Double-column acetabular fracture with unstable anterior pelvic ring treated by internal fixation with reconstruction titanium plate combined with trans-plate quadrilateral screws via the ilioinguinal approach: a case report

Guan-lin Lin¹, #, Xu Li², #, Zhuang-hong Chen¹, *, Xian-hua Cai¹, *, Xi-ming Liu¹, Hua-song Wang¹, Bao-cheng Zhang¹

Abstract

Objective to discuss the clinical application and therapeutic effect of anterior titanium plate combined with quadrilateral screw fixation for the treatment of acetabular double column fracture with unstable contralateral anterior pelvic ring. Methods 19 cases suffering unilateral acetabular double column fracture or combined with unstable contralateral anterior pelvic ring according to Judet-Letournel classification were retrospectively studied in our hospital from January 2007 to January 2013. Patients were treated with anterior oblique ilioinguinal approach. After fixing instable contralateral pelvic anterior ring with plate and screw, double column fractures of acetabulum were reconstructed by titanium plate and 3-5 cortical screws. The modified Merle d'Aubigné and Postel scoring criteria were used to evaluate hip function. Results the 19 patients were followed up for 12-36 months, with an average time of 18.3 months. The quality of postoperative fracture reduction was evaluated according to Matta score: anatomical reduction was achieved in 10 cases, with satisfactory outcome in 7 cases, and dissatisfactory results in 2 cases. The adopted Merle d'Aubigné and Postel hip joint function scores were improved at the last follow-up: excellent in 11 cases, good in 5 cases, acceptable in 2 cases and poor in 1 case, with the excellent rate of 84.2%. Conclusion anterior titanium plate combined with internal fixation using quadrilateral screw is one of the effective methods for the treatment of double anterior column fractures, but for those with instable contralateral pelvic anterior ring, stabilization of the contralateral pelvic anterior ring is the premise of effective internal fixation.
Introduction

With the development of transportation and construction, incidence of high-energy injuries has greatly increased, and the incidence of acetabular fractures is also increasing year by year [1], the incidence of which accounts for 1% of 3% of the total fractures as reported in the literatures. The disability rate of this type of injuries is about 50%-60%, with fatality rate as high as 5% 20% [1-3]. Acetabular double column fracture is the most complex type of acetabular fractures in clinical practice. For treatment of this types of fractures, anatomical reduction, rigid internal fixation and postoperative rehabilitation exercise are still the basic principles [4, 5]. However, due to the irregular shape of acetabular anatomy and its thin inner wall, which is deep in position and surrounded by important blood vessels and nerves, often only limited field exposure could be achieved during surgical treatment. At present, there are many kinds of internal fixation methods for double column fracture involving acetabulum. However, there is no single fixation method that can solve all the clinical and intraoperative problems [6, 7]. From January 2007 to January 2013, special shaped titanium plate and quadrilateral screw treatment via the ilioinguinal approach was used in our hospital to treat acetabular double column fracture, which has accumulated certain experience with clinical effects observed. In order to provide a reference for the clinical application of special shaped titanium plate in the treatment of acetabular double-column fracture, the current study retrospectively analyzed the clinical data of 19 patients.

Material and methods

General information

Inclusion criteria: 1) Patients were treated in our hospital from January 2007 to January 2013; 2) age between 18 to 60 years old, male or female; 3) acetabular double column fracture involving quadrilateral area, not significant posterior column displacement, with unsteadiness of the contralateral anterior pelvic ring and stable contralateral posterior pelvic ring; 4) patients receiving ilioinguinal reconstruction of titanium plate combined with quadrilateral screw fixation by bone surface. Exclusion criteria: 1) incomplete medical records and imaging data (including follow-up information); 2) pathological acetabular fractures suggested by imaging examination; 3) severe medical diseases such as liver and kidney dysfunction, respiratory or blood system diseases, poor general condition and mental illness; 4) old fracture with traumatic brain injury or spinal cord injury and paralysis. A total of 115 cases (Figure 1) involving acetabular fractures were treated in our hospital from January 2007 to January 2013, including 19 cases suffering unilateral acetabular double column fracture according to Judet-Letournel classification (12 male and 7 female, aging between 21-58 years old, average age of 35.6 years old). The causes of injury: 11 cases of traffic injuries, 5 cases smashed by heavy objects, and 3 cases of high falling injury. According to
Judet-Letournel classification, all patients suffered double-column fracture with unstable contralateral pelvic ring, and insignificant posterior column fracture displacement. Concurrent injuries: hemorrhagic shock in 3 cases, rib fractures and blood pneumothorax in 3 cases, limb fractures in 4 cases, lumbar compression fractures in 1 case, 2 cases of closed abdominal injury, and 1 case of traumatic brain injury. Patients suffering severe injuries were treated in the emergency room or related specialist departments before transferring into our department for further treatment after stabilizing the condition.

**Surgical methods**

After admission to the hospital, all patients received routine ipsilateral femoral condyle or tibial tuberosity traction. Traction weight of 12-15 kg was used for some patients with severe central dislocation of the hip for 3-15 d, with an average of 7.8 d. Re-examination of X-ray was performed after traction, with the traction weight changed to 6-10 kg after reduction. All patients underwent pelvis anteroposterior, obturator oblique, iliac oblique X-ray, and CT plain scan and three-dimensional reconstruction, with treatment of concurrent injuries (Figure 1). Before surgery, we firstly simulated the approximate acetabular fracture line in the pelvic model to determine the sequence and method of surgical reduction, as well as placement of internal fixtures. Autologous blood transfer machine as well as 400-800 ml blood was prepared before surgery. Patients received antibiotics at 0.5-2h before surgery to prevent infection.
15°. The titanium plate at both ends of the quadrilateral area is the opposite, so that when placed along the border of the pelvis, the titanium plate is upturned on both ends. At both ends, two or more AO cortical bone screws 3.5 mm in diameter (the ordinary type, Cindy Corporation) were used to stabilize the fracture of anterior column or partial fracture through the anterior column. Drill nail hole parallel to the surface of the quadrilateral area. Screw into 3 to 5 3.5mm AO cortical bone screws (ie, quadrilateral screw) (ordinary type, Cindy), and the length reached the distal fold for at least 10 mm. After fixation, the quadrilateral-shaped screws partially in the bone showed no displacement. Three-D X-ray image was taken to confirm good fracture reduction, stable internal fixation, and the screw did not enter the joint cavity, indwelling drainage tube was placed in the deep and shallow layers of the iliac fossa, and the incision was closed. Operating time of this group of patients was 2.0-5.5 h, with an average of 4.3 h, with blood loss of 300-2500 ml and an average of 850 ml (Figure 2).

**Postoperative treatment**

All patients were given traction for 14 d after the operation, with routine antibiotics treatment for 48 h, and the drainage tube was removed after 36 to 72 h. Re-examination was performed 3 days after the surgery (Figure 3), including the posterior pelvis, closed oblate, iliac oblique x-ray (Figure 4), CT plain scan and three-dimensional reconstruction. The patients were encouraged to do isometric contraction of the muscles of the lower extremities to allow the active movement of the ankle, and active flexion of the hip 14 d after the operation. The time for walking exercise was determined according to the fracture fixation and X-ray, and generally weight was gradually added after 10-12 weeks. Re-examination was performed at 1, 2, 3, 4, 6, 12 months after surgery, with follow-up clinic visit once every six months. At the last follow-up, patients were evaluated according to modified Merle d’Aubigné and Postel hip joint functional scores.

**Results**

All patients were followed up for 12-36 months (average 18.3 months). One of the patients had lateral parakeratosis but spontaneously recovered with no special treatment applied. Two patients had traumatic arthritis, manifested as weight-bearing activity pain, with articular sclerosis and narrowing joint space showed in X-ray, which was relieved after physical therapy and oral anti-inflammatory analgesic drugs. None of the patients in this group had other complications such as internal fixation failure, sciatic nerve injury, femoral nerve blood vessel injury and incision infection. The quality of postoperative fracture reduction in all patients was assessed according to Matta radiological criteria [8]: full anatomic reduction in 10 cases, good reduction in 7 cases and unsatisfactory reduction in 2 cases. All patients achieved clinical fracture healing during followed up, with healing time of 2 to 4 months and an average of 3.8 months. At the final follow-up, hip function was assessed using the modified Merle
d’Aubigne and Postel criteria [9]: excellent in 11, good in 5, fair in 2, and poor in 1, with an excel-

Figure 1 | The preoperative pelvis AP X-ray (A) and 3D reconstruction of CT (B-D) of the patient showed that double column fracture of right acetabulum and symphysis pubis separation.

Figure 2 | Intraoperative pictures (A-D) and body position (A) showed that the internal fixation was fine (B and D) and the ilioinguinal approach (C) was safe.

Figure 3 | Postoperative review via pelvi 3D reconstruction of CT (A-D) showed that the internal fixation was at good position.
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Figure 4 | Two months postoperative follow via pelvis 3D reconstruction of CT (A), the inlet (B), iliac oblique (C) and oblique position (D) X-ray showed the plates were at good position.

Discussion

Acetabular double-column fracture treatment is difficult as the medial acetabulum (ie, quadrilateral area) is extremely weak, which makes direct internal fixation extremely difficult. The minimum thickness in Chinese reported in the literature is only (2.35 ± 1.13) mm [10], which limits usage of internal fixation in our country. In order to change disadvantage of double approach traumatic surgery that often used in the current clinical treatment of acetabular double-column fractures such as massive trauma with large amount of intraoperative bleeding and to minimize surgical trauma, our hospital tried to explore the use of a single anterior fixation [11] in treatment of acetabular double-column fracture since 2005. As the role of anterior column is 2.75 times of that of posterior column in the stability of pelvic ring [12], after careful study of fracture and anatomical characteristics of the region, the ilio-inguinal approach was first used to reveal the quadrilateral area fracture involving the anterior column. The reconstruction titanium plate was still placed along the pelvic boundary line, but the radius of curvature of the titanium plate was increased, moving the titanium plate towards the pelvic cavity for 1 / 3~1 / 2 nail range in the quadrilateral area, and reducing the slope of the quadrilateral plate. Firstly, restore structure of the pelvic ring, and then placed in the shaped titanium plate, with pelvic ring fixed with at least two screws at both ends. After reduction of the quadrilateral fracture, drill parallel to the titanium plate surface, and placed 3-5 Cortical bone screws (quadrilateral screw), with the length reaching more than the distal end with 1/2 ~ 2/3 of the screw exposed to bone surface, avoiding entering the hip cavity. With the insertion of fixation screws at proximal and distal end, the partially "twisted" proximal and distal titanium plates, while in close contact with the bony borderline of the pelvis, will generate a strong torque force on the middle segment screws (quadrilateral screws), which can effectively maintain the reset...
of fracture block at quadrilateral area, and block the displacement of the quadrilateral fracture blocks towards the pelvic cavity. The screws with 1/3 - 1/2 length screwed into the bone surface of quadrilateral area have the effect of separating the bone block and fixing the fracture directly. Studies confirmed that the "raft effect" of multiple screws can effectively block the displacement shift of fracture block towards the pelvic cavity, achieving multi-point flexible fixation [13]. At the same time, some of the screws into the bone have a pulling effect that is anti-separation. Pushing force by quadrilateral screws and femoral head reached balance with the traction force of the sacral nodule and the sacrospinous ligament to the fracture block, which can effectively prevent postoperative fracture displacement. Previous studies [14, 15] have found that used this method to fix 36 cases of acetabular double-column fracture involving quadrilateral area, which achieved excellent and good rate of 86.1% in postoperative reduction, which was positively correlated with hip joint function recovery, and similar with literature reports of internal fixation using double-entry approach [16]. After 12 to 36 months of follow-up, there was no loosening, displacement and rupture of the screw in the quadrilateral area reported, which shows that the internal fixation method used in this study is a safe and effective treatment method. We performed biomechanics and finite element analysis of the standing position and the sitting position of the anterior pelvic ring [20] refers to the arcuate structure of bilateral suprapubic symphysis and pubic symphysis, which is also known as the constrain bow. As the anterior ring of pelvis is a relatively weak part of the pelvic ring, injury of the anterior pelvic ring is more common among pelvic injuries. When the symphys pubis is separated or the upper and lower branch of the pubis is broken, the restraining effect of two end bows in the symphysis pubis disappears, and the pelvic ring is in an unstable rotating state [21]. A joint separation of the pubic symphysis, or a fracture of the upper and lower branches of the pubis or bilateral symphysis pubis in the anterior side of the pelvis, produces a rotating and vertical instability in the pelvis (the anterior part structure accounts for 40% of pelvic stability, and the posterior structure accounts for 60%. The effect of anterior structure on the dynamic stability is in particularly significant [22]).

The need of simultaneous fixation of anterior and posterior pelvic ring instability remains controversial. Tile believes that the need of internal fixation of the acetabular fracture is one of the indicators for open reduction of the anterior part structure accounts for 40% of pelvic stability, and the posterior structure accounts for 60%. The effect of anterior structure on the dynamic stability is in particularly significant [22]).
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terior ring. Matta [23] believes that anterior ring fixation is essential when the separation of symphysis pubis is greater than 10 mm or displacement of pubic ramus is greater than 20 mm; in addition, the need for internal fixation of acetabular fractures is also one of the indicators for open reduction of the pelvic anterior ring. Through cyclic loading test after anterior and posterior ring fixation treatment of Tile-C type pelvic fracture, The previous studies [7] showed that although the pelvis did not achieve intact stability, it was enough to bear physiological load, which allowed walking exercise at earlier time. The biomechanical test of Simonian et al. [24] using fresh cadaver specimens showed that the anterior ring fixation alone couldn't stabilize the posterior pelvic ring, while fixation of posterior ring alone cannot stabilize the anterior ring either. The biomechanics of vertically unstable fracture shows that the pelvis structure is geometrically variable, which cannot maintain its original structure and morphology, the stability of which is poor. When the anterior and posterior rings are fixed at the same time, pelvis forms a closed ring structure, which can improve its stability. Therefore, most scholars believe that the anterior and posterior rings should be fixed at the same time [25].

We believe that the shaped titanium plate is the key to success of this operation [26]. Fixation screws on both ends of titanium plate are an important basis for the function of quadrilateral screws. With the insertion of proximal and distal titanium screws, the partially "twisted" titanium plates at proximal and distal end produce a strong torque force on the quadrilateral-shaped screws at the same time as they are in close contact with the pelvis. Normally quadrilateral area is subjected to combined inward and upward force from the femoral head, and the "raft effect" by multiple screws in the quadrilateral area can effectively prevent displacement or fracture of upper and lower ment of the quadrilateral block towards the pel-

With the study of the treatment of the double column fracture of the acetabulum with the special plastic titanium plate and quadrilateral screw in the ilioinguinal approach and its clinical application, we found that for contralateral the "raft effect" by multiple screws in the quadrilateral area can effectively prevent displacement or fracture of upper and lower part of the quadrilateral block towards the pelvis. Normally quadrilateral area is subjected to combined inward and upward force from the femoral head, and the "raft effect" by multiple screws in the quadrilateral area can effectively prevent displacement or fracture of upper and lower part of the quadrilateral block towards the pelvis.
vic cavity, achieving multi-point elastic fixation [27]. At the same time, part of the screws is inserted into the bone, providing upward pulling effect against the downward separation of fractured quadrilateral block [28]. The force of distal titanium plate on the pelvic ring is downward. When the contralateral pelvic ring is unstable, the lack of upward resistance strength to the pelvic ring affects the fixation of distal titanium plate. Secondly, during the torsional process, the titanium plate at both distal and proximal ends need to provide effective reaction force to assist the shaping of titanium plate [29]. In addition, the strong torque on the screws by the titanium plate need to be supported by stable and firm fixation of distal and proximal plates. Instable contralateral anterior pelvic ring prevents the close contract of shaping titanium plate with the boundary surface of pelvic bone, reduces the torque of titanium plate on screws, also weakened the upward and outward force of quadrilateral screw on the quadrilateral fracture, thus affecting the effective fixation of fracture blocks at quadrilateral area [30].

In conclusion, the precondition for treatment of a double column fracture of the acetabulum with a specially shaped titanium plate and quadrilateral screw using the ilioinguinal approach is the stability of contralateral pelvic ring. In this way, specially shaped titanium plate and quadrilateral screw using ilioinguinal approach can achieve effective elastic fixation. The limited case number in this study, as well as the short follow-up time in some patients may affect the results. In addition, lack of biomechanical analysis is also a shortage of this study, which will be further improved in our future work.

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