1 HO was observed in 23 patients (19.3%), grade 2 HO in 14 patients (11.7%), grade 3 HO in 11 patients (9.2%), and grade 4 HO in 1 patient (0.8%). The Kocher–Langenbeck (K-L) approach was used in all 26 patients with grade 2 and higher HO. Grade 2 and higher HO was seen in 26 (43.3%) of 60 patients who used the K-L approach. The acetabulum was visualized via the K-L approach in 74 patients (62.2%), the modified Stoppa+lateral window approach in 27 (22.7%), the modified Stoppa+lateral window+K-L approach in 10 (8.4%), the ilioinguinal in approach in 6 (5%), the ilioinguinal+K-L approach in 1 (0.8%), and the K-L+trochanteric osteotomy approach in 1 (0.8%).

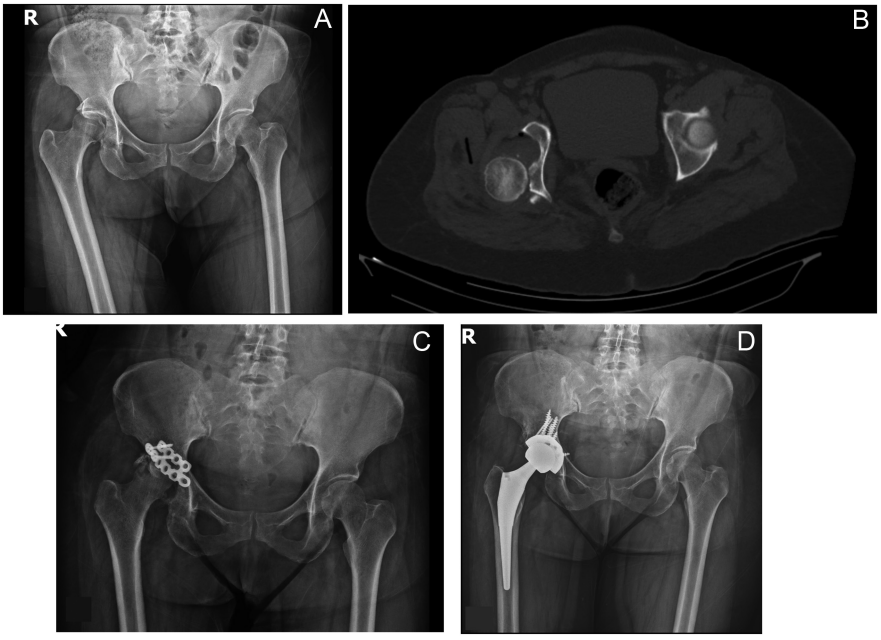

Figure 2. Case example of total hip arthroplasty due to postoperative avascular necrosis of femoral head. (A) Preoperative X-ray image. (B) Preoperative CT scan image. (C) X-ray image showing the development of avascular necrosis. (D) X-ray image after total hip arthroplasty. CT, computed tomography.

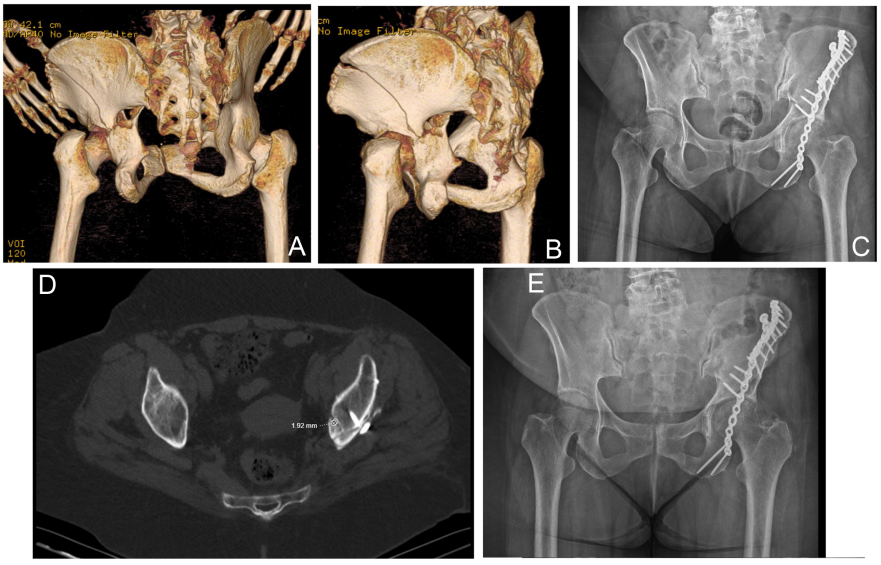

Figure 3. Example of a case without arthrosis after anterior column posterior hemitransverse acetabulum fracture with satisfactory reduction quality. (A) and (B) Preoperative CT scan with 3D reconstruction image. (C) Postoperative X-ray image. (D) Evaluation of reduction quality with postoperative CT scan. (E) Final follow-up X-ray image resulting in without arthrosis. 3D, 3-dimensional; CT, computed tomography.

The reduction quality was satisfactory in 97 patients (81.5%) (Figure 3A–Ee). Fifteen patients (12.6%) had traumatic sciatic nerve palsy, while 1 (0.8%) developed iatrogenic sciatic nerve palsy. Complete recovery was observed in 1 patient with iatrogenic nerve palsy and 8 patients with traumatic nerve palsy. The total recovery rate was found to be 56.2%. Eleven patients (9.2%) had superficial wound infections and 1 (0.8%) encountered deep wound infection. In 1 patient (0.8%) in which intra-articular screw penetration was observed, the screw position was revised (Figure 4). Deep vein thrombosis developed in 3 patients (2.5%).

In the evaluation of post-traumatic osteoarthritis on the final radiographs of 107 patients in which the hip joint was preserved, 54 patients (45.4%) had excellent, 25 (21%) had good, 11 (9.2%) had fair, and 17 (14.3%) had poor hip scores. Excellent and good results were considered to indicate low-grade arthrosis and poor and fair results were considered to indicate high-grade arthrosis. Accordingly, 79 of the 107 patients in whom the hip joint could be preserved were considered to have low-grade arthrosis and 28 high-grade arthrosis. The results of the univariate analysis revealed that older age ($P < .001$), smoking ($P = .001$), high ASA score ($P < .001$), history of hospitalization in the intensive care unit ($P = .008$), fracture type (T-shaped) ($P < .001$), presence of marginal impaction ($P = .005$), poor reduction quality ($P < .001$), and higher BMI ($P < .001$) were found to be the factors

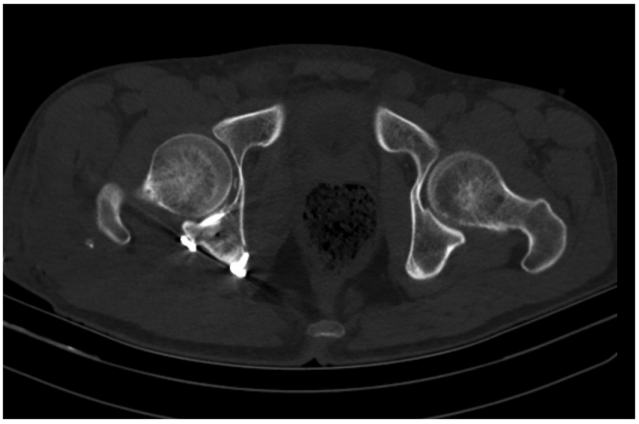

Figure 4. Recognized intra-articular screw penetration on postoperative CT scan image. CT, computed tomography.

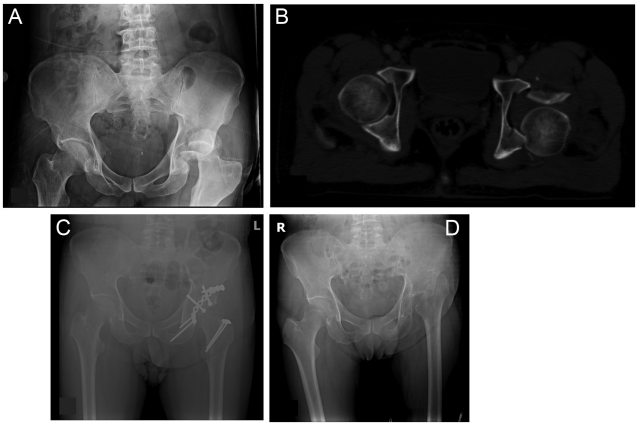

Figure 5. Case example of a transverse and posterior wall fracture with dislocation resulting in the Girdlestone procedure due to recurrent deep infections after surgery. (A) Preoperative X-ray image. (B) Preoperative CT scan image. (C) Postoperative X-ray image. (D) Final follow-up X-ray image resulting in Girdlestone procedure. CT, computed tomography.

Table 3. Distribution of predictive factors between good and bad outcome groups

Characteristics		Poor	Satisfactory	*P*
Gender	Men	9 (75%)	86 (80.4%)	.7
	Women	3 (25%)	21 (19.6%)	
Age, years	Mean	57.42 (±15.37)	46.39 (±16.13)	**.02**
Body mass index	Thin	0 (0%)	2 (1.9%)	
	Normal	0 (0%)	58 (54.1%)	**.004**
	Overweight	2 (16.7%)	22 (20.6%)	
	Obese	10 (83.3%)	25 (23.4%)	
Smoking	Yes	7 (58.3%)	43 (40.2%)	.36
	No	5 (41.7%)	64 (59.8%)	
ASA score	1	4 (33.3%)	72 (67.3%)	.06
	2	7 (58.4%)	28 (26.2%)	
	3	1 (8.3%)	7 (6.5%)	
Additional trauma	AI			
	Yes	6 (50%)	28 (26.2%)	.09
	No	6 (50%)	79 (73.8%)	
	LEF			
	Yes	4 (33.3%)	28 (26.2%)	.73
	No	8 (66.7%)	79 (73.8%)	
	CI			
	Yes	1 (8.3%)	29 (27.1%)	.29
	No	11 (91.7%)	78 (72.9%)	
	UEF			
	Yes	2 (16.7%)	24 (22.4%)	1.0
	No	10 (83.3%)	83 (77.6%)	
	VF			
	Yes	0 (0%)	19 (17.8%)	.21
	No	12 (100%)	88 (82.2%)	
	HT			
	Yes	2 (16.7%)	17 (15.9%)	1.0
	No	10 (83.3%)	90 (84.1%)	
Diabetes	Yes	6 (50%)	11 (10.3%)	**.002**
	No	6 (50%)	96 (89.7%)	
Postoperative intensive care need	Yes	3 (25%)	34 (31.8%)	.75
	No	9 (75%)	73 (68.2%)	
Dislocation	Yes	9 (75%)	31 (29%)	**.003**
	No	3 (25%)	76 (71%)	
Femoral head fracture	Pipkin type 1	3 (25%)	2 (1.9%)	<.001
	Pipkin type 2	3 (25%)	1 (0.9%)	
	No	6 (50%)	104 (97.2)	
Marginal impaction	Yes	4 (33.3)	13 (12.1%)	.06
	No	8 (66.7%)	94 (87.9%)	
Avascular necrosis	Yes	7 (58.3%)	1 (0.9%)	**<.001**
	No	5 (41.7%)	106 (99.1%)	
Traumatic nerve palsy	Yes	4 (33.3%)	11 (10.3%)	**.004**
	No	8 (66.7%)	96 (89.7%)	
Reduction quality	S	3 (25%)	94 (87.9%)	**<.001**
	US	9 (75%)	13 (12.1%)	
Wound site infection	Yes	5 (41.7%)	7 (6.5%)	**.004**
	No	7 (58.3%)	100 (93.5%)	
Fracture type	PW	3 (%25)	29 (27.1%)	.14
	PC	0 (0%)	1 (0.9%)	
	Transverse	0 (0%)	9 (8.4%)	
	PC+wall	2 (16.7%)	15 (14%)	
	AC+PHT	0 (0%)	11 (10.3%)	
	Both columns	0 (0%)	14 (13.1%)	
	T-type	6 (50%)	15 (14%)	
	Transverse+PW	1 (8.3%)	13 (12.2%)	
Surgical approach	II	2 (16.7%)	4 (3.7%)	**.008**
	K-L	6 (50%)	68 (63.6%)	
	II+K-L	0 (0%)	1 (0.9%)	
	K-L+TO	1 (8.3%)	0 (0%)	
	MS+LW	0 (0%)	27 (25.2%)	
	MS+LW+K-L	3 (25%)	7 (6.6%)	

Statistically significant *P*-values are written in bold.
AC+PHT, anterior column+posterior hemitransverse; AI, abdominal injury; ASA, American Society of Anesthesiologists; CI, chest injury; HT, head trauma; II, ilioinguinal; K-L, Kocher–Langenbeck; LEF, low extremity fracture; LW, lateral window; MS, modified Stoppa; PC, posterior column; PW, posterior wall; S, satisfactory; TO, trochanteric osteotomy; UEF, upper extremity fracture; US, unsatisfactory; VF, vertebral fracture.

that were significantly associated with high-grade post-traumatic osteoarthritis. As a result of multivariate logistic regression analysis performed with these significant parameters, age [odds ratio (OR): 1.06, confidence interval (CI): 1.01-1.10, *P*=.009], BMI (OR: 1.35, CI: 1.18-1.55, *P* < .001), marginal impaction (OR: 11.32, CI: 1.25-102.37, *P*=.031), and history of hospitalization in the intensive care unit (OR: 4.44, OR: 1.22-16.17, *P*=.024) were found to be predictive factors for osteoarthritis.

The number of patients in which the hip joint could not be preserved, which we considered as a poor outcome, was 12 (10.1%). Total hip arthroplasty was performed in 10 (8.4%) of them and the Girdlestone procedure in the other 2 (1.7%) (Figures 2D and 5A–D). The results of the univariate analysis suggested that older age (*P*=.026), higher BMI (*P* = .004), presence of diabetes (*P*=.002), presence of dislocation (*P*=.003), presence of femoral head fracture (*P* < .001), presence of avascular necrosis (*P* < .001), presence of traumatic nerve palsy (*P*=.04), surgical approach (*P*=.008), poor reduction quality (*P* < .001), and presence of wound site infection (*P*=.004) were found to be factors significantly associated with poor outcomes. The distribution of predictive factors between good and poor outcome groups is shown in Table 3. These factors were then evaluated with multivariate logistic regression analysis and as a result, the presence of dislocation (OR: 44.87, CI: 3.18-633.22, *P*=.005), presence of wound site problems (OR: 9.09, CI: 1.01-81.12, *P*=.04), poor reduction quality (OR: 77.88, CI: 5.95-1019.07, *P*=.001), and presence of diabetes (OR: 7.29, CI: 1.02-52.12, *P*=.04) were found to be the predictors that were associated with poor outcomes. The results of the univariate and multivariate analyses are outlined in Table 4.

Eight of the 12 patients with poor outcomes had a fair HHS and 4 had a poor HHS. Out of the 107 patients in which the hip joint was preserved, 68 had excellent, 9 had good, 11 had fair, and 19 had poor HHSs. The relationship between poor outcomes and HHS was found to be significant (*P* < .001). The mean SF-36 score of the 107 patients with a preserved hip joint was 71.68 ± 15.07 (40-95), while the mean score of the 12 patients with poor outcomes was 46.67 ± 14.19 (20-60). This difference between the 2 groups was statistically significant (*P* < .001). Among the patients with low-grade arthrosis, the HHS was excellent in 83.5%, good in 11.5%, fair in 2.5%, and poor in 2.5%. On the other hand, 60.7% of the patients with high-grade arthrosis had a poor and 39.3% a fair HHS. The HHS of the patients with high-grade arthrosis was significantly worse than those with low-grade arthrosis (*P* < .001). Finally, the mean SF-36 score of the patients with low-grade arthrosis was 77.59 ± 11.29 (40-95), while the mean score was 55 ± 11.54 (40-85) among high-grade arthrosis patients (*P* < .001). The distribution between radiological outcomes and functional scoring is shown in Table 5. We found out that patients with an excellent HHS had an average SF-36 (general health) score of 80.81, patients with a good HHS had an average SF-36 score of 66.11, patients with a fair HHS had an average SF-36 score of 51.58, and patients with a poor HHS had an average SF-36 score of 50.43. Therefore, we established general parallelism between the HHS and SF-36 scores.

Table 4. Results of the multivariate logistic regression analyses

Predictive factors	Multivariate regression		
	OR	CI	*P*
Diabetes	7.29	1.02-52.12	**.04**
Dislocation	44.87	3.18-633.22	**.005**
Reduction quality	77.88	5.95-1019.07	**.001**
Wound site infection	9.09	1.01-81.12	**.04**

CI, confidence interval; OR, odds ratio.
Statistically significant P-values are written in bold.

Discussion

With a better understanding of the surgical principles following the revolution brought by Judet et al[1] in the treatment of acetabulum fractures, surgery was adopted as the primary treatment for displaced acetabular fractures.[2] Subsequently, several authors reported the results of a series of surgically treated acetabular fractures involving varying numbers of patients.[1,6-11,15-23] Following the increasing number of studies in the literature, systematic reviews and meta-analysis studies were conducted.[3,10] The results of a meta-analysis by Giannoudis et al[3] suggested that the best possible reduction with a minimal surgical approach was important for obtaining a good outcome. In a systematic review by Dodd et al,[10] in which the functional results of surgically treated acetabular fractures were evaluated, it was stated that injury-specific and functional evaluation tools with proven effectiveness and more studies were needed for the evaluation of functional results. From the perspective of this knowledge in the literature, the factors affecting the radiological and functional results were examined in this study. The reduction quality emphasized by Giannoudis et al was evaluated with CT in all patients, unlike other studies. Also, Archdeacon et al[24] noted that surgically correctable factors were detected by postoperative CT in 2.5% of patients; this shows the importance of postoperative CT in acetabular fractures. As Dodd et al. stated, more reliable results were tried to be obtained by using injury-specific and general functional scoring together. Although this study confirmed the correlation between post-traumatic osteoarthritis and functional outcomes, it emphasized that the worst functional outcomes occur when the biological hip joint is not preserved. In addition, it showed that the predictive factors for poor outcomes were poor reduction quality, fracture accompanying dislocation, presence of wound site problems, and presence of diabetes.

In our study, the hip joint could not be preserved in 10.1% of the patients; thus, arthroplasty or the Girdlestone procedure had to be performed. In the largest meta-analysis in the literature,[3] this rate was reported as 8.5%, with the need for arthroplasty being reported to be mostly within 2 years after surgery.[2,3] The fact that the patients

Table 5 . Distribution of functional outcomes between poor and satisfactory outcome and low- to high-grade osteoarthritis

Characteristics	SF-36 score	Modified Harris Hip Score (mHHS)				*P* (mHHS)	*P* (SF-36)
		Excellent	Good	Fair	Poor		
Poor outcome	46.67 (±14.19)	0 (0%)	0 (0%)	8 (66.7%)	4 (33.3%)	**<.001**	**<.001**
Satisfactory outcome	71.68 (±15.07)	68 (63.6%)	9 (8.4%)	11 (10.3%)	19 (17.8%)		
Osteoarthrosis							
Low-grade	77.59 (±11.29)	66 (83.5%)	9 (11.5%)	2 (2.5%)	2 (2.5%)	**<.001**	**<.001**
High-grade	55 (±11.54)	2 (7.1%)	0 (0%)	9 (32.1%)	17 (60.8%)		

SF-36, 36-item Short-Form Health Survey.
Statistically significant P-values are written in bold.

were followed up for a minimum of 2 years in our study makes this finding reliable. Considering that the rate of high-grade osteoarthritis is 23.5% and the rate of avascular necrosis is 6.7%, the rate of arthroplasty or the Girdlestone procedure of 10.1% is an issue that needs to be clarified. Giannoudis et al[3] similarly reported that the rate of arthroplasty was less than 10%, despite the rate of approximately 20% for osteoarthritis and 5% for avascular necrosis. Some authors suggested that the reason for this was the patients that refused to undergo surgery.[23,25,26] In our study, we found that there was a direct correlation between the development of osteoarthritis and the functional scores of the patients. However, we observed that this situation could be tolerated, especially in elderly and low-expectancy patients. This may be the reason why the rate of arthroplasty is less than expected.

In our study, high-grade osteoarthritis was observed in 23.5% of the patients in whom the hip joint was preserved. This finding supports the information that the most common complication after the surgical treatment of acetabular fractures is post-traumatic osteoarthritis. In the meta-analysis of Giannoudis et al,[3] this rate was reported as 19%, whereas Judet et al[1] mentioned lower rates and Matta[12] higher ones. Fracture type,[23] chondral lesions and reduction quality[3,13,23] have been reported as risk factors for the development of post-traumatic osteoarthritis. In our study, age, marginal impaction, history of hospitalization in the intensive care unit, and a high BMI were found to be risk factors for post-traumatic osteoarthritis. Fracture type (T-shaped) and reduction quality were found to be significantly associated with post-traumatic osteoarthritis in the univariate analysis, but this significant relationship could not be established with the multivariate logistic regression.

The mHHS and SF-36 (general health) scores were used to evaluate the functional outcomes in our study, and excellent and good results were observed in 64.7% of the patients. The mean SF-36 (general health) score was 69.16 (range: 20 to 95). In numerous studies evaluating the outcomes in acetabular fractures, the Merle d'Aubigné grading system and HHS were frequently used for the evaluation of functional results, with 75% of excellent and good results being reported.[2,7,13,23] These results are consistent with those from our study. In our study, we used both HHS, which is a joint-specific functional scoring system, and the SF-36, which indicates the general health status of the patient. Since joint-specific scoring may not accurately reflect the patient's general functionality in daily life, we aimed to evaluate the reliability of functional scores using both scoring systems. On the other hand, we observed that there was a parallelism between the results of both functional scoring systems. Although we noticed a relationship between functional outcomes and post-traumatic osteoarthritis, the more striking results were seen in patients in whom the hip joint could not be preserved. Eight of the 12 patients in whom the hip joint could not be preserved had a fair HHS and 4 had a poor HHS, while their mean SF-36 score was 46.67. The preservation of the hip joint has a primary role considering the functionality of the patient in the long term.

The present study showed that the most common fracture pattern was the posterior wall fracture. In the case series of Judet et al,[1] the most common type of fracture was similarly reported to be posterior wall fracture. The results reported in the meta-analysis of Giannoudis et al[3] are also similar to the distribution of the fracture types in our study. In our study, we noticed that the K-L approach was used in 62.2% of the patients. The most frequently used approach in similar studies in the literature is also K-L.[2,7,9,13,15-21] Frietman et al,[22] on the other hand, reported that the most frequently used approach was the ilioinguinal one. This may be due to the difference in fracture type distribution. In the present study, the rate of traumatic nerve palsy was 12.6% and the rate of iatrogenic nerve palsy was 0.8%. In the meta-analysis of Stavrakakis et al,[27] the rates of post-traumatic sciatic nerve palsy were 5.1%, iatrogenic nerve plasma rates were 1.4%, and total recovery rates were 64.7%. We think that the reason for the high rate of traumatic nerve palsy is the high rate of posterior wall fracture in the fracture distribution. In this study, the total recovery rate was found to be 56.2%, which is consistent with the literature.

Giannoudis et al[3] reported in their meta-analysis that they achieved a satisfactory reduction in 85% of the patients. In our study, we also observed that 81.5% of the patients could attain satisfactory reduction with a displacement of 2 mm or less. In some studies, it has been reported that there is a strong relationship between reduction quality and fracture type.[2,12,13] Mears et al[2] showed that 87% of elementary fractures can be reduced anatomically, whereas associated fractures can be reduced anatomically in only 59%. According to Matta,[12] the least anatomic reduction could be achieved in both-column and T-shaped fractures. In parallel with these findings, out of the 22 patients who could not have a satisfactory reduction, 14 had T-shaped fractures, 4 had both-column fractures, 2 had transverse+posterior wall fractures, 1 had a posterior column+wall fracture, and 1 had a transverse fracture. The prevalence of avascular necrosis of the femoral head has been reported to vary between a wide range of 3%-53%.[3] Giannoudis et al[3] reported this rate as 5.6% and they suggested that most of the exaggerated rate in the literature is probably because of the changes in the femoral head due to osteoarthritis. We observed avascular necrosis of the femoral head in 6.7% of our patients. This is similar to the rate reported in the meta-analysis.[3]

The main limitations of our study were its retrospective design and the limited number of patients. The fact that surgical delay, a factor that has been associated with reduction quality,[2] was not evaluated was another limitation. Another limitation is that we did not evaluate the long-term prognosis of HO and its effect on outcomes. However, in our study, the reliable use of a database was ensured thanks to the prospective archiving of patient data, especially of the preoperative and postoperative CT scans. In addition, we tried to increase the reliability of our study by using scoring systems that evaluate both general health and joint-specific conditions of patients.

The predictive factors for postoperative osteoarthritis in patients in whom the hip joint could not be preserved, which was evaluated as a poor outcome in this study, were found to be fracture accompanying dislocation, wound problem, reduction quality, and diabetes. If we are to take into account that the failure to protect the hip joint is directly related to the patient's functionality in the long term, providing a good reduction quality and avoiding wound infection can be considered as modifiable factors that affect the long-term outcomes.

Ethics committee approval: This study was approved by Ethics Committee of Eskisehir Osmangazi University (Approval No: 24, Date: October 16, 2020).

Informed consent: Verbal informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author contributions: Concept – U.İ., M.K.; Design – M.K.; Supervision – U.İ.; Resources – B.T., M.K.; Materials – M.K., A.H.Ç.; Data Collection and/or Processing– A.H.Ç., B.T.; Analysis and/or Interpretation – M.K., B.T.; Literature Search – M.K., A.H.Ç.; Writing – M.K., A.H.Ç.; Critical Review – U.İ.

Declaration of interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

References

1. 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. [CrossRef]
2. Mears DC, Velyvis JH, Chang CP. Displaced acetabular fractures managed operatively: indicators of outcome. *Clin Orthop Relat Res*. 2003;407(407):173-186. [CrossRef]
3. Giannoudis PV, Grotz MR, Papakostidis C, Dinopoulos H. Operative treatment of displaced fractures of the acetabulum. A meta-analysis. *J Bone Joint Surg Br*. 2005;87(1):2-9.
4. Tannast M, Najibi S, Matta JM. Two to twenty-year survivorship of the hip in 810 patients with operatively treated acetabular fractures. *J Bone Joint Surg Am*. 2012;94(17):1559-1567. [CrossRef]
5. Clarke-Jenssen J, Røise O, Storeggen SAØ, Madsen JE. Long-term survival and risk factors for failure of the native hip joint after operatively treated displaced acetabular fractures. *Bone Joint J*. 2017;99-B(6):834-840. [CrossRef]
6. Matta JM, Anderson LM, Epstein HC, Hendricks P. Fractures of the acetabulum. A retrospective analysis. *Clin Orthop Relat Res*. 1986;205(205):230-240.
7. Brueton RN. A review of 40 acetabular fractures: the importance of early surgery. *Injury*. 1993;24(3):171-174. [CrossRef]
8. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am*. 1969;51(4):737-755. [CrossRef]
9. Ragnarsson B, Mjöberg B. Arthrosis after surgically treated acetabular fractures. A retrospective study of 60 cases. *Acta Orthop Scand*. 1992;63(5):511-514. [CrossRef]
10. Dodd A, Osterhoff G, Guy P, Lefaivre KA. Assessment of functional outcomes of surgically managed acetabular fractures: a systematic review. *Bone Joint J*. 2016;98-B(5):690-695. [CrossRef]
11. Letournel E. Acetabulum fractures: classification and management. *Clin Orthop Relat Res*. 1980;151(151):81-106. [CrossRef]
12. Matta JM. Fractures of the acetabulum: accuracy of reduction and clinical results in patients managed operatively within three weeks after the injury. *J Bone Joint Surg Am*. 1996;78(11):1632-1645. [CrossRef]
13. Brooker AF, Bowerman JW, Robinson RA, Riley LH Jr. Ectopic ossification following total hip replacement: incidence and a method of classification. *J Bone Joint Surg Am*. 1973;55(8):1629-1632. [CrossRef]
14. Ware JE Jr, Sherbourne CD, The Maryland Ornithological Society. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care*. 1992;30(6):473-483. [CrossRef]
15. de Ridder VA, de Lange S, Kingma L, Hogervorst M. Results of 75 consecutive patients with an acetabular fracture. *Clin Orthop Relat Res*. 1994;305(305):53-57. [CrossRef]
16. Kebaish AS, Roy A, Rennie W. Displaced acetabular fractures: long-term follow-up. *J Trauma*. 1991;31(11):1539-1542. [CrossRef]
17. Chiu FY, Chen CM, Lo WH. Surgical treatment of displaced acetabular fractures – 72 cases followed for 10 (6-14) years. *Injury*. 2000;31(3):181-185. [CrossRef]
18. Deo SD, Tavares SP, Pandey RK, El-Saied G, Willett KM, Worlock PH. Operative management of acetabular fractures in Oxford. *Injury*. 2001;32(7):581-586. [CrossRef]
19. Moed BR, WillsonCarr SE, Watson JT. Results of operative treatment of fractures of the posterior wall of the acetabulum. *J Bone Joint Surg Am*. 2002;84(5):752-758. [CrossRef]
20. Rommens PM, Broos PL, Vanderschot P. Vorbereitung und Technik der operativen Behandlung von 225 Acetabulumfrakturen. Zweijahresergebnisse in 175 Fällen [Preparation and technique for surgical treatment of 225 acetabulum fractures. 2 year results of 175 cases]. *Unfall*. 1997;100(5):338-348.
21. Murphy D, Kaliszer M, Rice J, McElwain JP. Outcome after acetabular fracture. Prognostic factors and their inter-relationships. *Injury*. 2003;34(7):512-517. [CrossRef]
22. Frietman B, Biert J, Edwards MJR. Patient-reported outcome measures after surgery for an acetabular fracture. *Bone Joint J*. 2018;100-B(5):640-645. [CrossRef]
23. Tscherne H, Pohlemann T. *Becken und Azetabulum* [*Pelvis and Acetabulum*]. Berlin: Springer Verlag; 1998.
24. Archdeacon MT, Dailey SK. Efficacy of routine postoperative CT scan after open reduction and internal fixation of the acetabulum. *J Orthop Trauma*. 2015;29(8):354-358. [CrossRef]
25. Liebergall M, Mosheiff R, Low J, Goldvirt M, Matan Y, Segal D. Acetabular fractures. Clinical outcome of surgical treatment. *Clin Orthop Relat Res*. 1999;366(366):205-216. [CrossRef]
26. Pantazopoulos T, Nicolopoulos CS, Babis GC, Theodoropoulos T. Surgical treatment of acetabular posterior wall fractures. *Injury*. 1993;24(5):319-323. [CrossRef]
27. Stavrakakis IM, Kritsotakis EI, Giannoudis PV, et al. Sciatic nerve injury after acetabular fractures: a meta-analysis of incidence and outcomes. *Eur J Trauma Emerg Surg*. 2022;48(4):2639-2654. [CrossRef]