Int J Clin Exp Med 2016;9(10):20454-20461
www.ijcem.com /ISSN:1940-5901/IJCEM0012086

Original Article

Comparison of open reduction and internal fixation in treatment of delayed and early acetabular fractures

Bin Wu, Haibin Wang, Chunyang Meng, Cunling Jia, Yifeng Zhao

Department of Orthopedic Surgery, Affiliated Hospital of Jining Medical University, Jining 272029, Shandong, China

Received June 29, 2015; Accepted September 10, 2015; Epub October 15, 2016; Published October 30, 2016

Abstract: To retrospectively compare the clinical efficacy of open reduction and internal fixation (ORIF) in treating delayed and early acetabular fractures. Ninety cases with delayed (n = 35) and early acetabular fractures (n = 55) undergoing ORIF between September 2009 and March 2013 were retrospectively analyzed. Patients in the delayed acetabular fracture group underwent ORIF at 22-65 d (mean 36 d) after injury and those in the early acetabular fracture group received ORIF at 3-20 d (mean: 8.1 d) after trauma. Ilioinguinal, Kocher-Langenbenk or combined approaches were adopted according to the types of fracture. Fracture reduction was evaluated using the Matta standard. Clinical efficacy was assessed by Matta modified D'Aubigne and Postel grading system. Postoperative follow-up endured for 18-36 months, 25 months on average. In the delayed fracture group, 15 (43%) cases had anatomical reduction, 17 (49%) were satisfied with the reduction whereas 3 (9%) were unsatisfied. In the early fracture group, 35 (64%) cases had anatomical reduction, 19 (35%) cases were satisfied with the reduction and only 1 (3%) patient was unsatisfied with no statistical significance between two groups. In the delayed fracture group, 16 cases obtained excellent outcomes, 15 good, 2 average and 2 had poor results, and 35 excellent, 18 good, 1 average and 1 poor in the early fracture group. Excellent rate did not significantly differ between two groups. Satisfactory and excellent rates of ORIF did not significantly differ between two groups. ORIF is an effective and feasible treatment of delayed acetabular fracture.

Keywords: Delayed acetabular fracture, early acetabular fracture, open reduction, internal fixation

Introduction

The incidence of acetabular injury complicated with severe damage in other organs has been dramatically increased along with the high-energy trauma occurring in the transportation and mining industries. Recent advances in surgical techniques have increased the use of open reduction and internal fixation (ORIF) of acetabular fractures. Early internal fixation of acetabular fractures allows rapid mobilization of severely injured patients and provides trauma patients optimal, long-term, functional results [1, 2]. However, the high-energy acetabular injury complicated with other organ trauma is likely to delay the recovery of acetabular fracture and negatively affect the surgical efficacy [3-5]. Compared with early acetabular fracture, it is more difficult and higher risk to treat delayed acetabular fracture. In this retrospective analysis, 35 patients diagnosed with delayed and 55 early acetabular fractures underwent ORIF at our institution between September 2008 and March 2012. The effect of reduction and clinical outcomes were statistically compared between two pools of patients.

Materials and methods

General data

In this study, 35 patients with delayed acetabular fracture were treated with ORIF, 23 males and 12 females, aged 23-67 years, 40 years on average. Twenty seven were injured by road traffic accidents and 8 by falling. According to Letournel and Judet classification, 25 cases had simple fracture, 15 with posterior wall fracture, 4 anterior wall fracture, 3 posterior column fracture, 1 anterior column fracture and 2 transverse fracture; 10 patients were diagnosed with complicated fracture including 6 posterior col-

Table 1. General data of patients with acetabular fractures

	Delayed acetabular fracture	Early acetabular fracture
Cases (n)	35	55
Age	23-67 years	17-86 years
Waiting time	22-65 d	3-20 d
Traffic injury	27	36
Falling injury	8	19
Single fracture	25	16
Posterior wall injury	15	9
Anterior wall injury	4	3
Anterior column injury	3	1
Posterior column injury	1	2
Transverse injury	2	1
Complicated fracture	10	39
Posterior column complicated with posterior wall injury	6	14
Transverse complicated with posterior wall injury	1	12
"T" shape	1	5
Anterior/posterior column complicated with transverse	1	6
Dual column injury	1	6
Complicated with ischial nerve injury	6	9

Inclusion criteria: [6]the subjects with acetabular fractures shift > 5 mm, which severely affected the movement of hip joint; those with stable vital signs; those with heart and lung diseases or distal femur fracture were excluded; no alternative surgical contraindications could be noted; those who were able to independently work prior to the trauma and the patients whose family relatives required performing the surgery.

Table 2. Clinical data of ORIF

Group	n	Anterior approach	Posterior approach	Combined approach	Operation time	Intraoperative blood loss
Delayed acetabular fracture	35	25 (71.4%)	7 (20%)	3 (8.6%)*	(180±67) min*	(1500±700) mL*
Early acetabular fracture	55	32 (58.2%)	10 (18.2%)	13 (23.6%)	(120±45) min	(500±200) mL

Note: *in the delayed acetabular fracture group, operation time was significantly longer and intraoperative blood loss was larger compared with those in the early acetabular fracture group. Operation time and blood loss compared with delayed acetabular fractures, *$P < 0.05$ denotes a statistical significance. Postoperative processing.

Table 3. Clinical results of articular surface reduction

Group	n	Anatomic reduction	Satisfactory reduction	Unsatisfactory reduction	Overall satisfactory rate
Delayed acetabular fracture	35	15 (42.9%)*	17 (48.6%)	3 (8.5%)*	91.4%
Early acetabular fracture	55	35 (63.7%)	19 (34.5%)	1 (1.8%)	98.2%

Note: *denotes statistical significance. Overall satisfactory rate did not significantly differ between two groups ($\chi^2 = 0.98$, $P > 0.05$), whereas statistical significance was observed regarding the rates of anatomic reduction and unsatisfactory reduction (all $P < 0.05$) between two groups.

Table 4. Clinical outcomes of ORIF

Group	n	Excellent rate	Good rate	Average rate	Poor rate	Overall satisfactory rate
Delayed acetabular fracture	35	16 (45.7%)*	15 (42.9%)	2 (5.7%)	2 (5.7%)	31 (88.6%)
Early acetabular fracture	55	35 (63.6%)	18 (32.8%)	1 (1.8%)	1 (1.8%)	53 (96.4%)

Note: *No statistical significance was noted in overall satisfactory rate (excellent and good outcomes) between two groups ($\chi^2 = 0.02$, $P > 0.05$), whereas statistical significance existed in excellent rate between two groups ($P < 0.05$).

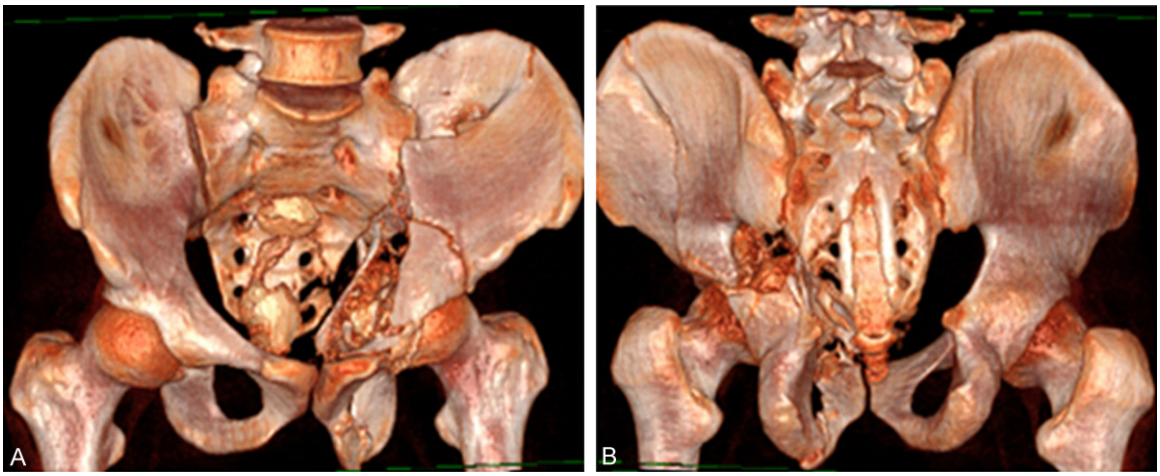

Figure 1. Preoperative CT scan. A. Preoperative 3D CT (frontal view). B. Preoperative 3D CT (posterior view).

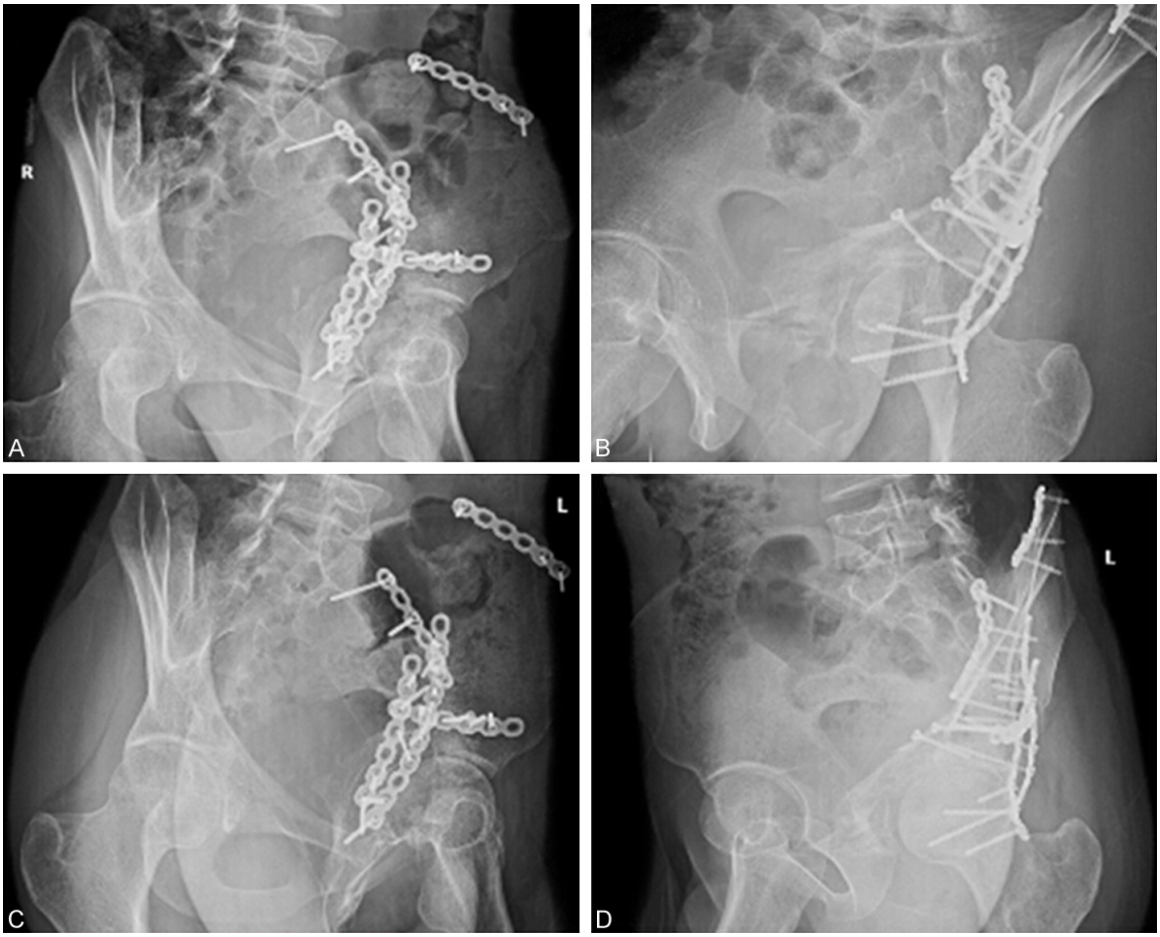

Figure 2. Preoperative and postoperative χ-ray imaging. A. Postoperative χ-ray (ilial bone position); B. Postoperative χ-ray (obturator position); C. χ-ray at postoperative 3 months (ilial bone position); D. χ-ray at postoperative 3 months (obturator position).

umn complicated with posterior wall fracture, 1 transverse complicated with posterior wall fracture, 1 "T" shape fracture, 1 anterior and posterior column complicated with transverse frac-

Figure 3. The patient restored normal hip joint function at postoperative 3 months.

ture and 1 dual column fracture. Two cases were complicated with posterior dislocation of the femoral head, 5 central dislocation of varying degree, 1 fracture of the femoral head and 6 ischial nerve injury. Five cases were complicated with brain trauma, 3 chest trauma and abdominal injury and 2 urinary injury. The injury of other positions was treated in other departments or hospitals. The acetabular fractures were merely handled with traction treatment. They had to wait for 22 to 65 d before undergoing the operation, 36 d on average. Fifty five patients with early acetabular fracture underwent surgery, 39 males and 16 females, aged 17-86 years, 46 years on average. Among them, 36 were injured from road traffic and 16 from accidental falling. According to Letournel and Judet classification 16 cases had simple fracture, 9 posterior wall fracture, 3 anterior wall fracture, 2 posterior column fracture, 1 anterior column fracture and 1 transverse fracture; 39 patients were diagnosed with complicated fracture including 14 posterior column complicated with posterior wall fracture, vernolicacid transverse complicated with posterior wall fracture, 5 "T" shape fracture, 6 anterior and posterior column complicated with transverse fracture and 2 dual column fracture. Nine patients suffered from ischial nerve injury. Fifteen cases were complicated with cerebral trauma, 5 chest trauma, 3 abdominal trauma and 2 urinary injury. They had to wait for 3-20 d to undergo the surgery, 8.1 d on average (**Table 1**).

Surgical approach

Preoperative examinations: Conventional χ-ray radiograph was conducted under AP pelvic, obturator oblique and iliac bone oblique views. Subsequently, 64-slice spiral CT scan and then three dimensional reconstruction was performed. Systemic conditions of the patients were assessed to verify their tolerance to ORIF and identify the condition of the skin and soft tissues in the surgical site. All contraindications should be excluded.

Surgical approach: The patients with transverse facture and complicated acetabular fractures involving with two columns underwent ORIF via anterior and posterior combined approach. Those presenting with single column or/and anterior wall, anterior column, posterior wall or/and posterior column injuries were subjected to ORIF via single surgical approach. Intraoperatively, the fracture ends of the bone were fully isolated and exposed. ORIF was first delivered to treat the single fracture. Then, the reduction and fixation of the acetabular fractures at the linear extension location were performed (from linear extension of the fracture to abarticular iliac bone, ischial bone, pubis and sacroiliac joint). The anatomic relationship of dislocated or disordered femoral head mortar was restored, bone fracture plate was reconstructed and fixed with proper tensile force simultaneously. Patients with posterior wall fracture defects received bone repairing and maintenance by using autologous iliac bone. Bone implantation was performed at the posterior wall to elevate the height of posterior wall. The posterior wall soft tissues repair was conducted to replace the function of joint capsule, aiming to prevent the posterior dislocation of hip joint and enhance the structural stability. The surgery was performed under general anesthesia. The patients were kept in semiprone position on the healthy side when single posterior approach was selected, in a lying posture when the anterior approach was adopted and in a "drifting" posture when combined approach was chosen. The operating table should be fully penetrable by the χ-ray. All patients were subjected to re-infusion of autologous blood during the surgery. Thus, the intra-

operative volume of blood transfusion only accounted for 1/3 to 1/2 of blood loss, which significantly reduced surgical risk and trauma. After the surgery, negative pressure drainage was placed, as shown in **Table 2**.

After the surgery, conventional application of broad-spectrum antibiotics was conducted for 48 h. During 48-72 h following the operation, the catheter was withdrawn when 24 h-drainage amount < 30 ml. Skin traction was performed to constrain the movement of acetabulum according to the situation of fixation. On the next day after surgery, lower extremity ankle pump exercises were taken by the patients. At 72 h after removal of drainage catheter, patients performed passive hip and ankle flexion exercises. Approximately after 1-month bed rest, the patients were re-examined by χ-ray and gradually started weight bearing exercise and recovery.

Follow-up and efficacy evaluation

The patients were subjected to outpatient and telephone follow-up after the surgery. During each outpatient follow-up, χ-ray radiograph was performed under AP pelvic, obturator oblique and iliac bone oblique views. The reduction of articular surface fracture was assessed by Matta standards [7]. Clinical outcomes were evaluated by modified D'Aubigne and Postel grading system.

Statistical analysis

Data analysis was conducted by using SPSS 20.0 statistical software (SPSS, Chicago, IL, USA). Quantitative data were statistically compared between two groups by *t*-test. Comparison of qualitative data between two groups was performed by *chi*-square test. $P < 0.05$ was considered as statistical significance.

Results

Articular surface fracture reduction by Matta standards: horizontal and vertical shift < 1 mm was defined as anatomic reduction; horizontal and vertical shift between 1 and 3 mm as satisfactory reduction and horizontal and vertical shift > 3 mm as unsatisfactory reduction, as illustrated in **Table 3**. Overall satisfactory rate did not significantly differ between two groups ($\chi^2 = 0.98$, $P > 0.05$), whereas statistical significance was observed regarding the rates of anatomic reduction and unsatisfactory reduction between two groups (both $P < 0.05$).

Clinical outcomes assessed by modified D'Aubigne and Postel grading system [7] include pain, movement and range of joint motion, etc. Clinical results of acetabular fractures were classified into four grades: excellent (18 points), good (15-17 points), average (13-15 points) and poor (< 13 points), as illustrated in **Table 4**. Overall satisfactory rate (excellent and good outcomes) did not significantly differ between two groups ($\chi^2 = 1.02$, $P > 0.05$), whereas statistical significance was noted in the excellent rate between two groups ($P < 0.05$).

Typical case: a male patient aged 25 years were diagnosed with complex delayed acetabular fractures complicated with infection and rupture of small intestine (**Figure 1**). He underwent ORIF via anterior approach at 59 d after injury in combination with postoperative recovery exercises. During 3-month follow-up, bone fracture was well healed with good hip joint function (**Figures 2** and **3**). During 2-year follow-up, good hip joint function was obtained with no pain.

Discussion

A majority of acetabular fracture cases are caused by high-energy trauma and thus conservative therapy yields mild clinical efficacy [8, 9]. A small proportion of patients who are complicated with severe chest, abdominal and skull trauma are likely to miss the optimal timing and postpone the surgery by 3 weeks even longer after bone fracture. De Bellis et al. [10] summarized previous findings and concluded that immediate total hip replacement (THR) can be successful in appropriately selected elderly patients or patients with extensive osteoporosis, combined acetabular and femoral neck fractures or pathological fractures. There is currently a limited evidence base for immediate THR in patients with acetabular fractures. Therefore, orthopedic surgeons' practice and expertise are the most useful tools in clinical practice.

In our institution, ORIF has been successfully performed in a substantial quantity of patients with early fracture. In this clinical trial, we are

attempting to conduct ORIF in those with delayed acetabular fracture. The reduction quality and clinical efficacy were statistically compared between these two populations. Favorable therapeutic effects have been obtained in both groups with no statistical significance.

Selection of timing and approach of ORIF

Previous studies have demonstrated that postoperative clinical efficacy of ORIF in treating acetabular fractures is significantly correlated with the waiting time for surgery. The earlier the surgery is conducted, the higher rate of anatomic reduction will be achieved. Mears et al. [11] reported a rate of anatomic reduction up to 76% at 2 d after injury, 68% at 3-10 d and 54% at 11-12 d. In this investigation, the total rate of anatomic reduction was 63.6% following ORIF, which is consistent with previous findings. However, the total rate of anatomic reduction in the delayed acetabular fracture group was merely 42.8%, suggesting that it is not feasible to perform ORIF immediately after injury because the acetabular fracture is caused by high-energy shock frequently accompanied by severe damages at multiple sites and unstable vital signs. Hence, simple pelvic external fixation is the only choice available. Peng et al. [12] regarded the 1st week after injury as the optimal timing for performing ORIF and insisted that it was difficult to conduct reduction successfully after 10 days after fracture, especially more challenging to achieve reduction exceeding 3 weeks, which could be categorized into delayed fracture. Zhou et al. [13] have demonstrated that it is reasonable to perform ORIF within 1-2 weeks following the incidence of complex acetabular fractures, whereas should be highly alerted to conduct ORIF over 3 weeks after delayed acetabular fracture. For those patients suffering from acetabular fractures for over 3-4 months due to poor systemic condition or alternative causes, other clinical therapies, such as THR, should be considered rather than ORIF. In this study, 55 patients diagnosed with early acetabular fractures steadily underwent reduction and exposure of the fracture ends, especially for those receiving ORIF within 1 week after fracture. Although significant fracture shifting may be observed, the operation time and quality of reduction could be significantly improved compared with their counterparts undergoing ORIF during late period. Despite it was extremely challenging to successfully perform ORIF for patients with delayed acetabular fracture and those waited for 65 d prior to surgery, excellent therapeutic effect of anatomic reduction was obtained due to simple fracture. Letournel and Letournel [14] categorized the surgical procedures into three stages according to the time interval between the injury and surgery: the 1st stage was 1-20 d after injury, the 2nd stage was 21-120 d and the 3rd stage over 120 d after fracture. It is convenient and efficacious to perform ORIF for patients with early fracture (belonging to the 1st stage). For those left untreated for > 3 weeks after bone fractures (acetabular fracture and dislocation, pubic branch fracture and dislocation, sacroiliac fracture and dislocation, as well as ala of ilium fracture, *etc*.), both the number and length of incision should be increased to guarantee the high quality of reduction. In addition, the delay of ORIF for acetabular fractures threatens the survival of femoral head, especially for those accompanied by persistent dislocation and semi-dislocation, and leads to abrasion of articular cartilage, chondrolysis, osteonecrosis of femoral head and posterior wall necrosis, *etc*. Although it is still easy to identify the fracture line and obtain relatively high quality of reduction within 120 d after injury, it becomes more challenging to identify the fracture line and achieve excellent anatomic reduction exceeding 120 days. Instead, alternative surgical approaches rather than ORIF should be considered to treat hip joint cartilaginous injury and abrasion.

At present, joint arthroplasty and fusion are being adopted to treat delayed acetabular fracture. During joint arthroplasty, the acetabular structure was found to be severely disrupted, even requiring impaction bone grafting or cages to repair the acetabulum. Eventually, postoperative therapeutic effect was not satisfactory in terms of unstable hip joint structure and high revision rate. Joint fusion is a surgical procedure which completely destroys the function of joint. Therefore, it is rarely recommended except specific conditions. Nowadays, osteotomy has been attempted by most orthopedic surgeons to perform three dimensional reconstruction of the acetabulum, whereas the surgical difficulty and risk are extremely high. ORIF is able to obtain the acetabulum of almost normal

anatomic position and creates favorable conditions for joint arthroplasty as a remedial surgery. The authors in this study suggested that ORIF should be adopted to treat acetabular fractures as possible by stripping callus and exposing the para-position of the fracture ends. This technique probably causes malreduction, whereas it offers solid foundation for hip joint arthroplasty. Based upon the experience from this study, it is recommended to perform ORIF to treat the acetabular fractures within 2 months after injury.

Surgical difficulty and approach selection ORIF

ORIF functions to attain fracture reduction, restore the anatomic relationship of mortar, stabilize the hip joint and recover the function of hip joint. Whether anatomic reduction could be obtained directly influences the functional recovery of the affected hip. We've accumulated a substantial quantity of clinical experience in treating and curing patients diagnosed with early acetabular fractures. However, reduction of delayed acetabular fracture is even more challenging due to the following primary factors, such as formation of fibrous callus, sclerosis of fibrous scar tissue, contracture, serious tissue adhesion, blurry layer and margin, difficulty in stripping and eliminating callus, anatomical structural injury and massive hemorrhage, which collectively increase the difficulty in exposure and reduction of acetabular fracture [15, 16]. The clinical findings of 35 cases in this study demonstrated that much attention should be paid to the followings. 1. Except anterior or posterior column fracture, dual column fracture should be treated by combined approach. ORIF via single approach is not recommended to repair the anterior and posterior factures in spite of the simple fracture since the structure of delayed acetabular fracture is relatively stable. 2. The subperiosteum stripping should be performed more extensively. The soft tissue scars surrounding the acetabulum should be completely separated and dislocated, and ORIF via an enlarged surgical approach should be chosen when necessary to facilitate the reduction of bone fracture. 3. All the callus and scars adjacent to the site of fracture should be explicitly identified and thoroughly eliminated to fully expose the fracture ends. 4. Posterior wall defects should be repaired by elevating the height of posterior wall. The soft tissue repair in the posterior wall should be conducted to replace the function of joint capsule, aiming to prevent the posterior dislocation of hip joint and enhance the structural stability. A majority of patients with delayed acetabular fracture are complicated with serious multiple trauma and possess a relatively high tolerance to pain. They have a lower expectation of the surgical outcomes. Combined with active and effective recovery exercises, relatively good clinical outcomes could be obtained. The excellent rates of ORIF efficacy did not significantly differ between the delayed (88.6%) and early acetabular fracture groups (96.4%).

To sum up, compared with early acetabular fracture, it is more difficult to treat delayed acetabular fracture via ORIF with longer operation time and more blood loss. A suitable surgical approach should be selected during acetabular fracture based upon systemic conditions and the type of fracture of the patients. After the surgery, favorable recovery training should be delivered to obtain satisfactory reduction and hip joint function. Although the reduction and excellent rates in the delayed acetabular fracture group were relatively low, they did not significantly differ from those in the early acetabular fracture group. ORIF is an efficacious approach in the treatment of delayed acetabular fracture.

Study limitations

The sample size in this clinical trial is relatively small (n = 35). The number of cases with complicated fracture is too small to integrate all types of delayed acetabular fractures. Next, a more comprehensive investigation with a larger sample size is urgently required.

Acknowledgements

This work was supported by grants from the Jining science and technology development plan (Funding NO. [2011] 57#).

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Bin Wu, Department of Orthopedic Surgery, Affiliated Hospital of Jining Medical University, 79# Guhuai Road, Jining 272-029, Shandong Province, China. Tel: 05372903003; Fax: 05372253554; E-mail: binwu2015@sina.com

References

[1] Giannoudis PV, Nikolaou VS, Kheir E, Mehta S, Stengel D, Roberts CS. Factors determining quality of life and level of sporting activity after internal fixation of an isolated acetabular fracture. J Bone joint Surg Br 2009; 91: 1354-1359.

[2] Culemann U, Holstein JH, Kvhler D, Tzioupis CC, Pizanis A, Tosounidis G, Burkhardt M, Pohlemann T. Different stabilization techniques for typical acetabulur fractures in the elderly. A biomechanical assessment. Injury 2009; 25: 469-473.

[3] Ortega R, Loder RT, Louis DS. Open reduction and internal fixation of forearm fractures in children. J Pediatr Orthop 1996; 16: 651-654.

[4] Koval KJ. Open reduction and internal Fixation. J Orthop Trauma 2005; 19: 61-62.

[5] Grewal R, Perey B, Wilmink M, Stothers K. A randomized prospective study on the treatment of intra-articular distal radius fractures: open reduction and internal fixation with dorsal plating versus mini open reduction, percutaneous fixation, and external fixation. J Hand Surg Am 2005; 30: 764-772.

[6] Wang MY, Wu XB, Zhu SW, Cao QY, Wu HH, Rong GW. Operative treatment of delayed acetabular fractures. Chinese J Surg 2003; 41: 130-133.

[7] Metta JM. Fractures of the acetabulum: Reduction accuracy and clinical results of fractures operated within three weeks of injury. J Bone Joint Surg Am 1996; 78: 1632-1645.

[8] Bellabarba C, Berger RA, Bentley CD, Quigley LR, Jacobs JJ, Rosenberg AG, Sheinkop MB, Galante JO. Cementless acetabular reconstruction after acetabular fracture. J Bone Joint Surg Am 2001; 83-A: 868-76.

[9] Weber M, Berry DJ, Harmsen WS. Total hip arthroplasty after operative treatment of an acetabular fracture. J Bone Joint Surg Am 1998; 80: 1295-1305.

[10] De Bellis UG, Legnani C, Calori GM. Acute total hip replacement for acetabular fractures: a systematic review of the literature. Injury 2014; 45: 356-261.

[11] Mears DC. Surgical treatment of acetabular fracture in elder patients with osteoporotic bone. J Am Acad Ortho Surg 1999; 7: 128-141.

[12] Peng AQ, Pan JS. Surgical complications and prevention of acetabular fracture. J Bone Joint Injury 2003; 18: 63-64.

[13] Zhou DS, Wang XQ, Wang BM, Wang LB. Treatment of complex acetabular fractures through combined approaches (46 cases reports). Orthoped J China 2004; 12: 170-172.

[14] Letournel E, Judet R. Fractures of the acetabulum, 2nd ed., New York: Springer-Verlag 2006; 5: 38-39.

[15] Liu YS, Yang SH. The surgical approach choices for acetabular fracture. Chinese J Joint Surg 2010; 4: 408-411.

[16] Zhou DS. Gupen Chuangshang Xue (2nd edition). Shandong Sci Technol Pre 2009; 220-223.