Predicting the poor clinical and radiographic outcomes after anatomical reduction and internal fixation of posterior wall acetabular fractures: a retrospective analysis

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Research Article

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Abstract

Background: Anatomical reduction is the fundamental principle of hip function restoration after posterior acetabular wall fractures (PWFs). Some patients exhibit poor outcomes despite anatomical reduction, and the prognostic factors leading to poor outcomes remain elusive. This study aimed to investigate the clinical and radiographic outcomes in patients with PWFs who had undergone anatomical reduction and internal fixation and to identify the predictors that impair clinical and radiologic outcomes.

Methods: Clinical records of 60 patients with elementary PWFs who had undergone anatomical reduction and internal fixation between January 2005 and July 2015 were reviewed retrospectively. The Harris hip score (HHS) and modified Merle d'Aubigné clinical hip scores (MMAS) were used to evaluate the clinical outcome. Pre-operative and final follow-up radiographs were cross checked to identify poor radiographic outcomes that included the presence of advanced osteoarthritis and osteonecrosis, as well as the need for conversion to total hip arthroplasty.

Results: Age was negatively correlated with functional outcomes (correlation coefficients were -0.41 and -0.39 in HHS and MMAS, respectively) and significantly related to the severity of osteoarthritis and osteonecrosis, and need for total hip arthroplasty. Regarding the radiographic factors, significantly worse post-operative HHS and MMAS were found in the fracture comminution group. In the subanalysis of the status of fracture comminution, patients with fragment comminution involving the acetabular dome had significantly lower functional scores than those with other fracture patterns.

Conclusions: Age, fracture comminution, and dome comminution were the prognostic indicators of advanced osteoarthritis and poor functional scores after anatomical reduction and internal fixation of PWFs. We further emphasized the relevance of acetabular dome comminution as an important contributing factor to clinical and radiographic outcomes.

Background

Posterior wall acetabular fracture (PWF) is the most common acetabular fracture, accounting for approximately one-third of all acetabular injuries [1]. The integrity of the posterior wall is mandatory to maintain the stability of the hip joint, and open reduction and internal fixation (ORIF) is usually recommended in the presence of joint instability or incongruity [2]. Anatomical reduction of the articular surface and stable fixation for early mobilization are widely propagated as the golden standards for the treatment of PWFs; Moreover, fracture reduction accuracy has been considered to be associated with long-term functional and radiological outcomes [3–6]. Unexpected incarcerated bone fragments and marginal cancellous impactions, which are usually encountered and affect surgical reduction during ORIF, are usually not found on routine plain radiographs. A pre-operative computed tomography (CT) scan helps to comprehensively overview the complexity of PWF, such as fragment comminution, marginal cancellous bone impaction, femoral head injury, and intra-articular fragments, and therefore helps in surgical planning. It is difficult to obtain anatomical reduction and maintain the stability of PWF, even with advanced radiological examinations, owing to the complexity of fracture patterns and patient conditions.

Several authors have proposed different surgical techniques to achieve stable fixation. Giannoudis et al. used a two-level reconstruction technique for comminuted PWFs and reported favorable clinical outcomes, with excellent results in 72% of cases [7]. Kim et al. used a similar technique and reported satisfactory results in 60.7% and 72.7% of clinical and radiological outcomes, respectively [8]. Lee et al. advocated the spring plate technique for adjuvant fixation in comminuted PWFs and reported excellent to good results in 92.3% of cases radiologically, and only 4 of 52 patients required conversion to total hip arthroplasty (THA) [9]. Despite the advances in imaging and surgical techniques, there is an apparent disparity in clinical outcomes and reduction quality. To date, there has been no study discussing the post-operative outcomes of anatomical reduction in PWFs patients. In this study, we aimed to investigate clinical and radiological outcomes in patients with PWFs after anatomical reduction and internal fixation and to identify the predictors that impair clinical and radiological outcomes.

Methods

Participants

This study was approved by the Institutional Review Board of our hospital. After approval, the medical records of patients with acetabular fractures admitted to the hospital over 10 years (January 2005 to July 2015) were retrospectively reviewed. The inclusion criteria were 1) age > 18 years; 2) acetabular fracture without any other combined fractures; 3) displaced PWFs (> 2 mm) confirmed by radiography and CT requiring surgical fixation as evaluated by an experienced hip surgeon and classified according to Letournel's classification; 4) post-ORIF with anatomical reduction; and 5) need for follow-up for more than 1 year. The exclusion criteria were: 1) concomitant intracranial hemorrhage requiring surgery or cerebrovascular accident; 2) advanced hip-joint osteoarthritis (OA) or femoral head osteonecrosis (ON) as indicated on pre-operative radiographs; and 3) PWFs with poor reduction quality showing a post-operative fracture gap > 3 mm, assessed using Matta's criteria.

Pre-operative Assessments And Treating Methods

All patients had undergone standard pre-operative treatment and examination. A skeletal traction was routinely applied while awaiting surgery to avoid further injury from joint motion. Standard pre-operative radiographic examinations included antero-posterior, lateral, and two 45° oblique Judet views of the injured hip. Routine pre-operative CT scans were performed to facilitate detailed fracture pattern evaluation, intra-articular fragment detection, and detailed surgical planning. All surgeries were conducted by two experienced senior hip surgeons using the Kocher-Langenbeck approach. The hip joint structure was inspected by gentle traction, and the intra-articular bone fragments were removed, if present. Marginal impaction of the posterior acetabular wall was elevated and then reduced using the femoral head as a template. Bone voids were firmly impacted with autologous cancellous bone that was harvested from the greater trochanter. Bone fragments were temporally fixed using K-wires. The reduction quality and K-wire position were verified using intra-operative fluoroscopy. After confirmation of joint congruity, lag screws were used to secure the bone fragments and replace K-wires. The lag screw positions were rechecked and confirmed to be in the extra-articular position. A buttress reconstruction plate or an additional spring plate was used to buttress the PWFs (Fig. 1). After surgery, muscular strength exercises, range of motion exercises, and gait training were allowed under the supervision of a physical therapist. Each patient was asked to bear no weight on the operated limb for 3 months. Progressive weight-bearing walking was allowed according to the results of the following images.

Clinical Outcome Evaluations

Clinical records, including patient features and clinical presentations, were retrospectively reviewed. Post-operative follow-up examinations were performed to assess the clinical and radiologic outcomes at 1, 3, 6, and 12 months and yearly thereafter. The clinical outcomes for hip function were assessed using the Harris hip score (HSS) and modified Merle d'Aubigné clinical hip scores (MMAS). The maximum HSS is 100, and results can be interpreted as poor (< 70), fair (70–79), good (80–89), and excellent (90–100). The MMAS was graded as poor (3–11), fair (12–14), good (15–17), and excellent (18). In this study, poor clinical results were defined as HSS < 80 and MMAS < 14.

Radiological Outcome Assessments

Pre-operative and final follow-up radiographs were crosschecked by two surgeons who were not involved in the surgery to evaluate the fracture pattern, reduction quality, and presence of post-traumatic OA or femoral head ON. The post-operative CT scans were not routinely used, except in cases of suspected screw malpositions. Fracture comminution was defined as the presence of three or more fragments on CT. Fracture comminution was further divided into two groups according to the presence or absence of acetabular dome comminution. Final follow-up radiographs were used to grade the stage of hip OA according to the Kellgren-Lawrence scale and classify the stage of femoral head ON using the criteria of Ficat and Arlet. Poor radiographic outcomes included the presence of advanced OA (stage 3/4) and ON (stage 3/4), or the need for conversion to THA.

Statistical analysis

Data are expressed as mean ± standard deviation and processed by an expert statistician using SPSS software (version 20.0, SPSS Inc., Chicago, Illinois, USA). Continuous variables between the groups were compared using Student's t-test or analysis of variance, as appropriate. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. Spearman's rho (correlation coefficient) between age and functional scores was calculated using Spearman's rank correlation. Functional scores in patients of different age groups with comminuted PWFs were compared using a general linear regression model. A post-hoc analysis was performed using the Bonferroni test.

Results

Pre- and post-operative clinical and radiographic results are shown in Table 1. Sixteen women (26.7%) and forty-four men (73.3%) with an average age of 39.1 years were included in this study. Only 18.3% of PWFs comprised a single large fragment without other radiographic factors. The majority of PWFs were multi-fragmentary (61.7%) and usually associated with hip dislocation (41.7%), acetabular dome comminution (31.7%), marginal impaction (18.3%), and femoral head injury (21.7%). Most patients achieved functional performance after surgery with excellent to good results (83.3% and 80% on the HHS and MMAS, respectively). The final radiographs revealed advanced OA, ON with femoral head collapse, and requirement of THA in 18.3%, 8.3%, and 10% of patients, respectively.

Table 1. Preoperative and postoperative clinical and radiographic data

	Total patients
N	60
Age, years	
Mean (SD)	39.1(17.3)
Sex, n (%)	
Female	16 (26.7)
Male	44 (73.3)
Pre-operative CT evaluation, n (%)	
Fracture comminution	37 (61.7)
Dome comminution	19 (31.7)
Dislocation	25 (41.7)
Marginal impaction	11 (18.3)
Femoral head injury	13 (21.7)
Clinical function outcomes	
HSS	
Mean (SD)	85.5 (20.1)
MMAS	
Mean (SD)	15.3 (2.5)
Radiographic outcomes, n (%)	
OA	
Early stage (stage 0-2)	49 (81.7)
Advanced stage (stage 3-4)	11 (18.3)
ON	
Early stage (stage 0-2)	55 (91.7)
Advanced stage (stage 3-4)	5 (8.3)
Convert to THA	
No	54 (90.0)
Yes	6 (10.0)

Age was found to be significantly negatively correlated with functional results in terms of HHS (-0.41; P=0.0012) and MMAS (-0.39; P=0.0019) (Figure 2). Common pre-operative CT scans revealed that fragment comminution of either the posterior wall or dome region was significantly associated with poor functional scores. Other factors, including hip dislocation, marginal impaction, and femoral head injury, were not significantly related to functional outcomes (Table 2). Patients with fragment comminution showed significantly lower post-operative functional scores than those without comminution (18.2% and 15.4% difference in the mean HHS and MMAS, respectively; both p<0.0001). Fracture comminution involving the dome was further associated with a lower HHS (reduction of 27.5%) and MMAS (reduction of 20.7%) than fracture comminution without dome area involvement.

Table 2. Prognostic factors related to clinical outcomes (HHS and MMAS)

	HSS	P	MMAS	P
Age, Spearman's rho*	-0.41	0.0012*	-0.39	0.0019*
Sex, Median (IQR)				
Female	92.5 (89.0-96.0)		16.0 (15.0 -17.0)	
Male	93.5 (85.0-96.0)	0.9665	16.0 (15.0-17.0)	0.7110
Pre-operative radiographic factors, Median (IQR)				
Fracture comminution				
No	96.0 (95.0-100.0)		17.0 (16.0-18.0)	
Yes	90.0 (78.0-93.0)	<0.0001*	15.0 (13.0-16.0)	<0.0001*
Dome comminution				
No	95.0 (93.0-96.0)		16.0 (16.0-17.0)	
Yes	80.0 (42.0-91.0)	<0.0001*	13.0 (10.0-16.0)	<0.0001*
Dislocation				
No	95.0 (88.0-96.0)		16.0 (16.0-17.0)	
Yes	92.0 (80.0-94.0)	0.0765	16.0 (14.0-16.0)	0.0717
Marginal impaction				
No	94.0 (86.0-96.0)		16.0 (15.0-17.0)	
Yes	91.0 (83.0-93.0)	0.1267	15.0 (15.0-16.0)	0.1805
Femoral head injury				
No	94.0 (88.0-96.0)		16.0 (15.0-17.0)	
Yes	92.0 (85.0-95.0)	0.3166	16.0 (15.0-16.0)	0.2553

HSS, Harris hip score; MMAS, modified Merled’Aubigné-Postel score

Age, fracture comminution, and dome comminution were significantly associated with poor radiographic outcomes (Table 3). The presence of fragment comminution was significantly related to the occurrence of advanced OA. Furthermore, both age and acetabular dome comminution were associated with higher risk of advanced OA and ON, as well as the need for THA.

Table 3. Prognostic factors related to radiographic outcomes (OA, ON and THA)

OA, osteoarthritis; ON: osteonecrosis; THA: total hip arthroplasty.

	OA			ON			THA		
	Early stage	Advanced stage	P	Early stage	Advanced stage	P	No	Yes	P
n	49	11		55	5		54	6	
Age,									
Mean (SD)	36.4 (17.3)	51.1 (12.1)	0.0100*	37.8 (17.4)	53.8 (7.3)	0.0468*	37.6 (17.5)	53 (6.4)	0.0374*
Median (IQR)	31.0 (22.0-43.0)	51.0 (46.0-60.0)	0.0057*	33.0 (24.0-51.0)	57.0 (46.0-59.0)	0.0302*	33.0 (24.0-51.0)	53.5 (46.0-59.0)	0.0226*
Sex female, n (%)	15 (30.6)	1 (9.1)	0.2586	16 (29.1)	0 (0.0)	0.3113	15 (27.8)	1 (16.7)	1.0000
Fracture comminution	26 (53.1)	11 (100.0)	0.0042*	32 (58.2)	5 (100.0)	0.1460	31 (57.4)	6 (100.0)	0.0733
Dome comminution	9 (18.4)	10(90.9)	<0.0001*	15 (27.3)	4 (80.0)	0.0312*	13 (24.1)	6 (100.0)	0.0005*
Dislocation	18 (36.7)	7 (63.6)	0.1744	22 (40.0)	3 (60.0)	0.6405	21 (38.9)	4 (66.7)	0.2234
Marginal impaction	9 (18.4)	2 (18.2)	1.0000	10 (18.2)	1 (20.0)	1.0000	10 (18.5)	1 (16.7)	1.0000
Femoral head injury	10 (20.4)	3 (27.3)	0.6899	12 (21.8)	1 (20.0)	1.0000	12 (22.2)	1 (16.7)	1.0000

To analyze the effect of fragment comminution, we classified patients into three groups according to dome area involvement: group 1 (PWFs without fragment comminution), group 2 (PWFs with fragment comminution but no dome area involvement), and group 3 (PWFs with acetabular dome comminution). The clinical functional scores went worse from group 1, 2 to 3. Patients with comminuted PWFs involving the dome (group 3) exhibited significantly lower HHS ($p < 0.0001$) and MMAS ($p < 0.0001$) than those are in the other groups (Table 4). In addition to functional scores, there was a significant difference in the development of advanced OA and need for conversion to THA among the groups (Table 4). Post-hoc comparisons further indicated that acetabular dome comminution was the most critical prognostic factor. Patients with dome comminution exhibited the lowest average functional scores (both in HHS and MMAS) and had a higher risk of advanced OA and need for THA than those with fragment comminution without dome involvement.

Table 4. Effect of different status of comminution to clinical and radiographic outcomes in patients with PWF

	Group 1	Group 2	Group 3	
	No fragment comminution	Fragment comminution but not dome comminution	acetabular dome comminution	P
Total patients, n	23	18	19	
HSS, LS-mean (SE) *	93.87 (3.11)	92.64 (3.50)	68.45 (3.33)	<0.0001*
MMAS, LS-mean (SE) *	16.62 (0.35)	15.98 (0.39)	13.06 (0.38)	<0.0001*
OA, n (%)†‡				
Early stage	23 (100.0)	17 (94.4)	9 (47.4)	<0.0001*
Advanced stage	0 (0.0)	1 (5.6)	10 (52.6)	
ON, n (%)†‡				
Early stage	23(100.0)	17 (94.4)	15 (78.9)	0.0333*
Advanced stage	0 (0.0)	1 (5.6)	4 (21.1)	
THA, n (%)†‡				
No	23(100.0)	18 (100.0)	13 (68.4)	0.0009*
Yes	0 (0.0)	0 (0.0)	6 (31.6)	

SE: standard error; LS-mean: Least-squares means.

Group 1: no fragment comminution; Group 2: fragment comminution but not dome comminution; Group 3: acetabular dome comminution.

HSS, Harris hip score; MMAS, modified MerledAubigné-Postel score; OA, osteoarthritis; ON, osteonecrosis; THA, total hip arthroplasty.

*Data set was calculated after adjusting for age using a generalized linear regression model.

†P values were calculated using Fisher's exact test to compare fracture comminution with clinical and radiographic outcomes.

Discussion

Anatomical reduction is the most fundamental determinant of good clinical outcomes in PWFs. However, some patients with PWFs still have poor post-operative functions even after anatomical reduction of the fracture. In our study, we comprehensively analyzed the relevance of possible patient factors and fracture pattern factors to both clinical and radiographic outcomes after anatomical reduction of isolated acetabular PWFs. We found that age, fracture comminution, and dome comminution were significantly related to clinical and radiographic outcomes. Age, a significant risk factor, showed a negative correlation with functional scores (HHS and MMAS) and radiographic changes. Furthermore, patients with fracture comminutions involving the weight-bearing zone of the acetabulum

Post-hoc analysis	Group 1 vs Group 2		Group 1 vs Group 3		Group 2 vs Group 3	
	Difference LS-mean (SE) /OR (95% CI)	P	Difference LS-mean (SE) /OR (95% CI)	p	Difference LS-mean (SE) /OR (95% CI)	p
Total patients, n						
HSS, LS-mean (SE) *	-1.24 (4.80)	1.0000	-25.43 (4.58)	<0.0001*	-24.19 (4.81)	<0.0001*
MMAS, LS-mean (SE) *	-0.64 (0.54)	0.4769	-3.56 (0.52)	<0.0001*	-2.92 (0.54)	<0.0001*
OA, n (%)†‡						
Early stage	1.00		1.00		1.00	
Advanced stage	4.03 (0.15-104.93)	0.4390	51.95 (2.76-978.12)	<0.0001*	58.96 (3.90-891.8)	0.0033*
ON, n (%)†‡						
Early stage	1.00		1.00		1.00	
Advanced stage	4.03 (0.15-104.93)	0.4390	13.65 (0.69-271.70)	0.0346*	6.43 (0.60-69.33)	0.1250
THA, n (%)†‡						
No	1.00		1.00		1.00	
Yes	-	-	-	-	22.63 (1.18-433.78)	0.0052*

presented significantly lower HHS and MMAS and poorer radiographic outcomes (advanced OA, ON, and THA) than those without dome involvement.

Some prognostic factors for outcomes in patients after surgical treatment of PWFs have been reported in the literature; however, most studies discuss outcomes in all types of acetabular fractures [4, 10, 11]. A few studies exclusively evaluating PWFs have indicated that fractures occurring at an older age with intra-articular comminution or with marginal impaction mainly contributed to adverse effects and emphasized the importance of anatomical reduction [3, 6]. The quality of reduction affects the prognosis of acetabular fractures; however, some fractures are too comminuted to achieve anatomical reduction, resulting in a poor prognosis. Moreover, some patients may experience fracture displacement after undergoing an initial anatomical reduction. Unsatisfactory clinical outcomes of PWFs that were perfectly reduced initially are not uncommon. Factors associated with adverse effects in PWFs that were initially anatomically reduced remain unclear. In this study, we evaluated only PWFs with radiographic anatomical reduction to eliminate the factors of surgical impropriety and aimed to explore the prognostic factors that could affect postoperative clinical and radiographic outcomes. We demonstrated that dome comminution was the most significant factor associated with poor functional scores, advanced OA, and the need for THA.

Extensive fracture comminution makes it difficult to achieve anatomical reduction and is more likely to lead to poor clinical results [12]. We excluded PWFs without radiographic anatomical reduction and focused on the significance of the area where the fracture was comminuted. The acetabular dome supports a tremendous weight-bearing load;

hence, a fracture involving the weight-bearing dome is considered a risk factor for poor clinical outcomes. Ovre et al. retrospectively reviewed 450 acetabular fractures to analyze the relationship between clinical outcome and roof arc angle (angle between a vertical line drawn from the center of the acetabulum towards the acetabular dome and a second line drawn from the center of the acetabulum to the fracture) converted to a roof arc score [13]. Their results indicated the significance of fracture lines in the acetabular dome to clinical outcomes. Our results showed a significant association between dome comminution and advanced OA. The acetabular dome is subjected to a lot of force during movement; therefore, a single buttress plate fixation may not be sufficient to stabilize the comminuted bone and prevent its displacement. The residual steps and diastasis causing joint incongruence on the weight-bearing dome seemed to be correlated with poor clinical outcomes and an increase in the risk of OA, femoral head ON, and rate of conversion to THA. THA for the treatment of failed acetabular fractures is a challenging procedure that usually results in inferior functional outcomes and higher complication rates than primary THA. Recently, experts have shown interest in performing THA for early rehabilitation in patients with femoral head impaction, pre-existing OA or ON, or osteoporotic bone with comminution in the acetabular dome [14]. However, the risk of heterotopic ossification (HO) in THA patients may hamper rapid rehabilitation [15]. Moreover, the incidence of HO was reported to be higher in patients undergoing acute THA for acetabular fractures and contributed to adverse effects on functional outcomes [16].

Age has been demonstrated to be a negative prognostic factor for acetabular fractures. The poor bone quality and higher rate of fragment comminution and marginal impaction in patients with advanced age preclude a secure fixation and lead to early implant failure and a higher rate of conversion to THA [17, 18]. Hence, some authors have suggested immediate THA for geriatric comminuted acetabular fractures for early mobilization [19]. Extensive research has been conducted on all types of acetabular fractures in elderly patients; however, studies focusing on PWFs in older patients are scarce. Ferguson et al. reviewed 31 PWFs from 235 geriatric acetabular fractures and found that 64% of fractures were comminuted and 52% were combined with marginal impaction; however, they did not report their associations with clinical outcomes [18]. The results from another review article including 15 studies on acetabular fractures in patients aged over 55 years indicated an average conversion rate to THA of 23.1% (0–45.5%) at a mean follow-up of 47.3 months [20]. As reported in previous studies, we noted mark higher rate of comminution (66.7%, 6/9) in patients older than 60 years; and age was correlated negatively with both clinical and radiographic outcomes even after anatomical reduction.

Marginal impaction injuries represent chondral depressions in PWFs in which an osteochondral fragment is rotated and impacted into the underlying subchondral bone [7]. Studies have reported that patients with PWFs and marginal impaction showed poor clinical outcomes because of the failure to identify the improperly reduced impacted fragments [7, 10]. With the advance in surgical techniques and awareness of fracture patterns from preoperative CT scans, clinical outcomes of PWFs with marginal impaction have improved [9, 21]. Preoperative CT scan provides more precise information about the status of margin impaction in an acetabular fracture and helps surgeons to ensure accurate fracture reduction, thereby preventing possible complications. A two-level reconstruction of marginal impaction, including reduction of the osteochondral fragment in an anatomical position using the femoral head as a template and impacting the void cavity with an autologous bone graft or freeze-dried allograft, can improve postoperative clinical outcomes [10]. In this study, routine preoperative CT scans were performed to inspect the defect of marginal impaction precisely and a two-level reconstruction technique was used to ensure accurate reduction in patients with PWFs. Although there was no significant difference in functional outcomes or THA rate, PWFs with marginal impaction still exhibited a higher risk of radiographic OA.

In this study, we evaluated PWFs with radiographic anatomical reduction to eliminate factors of surgical impropriety. We demonstrated that dome comminution was the most significant factor associated with poor outcomes. As a result of the tremendous load on the acetabular dome and inaccurate evaluation of bone union from radiography, these patients may require longer periods of activity restriction and non-weight-bearing exercises. We also inferred that an additional spring plate over the dome region may be beneficial for securing comminuted fragments. Studies on the use of an additional spring plate over the dome area are ongoing.

Our study has certain limitations. First, the study was retrospective and included only a limited number of patients, particularly elderly patients; therefore, statistical conclusions of the relational comparisons should be interpreted cautiously. Second, postoperative reduction was evaluated with X-ray images, which may result in under-diagnosis of inadequate reduction. Although postoperative CT scans provide precise evaluation of fracture reduction, it was reported limited benefits to patients after fixation of acetabular fractures [22]. There is still no consensus on the use of routine pelvic CT after surgery. Third, the follow-up period was relatively short and did not reveal the potential long-term complications associated with OA progression. Fourth, we evaluated only the impact of fracture-related factors on prognosis, and we did not consider differences in the soft tissue of individuals. Soft tissue composition before injury and degree of soft tissue injury may also have a significant impact on functional outcomes. A close relationship has been reported between hip OA and changes in collagen content in the fascia lata. The increase in collagen type I along with a decrease in collagen type III and hyaluronan levels results in facial stiffening, which may increase the risk of OA [23].

Conclusions

Age, fracture comminution, and dome comminution were the prognostic indicators of advanced OA and poor functional scores, even after anatomical reduction. We further emphasized the relevance of acetabular dome comminution as an important contributing factor to poor clinical and radiographic outcomes. Surgeons should be aware of the high complication rates of dome comminution and warn patients of the high incidence of poor outcomes. Although we noted a high complication rate of such fractures, the best treatment strategy for them is currently unknown. Further studies are needed to validate whether using an additional spring plate over the acetabular dome or performing THA in the acute phase can provide a better prognosis than traditional buttress fixation.

Abbreviations

CT : computed tomography

HHS : Harris hip score

HO : heterotopic ossification

MMAS : modified Merle d'Aubigné clinical hip scores

OA : osteoarthritis

ON : osteonecrosis

PWF : posterior acetabular wall fracture

THA : total hip arthroplasty

Declarations

Ethics approval and consent to participate

Institutional Review Board Statement: The study protocol received approval from the Institutional Review Board of Kaohsiung Medical University Hospital. The approved protocol number was KMU-HIRB-E(I)-20180175. The study was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. Informed consent was waived by the IRB of Ethics Committee of Kaohsiung Medical University Hospital.

Consent for publication

Not Applicable.

Availability of data and materials

The datasets in the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no conflict of interest.

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Contributions

Conceptualization, S.Y.-L. and C.C.-L.; methodology, S.Y.-L.,C.H.-C., T.C.-L and C.C.-L.; software, H.P.-T.; validation, C.J.-H., W.C.-L, and J.K.-C.; formal analysis, H.P.-T.; investigation, S.Y.-L., T.C.-L, C.J.-H. and J.K.-C; resources, J.K.-C, C.H.-C, and C.C.-L.; data curation, J.K.-C.; writing—original draft preparation, S.Y.-L. and C.J.-H.; writing—review and editing, C.C.-L.; visualization, W.C.-L; supervision, C.H.-C. and C.C.-L. All authors have read and agreed to the published version of the manuscript.

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Not Applicable

References

1. Mauffrey, C., et al., The epidemiology and injury patterns of acetabular fractures: are the USA and China comparable? Clin Orthop Relat Res, 2014. 472(11): p. 3332–7.
2. Moed, B.R., et al., Current management of posterior wall fractures of the acetabulum. Instr Course Lect, 2015. 64: p. 139–59.
3. Pascarella, R., et al., Surgical results and factors influencing outcome in patients with posterior wall acetabular fracture. Injury, 2017. 48(8): p. 1819–1824.

4. Briffa, N., et al., Outcomes of acetabular fracture fixation with ten years' follow-up. J Bone Joint Surg Br, 2011. 93(2): p. 229–36.
5. Magu, N.K., et al., Long term results after surgical management of posterior wall acetabular fractures. J Orthop Traumatol, 2014. 15(3): p. 173–9.
6. Bhandari, M., et al., Predictors of clinical and radiological outcome in patients with fractures of the acetabulum and concomitant posterior dislocation of the hip. J Bone Joint Surg Br, 2006. 88(12): p. 1618–24.
7. Giannoudis, P.V., C. Tzioupis, and B.R. Moed, Two-level reconstruction of comminuted posterior-wall fractures of the acetabulum. J Bone Joint Surg Br, 2007. 89(4): p. 503–9.
8. Kim, H.T., et al., Reconstruction of acetabular posterior wall fractures. Clin Orthop Surg, 2011. 3(2): p. 114–20.
9. Lee, C. and E.E. Johnson, Use of Spring Plates in Fixation of Comminuted Posterior Wall Acetabular Fractures. J Orthop Trauma, 2018. 32 Suppl 1: p. S55-s59.
10. Giannoudis, P.V., et al., Acetabular fractures with marginal impaction: mid-term results. Bone Joint J, 2013. 95-b(2): p. 230–8.
11. Zha, G.C., J.Y. Sun, and S.J. Dong, Predictors of clinical outcomes after surgical treatment of displaced acetabular fractures in the elderly. J Orthop Res, 2013. 31(4): p. 588–95.
12. Kreder, H.J., et al., Determinants of functional outcome after simple and complex acetabular fractures involving the posterior wall. J Bone Joint Surg Br, 2006. 88(6): p. 776–82.
13. Øvre, S., J.E. Madsen, and O. Røise, Acetabular fracture displacement, roof arc angles and 2 years outcome. Injury, 2008. 39(8): p. 922–31.
14. Chémaly, O., et al., Heterotopic ossification following total hip replacement for acetabular fractures. Bone Joint J, 2013. 95-b(1): p. 95–100.
15. Biz, C., et al., Heterotopic ossification following hip arthroplasty: a comparative radiographic study about its development with the use of three different kinds of implants. J Orthop Surg Res, 2015. 10: p. 176.
16. Ward, A.J. and T.J. Chesser, The role of acute total hip arthroplasty in the treatment of acetabular fractures. Injury, 2010. 41(8): p. 777–9.
17. Navarre, P., et al., Outcomes following operatively managed acetabular fractures in patients aged 60 years and older. Bone Joint J, 2020. 102-b(12): p. 1735–1742.
18. Ferguson, T.A., et al., Fractures of the acetabulum in patients aged 60 years and older: an epidemiological and radiological study. J Bone Joint Surg Br, 2010. 92(2): p. 250–7.
19. Giunta, J.C., et al., Outcomes of acetabular fractures in the elderly: a five year retrospective study of twenty seven patients with primary total hip replacement. Int Orthop, 2019. 43(10): p. 2383–2389.
20. Daurka, J.S., et al., Acetabular fractures in patients aged > 55 years: a systematic review of the literature. Bone Joint J, 2014. 96-b(2): p. 157 – 63.
21. Perumal, R., et al., Marginal impaction in complex posterior wall acetabular fractures: role of allograft and mid-term results. Eur J Orthop Surg Traumatol, 2020. 30(3): p. 435–440.
22. Archdeacon, M.T. and S.K. Dailey, Efficacy of Routine Postoperative CT Scan After Open Reduction and Internal Fixation of the Acetabulum. J Orthop Trauma, 2015. 29(8): p. 354–8.
23. Fantoni, I., et al., Fascia Lata Alterations in Hip Osteoarthritis: An Observational Cross-Sectional Study. Life (Basel), 2021. 11(11).

Figures

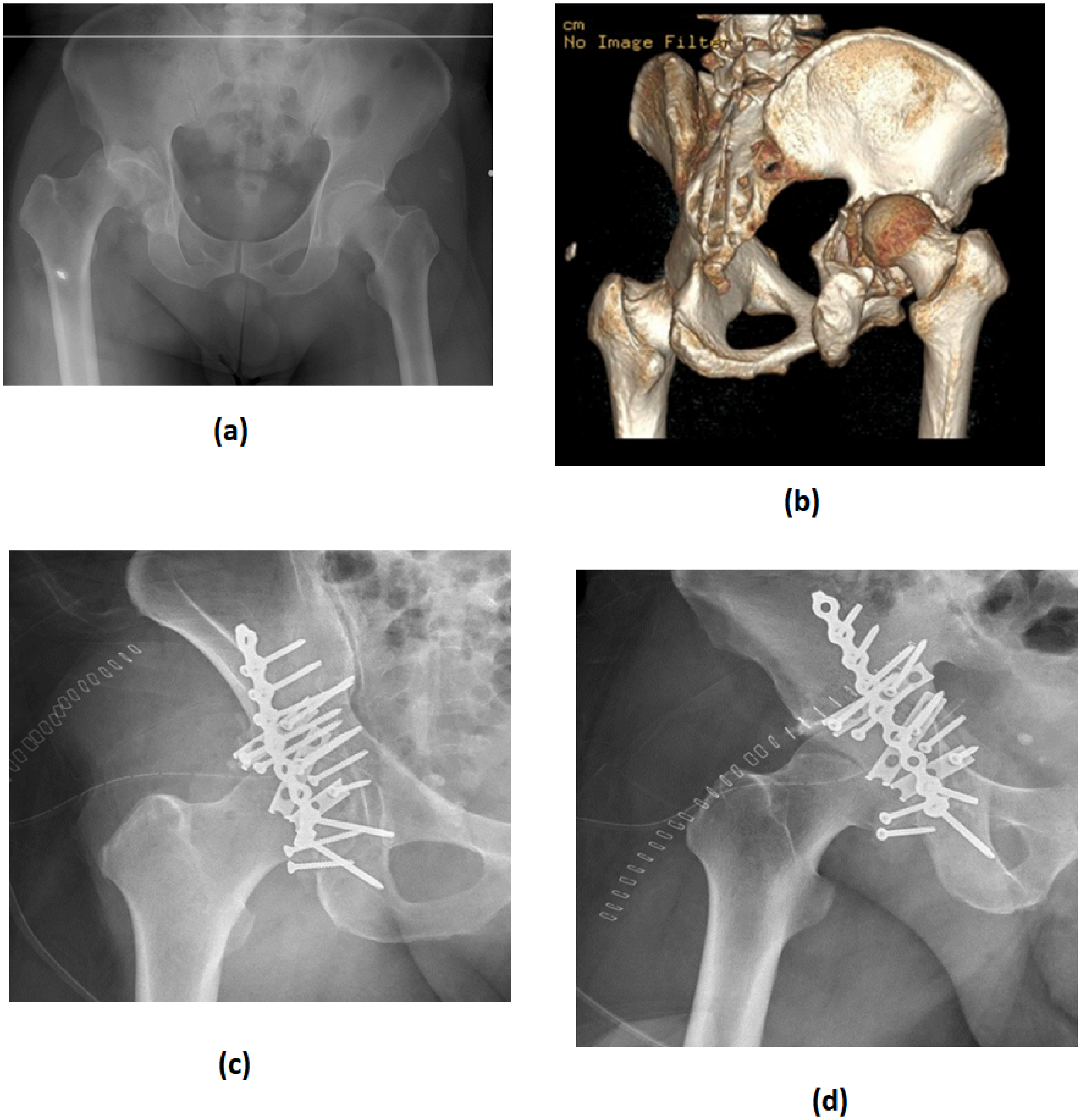
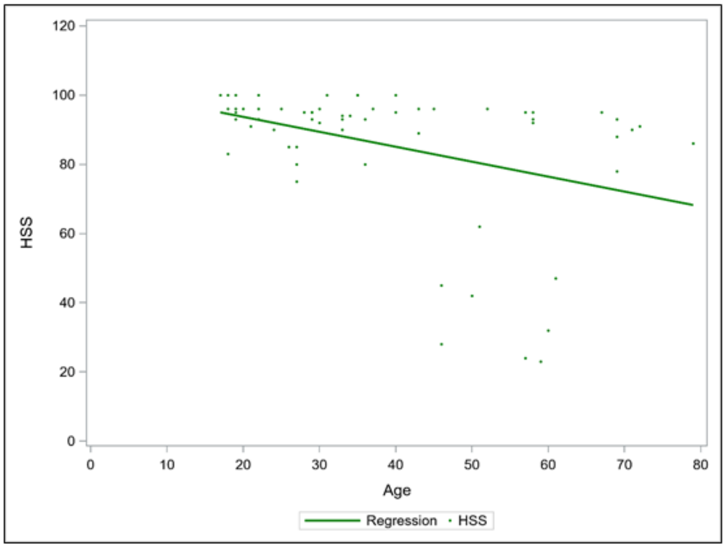
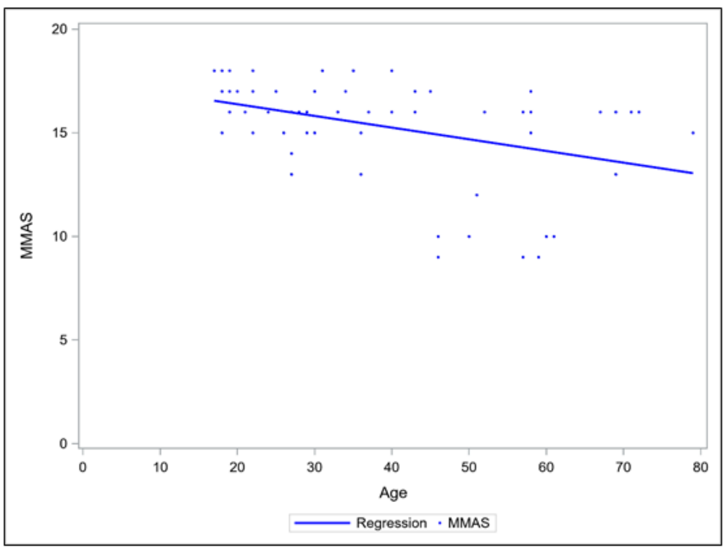


Figure 1

A 55 year old male patient with injury to the right hip in a traffic accident. Pre-operative radiography and CT scan reveal comminuted posterior right acetabular wall fracture associated with dome comminution (a-b). Open reduction and internal fixation with additional three spring plates have been performed to stabilize the comminuted fragments. Post-operative radiography shows good reduction of acetabular joint surface (c-d).



(a)



(b)

Figure 2

Correlation between patient age and post-operative functional scores. The Spearman rank correlation is -0.41 in (a) HHS (P<0.0012) and -0.39 in (b) MMAS (P=0.0019), indicating a negative moderate correlation between patient age and functional scores.