Surgical Outcomes of Transverse Acetabular Fractures and Risk Factors for Poor Outcomes

Jae Hoon Jang
Department of Orthopaedic Surgery, Bio-medical Research Institute, Trauma Center, Pusan National University Hospital

Nam Hoon Moon
Department of Orthopaedic Surgery, Bio-medical Research Institute, Pusan National University Hospital

Seung Joon Rhee
Department of Orthopaedic Surgery, Bio-medical Research Institute, Pusan National University Hospital

Seok Jin Jung
Department of Orthopaedic Surgery, Bio-medical Research Institute, Pusan National University Hospital

Tae Young Ahn (✉ ahnty@pusan.ac.kr)
Department of Orthopaedic Surgery, Bio-medical Research Institute, Pusan National University Hospital

Research Article

Keywords: transverse acetabular fracture, surgical outcome, prognostic factor

DOI: https://doi.org/10.21203/rs.3.rs-109403/v1

License: ☇ ① This work is licensed under a Creative Commons Attribution 4.0 International License.  Read Full License
Abstract

Background: Transverse acetabular fractures, although classified as elementary, have been considered to have worse outcomes than other types of acetabular fractures. Prognostic factors for this type of fracture are not clearly established. The purpose of this study was to assess the surgical outcomes of transverse acetabular fractures and subtypes thereof and to investigate the prognostic factors.

Methods: Between 2014 and 2019, 39 patients (39 hips) had transverse fractures or subtypes thereof. We reviewed the surgical outcomes and investigated patient factors, injury factors, and surgical factors in relation to osteoarthritis (OA) and conversion to total hip arthroplasty (THA). Additionally, we analyzed the cutoff values for postoperative residual gaps and steps.

Results: Twenty-three male patients and 16 female patients with a mean age of 41.7 years (range, 18–78 years) were included. There were 29 satisfactory reductions (74.4%). Eleven hips (28.2%) developed OA. Five (12.8%) of them underwent THA. Dome impaction (odds ratio [OR], 41.173; 95% confidence interval [CI], 1.804–939.814; P=0.020) and residual gaps (OR, 4.251; 95% CI, 1.248–14.479; P=0.021) were correlated with poor outcomes. Residual gaps (≥3 mm) and residual steps (≥1 mm) were significantly associated with OA.

Conclusion: Relatively poor reduction were found for transverse acetabular fractures and subtypes thereof. However, the rates of OA and conversion to THA were not high. Dome impaction and wide residual gaps were identified as risk factors for poor outcomes. The development of OA significantly increased if the residual gap and step were more than 3 mm and 1 mm, respectively.

Background

Although transverse acetabular fractures are classified as an elementary type of fracture by Judet and Letournel,1,2 their anatomical reduction and sound fixation, which are mandatory for surgical treatment of articular fractures, are not easy to achieve.3 Furthermore, this fracture type is frequently associated with posterior wall (PW) and caudally oriented (T-component) fractures, and these associated fracture types are more difficult to manage surgically. Therefore, surgical outcomes of transverse acetabular fractures are considered to be worse than those of other types.4–7

There have been many reports of surgical outcomes of and prognostic factors for all types of acetabular fractures. However, to our knowledge, only limited studies have examined the surgical outcomes of and prognostic factors for transverse acetabular fractures and subtypes of these fractures. This study aimed to verify surgical outcomes of the transverse acetabular fracture and its subtypes and to investigate prognostic factors for poor surgical outcomes.

Methods

Study population

This retrospective study was approved by our institutional review board. All methods were carried out in accordance with relevant guidelines and regulations. We investigated the medical records and radiographs of 158 skeletally mature patients who underwent open reduction and internal fixation (ORIF) for an acetabular fracture at a level 1 trauma center between March 2014 and March 2019. Patients with an acetabular fracture including a transverse fracture with or without a PW and/or T-component fracture were eligible for inclusion. The exclusion criteria were having another type acetabular fracture, participation in less than 12 months of follow-up (except for early conversion to total hip arthroplasty [THA]), incomplete medical records or radiographs, periprosthetic fracture, preexisting hip disease, and open pelvic fracture.

Surgical procedure and postoperative protocol
All surgeries were performed by a single surgeon trained in the field of orthopaedic trauma. Surgical timing was determined based on the patient's condition and associated injuries. An anterior intrapelvic approach with or without the lateral window of the ilioinguinal approach in the supine position and/or the Kocher-Langenbeck approach in the lateral decubitus position was chosen as the surgical approach based on the configuration of the fracture, the site where the main displacement was involved, and consideration of the associated pelvic ring injury (PRI). Whether to fix the single-column or the double-column, how to perform fixation, and the sequence of reduction and fixation were determined at the discretion of the surgeon based on the fracture configuration, the site of the major fracture, reduction quality, associated PRI, and surgical approach. All implants used for fixation were 3.5 reconstruction plates (titanium; DePuy Synthes, Oberdorf, Switzerland) and/or 3.5 low-profile pelvic plates (stainless steel; DePuy Synthes).

Serial radiographs including pelvic series (anteroposterior, iliac/obturator oblique, and inlet/outlet views) were obtained immediately after surgery and periodically during follow-up. After the drain was removed within 48 to 72 hours after surgery, computed tomography (CT) scans including axial, coronal, and sagittal views were obtained to evaluate the reduction quality and position of the implants in all study participants. Passive or active range of motion exercises were encouraged as tolerated within the first two to three days after surgery. Partial weight-bearing with crutches or a walker and full weight-bearing were allowed at six to eight weeks and 12 weeks after surgery, respectively, depending on the patient's general condition and associated injuries.

**Assessment of measurements**

Measurements of demographic data, fracture configurations, and surgical factors and outcomes were recorded. Demographic data included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, diabetes mellitus (DM), smoking history, injury mechanism, injury severity score (ISS), and injury side (right or left). Fracture configurations included the plane of the transverse fracture (infratectal, juxtatectal, or transtectal), dome impaction, PW involvement, PW comminution, PW impaction, associated fracture of the T-component, femoral head injury, hip dislocation at the time of the initial injury, and association of the displaced PRI. Surgical factors included the surgical approach, single-column or double-column fixation, postoperative residual gap and step, and classification of reduction quality according to Matta's criteria.

Surgical outcomes included time to union, osteoarthritis (OA), osteonecrosis of the femoral head (ONFH), and conversion to THA.

The plane of the transverse fracture was classified as follows: infratectal, the main fracture line was oriented across the acetabular fossa; juxtatectal, at the transition of the acetabular fossa to the cranial/superior joint surface; and transtectal, across the superior dome of the acetabulum. PW comminution was defined as a fracture with three or more separate articular fragments. Fracture union was defined as the absence of a fracture line and/or bridging callus across fracture sites on the follow-up radiographs of the pelvic series and the ability to perform full weight-bearing ambulation without joint pain and progressive loss of reduction.

Two orthopaedic surgeons who did not participate in surgery and were blinded to the surgical outcomes independently measured the postoperative residual gap and step using a standardized CT-based method on a picture archiving and communication system. The averages of each value were used for analyses. Reduction quality was classified as anatomical (≤1 mm), imperfect (1–3 mm), or poor (>3 mm). The other demographic data, fracture configurations, surgical factors, and surgical outcomes were assessed and documented by one of the authors.

Demographic data, fracture configurations, and surgical factors and outcomes were verified. Additionally, OA and/or ONFH considered poor according to Matta's grading system and required conversion to THA indicated poor outcomes. Risk factors for the outcomes and cutoff points of related variables were statistically analyzed.

**Statistical analysis**
Interobserver reliability of the residual gap and step measurements was evaluated by the intraclass correlation coefficient (ICC). Univariate and multivariate logistic regression tests were performed to determine risk factors for postoperative OA. A receiver-operating characteristic (ROC) curve analysis was used to identify cutoff points for factors that affect OA. MedCalc software (version 18.11; MedCalc Software, Ostend, Belgium) was used for the ROC curve analysis and SPSS software (version 22.0; SPSS Inc, Chicago, IL, USA) was used for the other statistical analyses. Statistical significance was set at P<0.05.

Results

Thirty-nine patients (23 men and 16 women) met the criteria and had unilateral acetabular fractures. The mean age and BMI were 41.7 years (range, 18–78 years) and 23.0 kg/m\(^2\) (range, 16.2–31.3 kg/m\(^2\)), respectively. There were 12 falls from a height, 26 motor vehicle accidents, and one crushing injury. The mean ISS was 28.6 (range, 4–66). There were 24 (61.5%) transverse fractures in the juxtatectal region and 15 (38.5%) in the transtectal region. Ten dome impactions (25.6%), 22 PW fractures (56.4%), 12 T-fractures (30.8%), and 17 displaced PRI (43.6%) were associated with the injury. Of the 22 PW fractures, there were 17 cases (43.6%) of comminution and four cases (10.3%) of marginal impaction. Six (15.4%) femoral head injuries and 5 (12.8%) hip dislocations were observed at the time of the initial injury (Table 1).

ORIF for the fractures was performed after an average of 6.5 days (range, 1–17 days). The Kocher-Langenbeck approach was used for 17 cases, the anterior intrapelvic approach was used for 18 cases, and both of these approaches were used for four cases chosen for the ORIF approach. Single-column fixation was performed for 18 cases (46.2%). Double-column fixation was performed for 21 cases (53.8%). The mean residual gap and step after ORIF were 2.3 mm (range, 0.0–7.0 mm) and 0.6 mm (range, 0.0–4.0 mm), respectively, and there were 14 anatomical (35.9%), 15 imperfect (38.5%), and 10 poor (25.6%) reductions. An average of 4.7 months (range, 2.1–8.3) was required for fracture union, and there were no cases of non-union. OA was diagnosed in 11 cases (28.2%) during follow-up and in two cases (5.1%) accompanied by ONFH. Five (12.8%) of the 11 cases with OA underwent THA (Table 2). The ICC was 0.868 (95% confidence interval [CI], 0.747–0.931) for the residual gap and 0.881 (95% CI, 0.773–0.938) for the residual step.

In the unadjusted model with the univariate analysis, age (odds ratio [OR], 1.054; 95% CI, 1.009–1.101), BMI (OR, 1.302; 95% CI, 1.018–1.666), dome impaction (OR, 14.583; 95% CI, 2.623–81.084), PW comminution (OR, 4.800; 95% CI, 1.034–22.293), residual gap (OR, 3.612; 95% CI, 1.549–8.420), and residual step (OR, 2.846; 95% CI, 1.346–6.021) were significantly associated with poor outcomes. However, the adjusted model with the multivariate analysis showed that dome impaction (OR, 41.173; 95% CI, 1.804–939.814) and residual gap (OR, 4.251; 95% CI, 1.248–14.479) were significantly associated with poor outcomes (Table 3).

ROC curves showed areas under the curve of 0.859 (95% CI, 0.710–0.949; P <0.0001) for the residual gap and 0.737 (95% CI, 0.572–0.865; P = 0.0062) for the residual step (Fig. 1). A residual gap of 3.0 mm (sensitivity, 72.73%; specificity, 92.86%) and residual step of 1.0 mm (sensitivity, 54.55%; specificity, 92.86%) were proven to be significant cutoff points for poor outcomes (Table 4).

Discussion

We included pure transverse, transverse and PW, and T-type acetabular fractures in this study; furthermore, transverse fractures and their subtypes have been reported to account for as little as 10% and as much as 40% of all acetabular fractures. However, few studies have focused on only these fractures, which are considered difficult because it is challenging to obtain anatomical reduction and sound fixation and they result in worse surgical outcomes than other types. Therefore, we sought to examine surgical outcomes of and prognostic factors for poor outcomes of these types of acetabular fractures. In this study, 39 (24.7%) of the 158 patients who underwent ORIF for an acetabular fracture had a transverse acetabular fracture or one its subtypes (pure transverse fractures, 5 cases [12.8%]; PW fractures, 16 cases
[41.0%]; T-component fractures, 12 cases [30.8%]; PW and T-component fractures, 6 cases [14.4%]). Fourteen anatomical (35.9%), 15 imperfect (38.5%), and 10 poor (25.6%) reductions were obtained postoperatively. Eleven cases (28.2%) had poor grades according to Matta's grading system, and age, BMI, dome impaction, PW comminution, and residual gap and step were risk factors for these poor outcomes according to the univariate analysis. However, dome impaction and residual gap were identified as significant risk factors in the multivariate analysis. Furthermore, a residual gap more than 3.0 mm and residual step more than 1.0 mm were significant predictors of poor outcomes according to the ROC curve analysis.

Previous studies have reported satisfactory reduction rates from 57% to 100%. The current study showed a satisfactory reduction rate of 74.4%, which was worse than that found by studies that examined the rate based on plain radiographs. However, Frietman et al. found worse results (57%) when measuring reduction quality using CT scans. We think that these differences could be explained by the accuracy of the assessment modality. Reduction quality was more apparent and could be classified more precisely using CT images compared to plain radiographs, which resulted in a low rate of satisfactory reduction in our study. Posttraumatic OA is found in 20% to 40% of patients with an acetabular fracture, and 9% to 35% of patients undergo THA. This study found that 11 cases (28.2%) developed posttraumatic OA and five cases (12.8%) underwent THA, which is similar to the results of previous studies. In most studies, unsatisfactory Merle D’Aubinge and Postel scores or THA conversion indicated poor outcomes. Based on that criteria, risk factors for poor outcomes included old age (age 50 years or older), overweight, high-energy trauma, articular surface comminution or impaction, large initial displacement, femoral head dislocation, residual gap, residual step, and even surgeon training. However, the functional score has limited ability to represent patients’ daily functions, and THA is the end result of OA. Therefore, we considered OA and/or conversion to THA as indicators of poor outcomes, and residual gap and dome impaction were identified as significant risk factors in the multivariate analysis (Table 5).

Previous studies reported that 27% to 30% of acetabular fractures are associated with PRI. However, 17 (43.6%) of 39 cases were associated with PRI in this study. Although it is not clear whether more PRI are accompanied by transverse acetabular fractures compared with other acetabular fracture types, this study dealt with only transverse acetabular fractures and subtypes, which are commonly caused by lateral compression; furthermore, lateral compression is one of the main mechanisms of PRI. Additionally, this study was conducted at a level 1 territory trauma center. Most patients had been injured by high-energy trauma, which results in complex injuries. It has been reported that when the PRI is associated with an acetabular fracture, anatomical restoration of the articular surface is difficult due to disruption of the pelvic ring structure and the prognosis is poorer. To overcome this difficulty, reduction was performed from the site where it is easier to obtain more accurate reduction to the site where it is more difficult according to the PRI configuration. Fixation was completed by repeating partial fixation sequentially and alternately without immediate firm fixation for each site. Through this process, we could create a proper environment for obtaining accurate reduction of the acetabular fracture. We believe these attempts might reduce the negative effects of PRI. Statistical significance could not be identified as a risk factor.

All surgeries were performed by a single surgeon at a single institution, which are strengths of this study that could have reduced bias. However, this study had several limitations, including a retrospective design and small sample size, which could have generated an underpowered analysis. Patients with high-energy trauma had various conditions and associated injuries that acted as confounding variables. Therefore, clinical results and functional scores that are significant to the prognosis of acetabular fractures were omitted from this study. To obtain more accurate results, a large multicenter study that includes additional variables should be performed.

This study showed a relatively low rate of satisfactory reduction based on CT measurements of the transverse acetabular fracture and its subtypes. However, the rates of OA and conversion to THA were not high. Dome impaction and a wide residual gap were identified as risk factors for poor outcomes, and the development of OA significantly increased if the residual gap and step were more than 3 mm and 1 mm, respectively. Worse surgical outcomes and specific prognostic
factors were not found for these fractures. Anatomical reduction is mandatory to optimize surgical outcomes, especially when dome impaction is involved.

**Abbreviations**

PW: Posterior wall; ORIF: Open reduction and internal fixation; THA: Total hip arthroplasty; PRI: Pelvic ring injury; CT: Computed tomography; BMI: Body Mass Index; ASA: American Society of Anaesthesiologists; DM: Diabetes Mellitus; ISS: Injury severity score; OA: Osteoarthritis; ONFH: Osteonecrosis of the femoral head;

**Declarations**

**Acknowledgements**

This work was supported by clinical research grant in 2020 from Pusan National University Hospital.

**Authors’ contributions**

All authors (JJ, AT, JS, RS and MN) contributed in this research. JJ and AT were the major contributors in writing this manuscript and data interpretation, and were the First Author and Corresponding Author respectively. JS, RS and MN compiled and analyzed the data. All authors read and approved the final manuscript.

**Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Availability of data and materials**

The datasets analyzed during the current study are not publicly available due to the health policy of protection of patient privacy announced by the Ministry of Health and Welfare of Korea but are available from the corresponding author on reasonable request.

**Ethics approval and consent to participate**

This article consisted of a retrospective cohort study which contained information of patients and has been approved by The Institutional Review Board of Pusan National University Hospital with PNUH IRB No. H-2008-010-094. Informed consents were written and obtained from all individual participants included in the study.

**Consent for publication**

Not Applicable.

**Competing interests**

The authors declare that they have no competing interest in this study.

**References**

1. Letournel E. Acetabulum fractures: classification and management. Clin Orthop Relat Res. 1980;151:81–106.
2. Letournel E, Judet R. Fractures of the acetabulum. 2nd ed. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg; 1993:63-66, 565-8.
3. Byun S, Mauffrey C, Yoo J, Park C, Hwang J. Simulation for reduction of transverse acetabular fractures in sawbones models. J Korean Fract Soc. 2019;32:196–203.
4. 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;78:1632–45.

5. Mears DC, Velyvis JH, Chang CP. Displaced acetabular fractures managed operatively: indicators of outcome. Clin Orthop Relat Res. 2003;407:173–86.

6. Oh CW, Kim PT, Park BC, et al. Results after operative treatment of transverse acetabular fractures. J Orthop Sci. 2006;11:478–84.

7. Meena UK, Tripathy SK, Sen RK, Aggarwal S, Behera P. Predictors of postoperative outcome for acetabular fractures. Orthop Traumatol Surg Res. 2013;99:929–35.

8. Verbeek DO, van der List JP, Villa JC, Wellman DS, Helfet DL. Postoperative CT is superior for acetabular fracture reduction assessment and reliably predicts hip survivorship. J Bone Joint Surg Am. 2017;99:1745–52.

9. Verbeek DO, van der List JP, Tissue CM, Helfet DL. Predictors for long-term hip survivorship following acetabular fracture surgery: Importance of gap compared with step displacement. J Bone Joint Surg Am. 2018;100:922–9.

10. Frietman B, Biert J, Edwards MJR. Patient-reported outcome measures after surgery for an acetabular fracture. Bone Joint J. 2018;100-B:640–5.

11. 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;87:2–9.

12. Masse A, Aprato A, Rollero L, Bersano A, Ganz R. Surgical dislocation technique for the treatment of acetabular fractures. Clin Orthop Relat Res. 2013;471:4056–64.

13. Mayo KA. Open reduction and internal fixation of fractures of the acetabulum. Results in 163 fractures. Clin Orthop Relat Res. 1994;305:31–7.

14. Fahmy M, Abdel Karim M, Khaled SA, Abdelazeem AH, El Nahal WA, El Nahal A. Single versus double column fixation in transverse fractures of the acetabulum: A randomised controlled trial. Injury. 2018;49:1291–6.

15. Li XG, Tang Ts, Sun JY. Results after surgical treatment of transtectal transverse acetabular fractures. Orthop Surg. 2010;2:7–13.

16. Dunet B, Tournier C, Billaud A, Lavoinne N, Fabre T, Durandieu A. Acetabular fracture: long-term follow-up and factors associated with secondary implantation of total hip arthroplasty. Orthop Traumatol Surg Res. 2013;99:281–90.

17. Boudissa M, Ruatti S, Kerschbaumer G, Milaire M, Merloz P, Tonetti J. Part 2: outcome of acetabular fractures and associated prognostic factors-a ten-year retrospective study of one hundred and fifty six operated cases with open reduction and internal fixation. Int Orthop. 2016;40:2151–6.

18. Gänsslens A, Hildebrand F, Kretek C. Transverse + posterior wall fractures of the acetabulum: epidemiology, operative management and long-term results. Acta Chir Orthop Traumatol Cech. 2013;80:27–33.

19. Long HT, Deng ZH, Zou M, Lin ZY, Zhu JX, Zhu Y. Effects of the acetabular fracture index and other factors of posterior wall acetabular fracture on functional outcome. J Int Med Res. 2017;45:1394–405.

20. Moed BR, McMahon MJ, Armbrecht ES. The acetabular fracture prognostic nomogram: Does it work for fractures of the posterior wall? J Orthop Trauma. 2016;30:208–12.

21. Moed BR, McMichael JC. Outcomes of posterior wall fractures of the acetabulum. J Bone Joint Surg Am. 2007;89:1170–6.

Tables

Table 1. Preoperative demographic data and fracture configurations
Table 2. Surgical factors and outcomes

| Number   | 39 |
|----------|----|
| Age (years) | 41.7±18.3 (18–78) |
| Gender (male) | 23 (59.0) |
| Body mass index (kg/m²) | 23.0±3.4 (16.2–31.3) |
| ASA physical status classification | |
| 2 | 16 (41.0) |
| 3 | 22 (56.4) |
| 4 | 1 (2.6) |
| DM | 2 (5.1) |
| Smoking | 11 (28.2) |
| Injury severity score | 28.6±14.4 (4–66) |
| Injury Mechanism | |
| Fall from height | 12 (30.8) |
| Motor vehicle accident | 26 (66.7) |
| Cushing | 1 (2.6) |
| Side (right) | 17 (43.6) |
| Fracture plane | |
| Juxtatectal | 24 (61.5) |
| Transtectal | 15 (38.5) |
| Dome impaction | 10 (25.6) |
| Posterior wall involvement | 22 (56.4) |
| Posterior wall comminution | 17 (43.6) |
| Posterior wall impaction | 4 (10.3) |
| Associated T-component | 12 (30.8) |
| Femoral head injury | 6 (15.4) |
| Hip dislocation | 5 (12.8) |
| Association of displaced pelvic ring injury | 17 (43.6) |

Values are presented as mean ± standard deviation (range), or number (%)

ASA, American Society of Anesthesiologists; DM, diabetes mellitus.
| Time from injury to ORIF (days) | 6.5±3.4 (1–17) |
|--------------------------------|-----------------|
| **Approach**                   |                 |
| Kocher-Langenbeck              | 17 (43.6)       |
| Anterior intrapelvic (±lateral window) | 18 (46.2) |
| Both                           | 4 (10.3)        |
| **Fixation**                   |                 |
| Single column                  | 18 (46.2)       |
| Double column                  | 21 (53.8)       |
| **Residual gap (mm)**          | 2.3±1.5 (0.0–7.0) |
| **Residual step (mm)**         | 0.6±1.2 (0.0–4.0) |
| **Quality of reduction**       |                 |
| Anatomical                     | 14 (35.9)       |
| Imperfect                      | 15 (38.5)       |
| Poor                           | 10 (25.6)       |
| **Time to union (months)**     | 4.7±1.6 (2.1–8.3) |
| **Osteoarthritis**             | 11 (28.2)       |
| **Osteonecrosis of femoral head** | 2 (5.1)   |
| **Conversion to total hip arthroplasty** | 5 (12.8) |

Values are presented as mean ± standard deviation (range), or number (%)

ORIF, open reduction and internal fixation.

**Table 3.** Binary logistic regression analysis of fractures associated with postoperative osteoarthritis in transverse acetabular fractures
|                                | Univariate                  |          |          | Multivariate                  |          |
|--------------------------------|-----------------------------|----------|----------|------------------------------|----------|
|                                | Unadjusted OR (95% CI)      | P value  | Adjusted OR (95% CI)      | P value  |
| **Patient factors**            |                             |          |          |                              |          |
| Age                            | 1.054 (1.009–1.101)         | 0.018    | 1.066 (0.974–1.166)       | 0.164    |
| Gender                         |                             |          |          |                              |          |
| Male                           | Reference                   |          |          |                              |          |
| Female                         | 1.288 (0.315–5.267)         | 0.725    |          |                              |          |
| Body mass index                | 1.302 (1.018–1.666)         | 0.035    | 1.114 (0.694–1.790)       | 0.655    |
| Smoking                        | 0.938 (0.197–4.460)         | 0.935    |          |                              |          |
| **Injury factors**             |                             |          |          |                              |          |
| Injury severity score          | 0.950 (0.896–1.008)         | 0.089    |          |                              |          |
| Fracture plane                 |                             |          |          |                              |          |
| Juxtatectal                    | Reference                   |          |          |                              |          |
| Transtectal                    | 2.533 (0.608–10.559)        | 0.202    |          |                              |          |
| Dome impaction                 | 14.583 (2.623–81.084)       | 0.002    | 41.173 (1.804–939.814)    | 0.020    |
| Posterior wall involvement     | 3.150 (0.738–13.448)        | 0.121    |          |                              |          |
| Posterior wall comminution     | 4.800 (1.034–22.293)        | 0.045    | 17.401 (0.685–442.182)    | 0.084    |
| Posterior wall impaction       | 10.125 (0.922–111.247)      | 0.058    |          |                              |          |
| Associated T-component         | 0.792 (0.169–3.714)         | 0.767    |          |                              |          |
| Femoral head injury            | 3.125 (0.523–18.669)        | 0.212    |          |                              |          |
| Hip dislocation                | 1.852 (0.265–12.947)        | 0.535    |          |                              |          |
| Association of displaced pelvic ring injury | 1.111 (0.273–4.520) | 0.883 |          |                              |          |
| **Surgical factors**           |                             |          |          |                              |          |
| Time from injury to ORIF       | 1.162 (0.941–1.434)         | 0.163    |          |                              |          |
| Approach                       |                             |          |          |                              |          |
| Kocher-Langenbeck              | Reference                   |          |          |                              |          |
| Anterior intrapelvic (±lateral window) | 0.524 (0.118–2.327) | 0.395 |          |                              |          |
| Both                           | 0.611 (0.052–7.240)         | 0.611    |          |                              |          |
| Fixation                       |                             |          |          |                              |          |
| One-column                     | Reference                   |          |          |                              |          |
| Two-column                     | 1.040 (0.256–4.218)         | 0.956    |          |                              |          |
| Residual gap                   | 3.612 (1.549–8.420)         | 0.003    | 4.251 (1.248–14.479)      | 0.021    |
P value < 0.05 by univariate analysis were included in the multivariate logistic regression analysis.

OR, odds ratio; CI, confidence interval; ORIF, open reduction and internal fixation.

**Table 4.** ROC curves analysis for cutoff points of residual gap and step

|                        | AUC (95% CI)     | Cutoff points | Sensitivity (95% CI) | Specificity (95% CI) | P      |
|------------------------|------------------|---------------|----------------------|----------------------|--------|
| Residual gap (mm)      | 0.859 (0.710–0.949) | 3.0           | 72.73 (39.0–94.0)    | 92.86 (76.5–99.1)    | <0.0001|
| Residual step (mm)     | 0.737 (0.572–0.865) | 1.0           | 54.55 (23.4–83.3)    | 92.86 (76.5–99.1)    | 0.0062 |

The cutoff points were selected using Youden index J.

ROC, receiver operating characteristic; AUC, area under the ROC curve; CI, confidence interval.

**Table 5.** Comparison of results with previous studies published.
| Author               | Age | Enrolled type of acetabular fracture | Number | Satisfactory reduction | OA | THA conversion | Poor outcome setting | Risk factors for poor outcome                                                                 |
|----------------------|-----|-------------------------------------|--------|------------------------|----|----------------|----------------------|------------------------------------------------------------------------------------------------|
| Mears et al.⁵         | 46.5| All types                           | 424    | 372 (88%)              | 98 (23%) | 48 (11%)     | Low Harris hip score | N/A                                                              |
| Dunet et al.¹⁶        | 41.6| All types                           | 72     | N/A                    | 29 (40%) | 25 (35%)     | Unsatisfactory MDP   | Overweight, road accident, posterior wall fracture, initial intraarticular foreign body, unsatisfactory reduction |
| Meena et al.⁷         | 38.8| All types                           | 118    | 110 (93%)              | 34 (29%) | 10 (9%)      | Unsatisfactory MDP   | Femoral head dislocation, initial displacement (>20mm), associated injury, delay in surgery (>14 days) |
| Frietman et al.¹⁰     | 48.5| All types                           | 220    | 125 (57%)              | 55 (25%) | 33 (15%)     | THA conversion       | Old age, marginal impaction, extended iliofemoral approach, unsatisfactory reduction              |
| Verbeek et al.⁹       | 51.2| All types                           | 227    | N/A                    | N/A   | 55 (24%)     | THA conversion       | Age ≥ 50 yr, gap ≥ 5mm, step ≥ 1mm in young patients                                                      |
| Oh et al.⁶            | 46.6| Tr ± PW                             | 15     | 11 (69%)               | 2 (27%) | N/A          | Unsatisfactory MDP   | Gap >2mm, dome comminution, femoral head cartilage injury                                              |
| Li et al.¹⁵           | 34.0| Transectal Tr                       | 37     | 35 (95%)               | N/A   | N/A          | Unsatisfactory MDP   | Acetabular roof comminution                                                                         |
| Masse et al.¹²        | 35.3| Tr ± PW or T                        | 31     | 25 (81%)               | 4 (13%) | 4 (13%)      | N/A                  | N/A                                                              |
| Fahmy et al.¹⁴        | 31.0| Tr ± PW                             | 30     | 30 (100%)              | 3 (10%) | N/A          | N/A                  | N/A                                                              |
| Current study         | 41.7| Tr ± PW and/or T                    | 39     | 29 (74.4%)             | 11 (28.2%) | 5 (12.8%)  | OA ± ONFH THA conversion | Residual gap, dome impaction                                                                         |

OA, osteoarthritis; THA, total hip arthroplasty; Tr, transverse; PW, posterior wall; T, T-component; AFI, acetabular facture index; ONFH, osteonecrosis of femoral head; MDP, Merle D’Aubinge and Postel score; N/A, non available.