

CLINICAL ARTICLE

The Short- and Mid-term Follow-Up of Single-Column Fixation in Transverse and Posterior Wall Acetabular Fractures

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Objective: To evaluate the radiological and clinical outcomes of the surgical treatment for transverse and posterior wall fractures using single-column posterior fixation.

Methods: From January 2009 to January 2018, a total of 24 patients with transverse and posterior wall acetabular fractures in our center were included in this retrospective study, including 17 males and seven females with a mean age of 47 years and a minimum follow-up of 1 year. All cases were closed fractures. All fractures were fixed with single-column fixation *via* the Kocher–Langenbeck approach. Primary outcome measures, including quality of reduction and clinical outcomes, were recorded by an independent observer, who also noted secondary outcome measures, including time to surgery, surgical time, intraoperative blood loss, and postoperative complications.

Results: Twenty-four patients (range, 26–74 years) included 17 males and seven females. There were 14 cases on the left side and 10 cases on the right side. The mean time from injury to surgery was 7.1 days. Mean intraoperative blood loss and surgical time were 405.4 mL and 135.8 min, respectively. The mean follow-up time was 29.5 months (range 12–96 months). All the acetabular fractures united within 5 months after surgery. The quality of reduction was graded as anatomical in 17 cases (70.8%), imperfect in three cases (12.5%), and poor in four cases (16.7%). According to grading system of Merle d' Aubigne and Postel, clinical outcomes at the final follow-up were excellent in 10 cases (41.7%), good in six cases (25.0%), fair in five cases (20.5%), and poor in three cases (12.5%). The excellent and good rate was 66.7%. There was a significant relation between the quality of reduction and clinical outcomes ($P < 0.05$). At follow-up, there were one case of sciatic nerve injury, one case of wound infection, two cases of deep vein thrombosis, two cases of avascular necrosis, three cases of heterotopic ossification, and five cases of postoperative traumatic arthritis. Three of these patients underwent reoperation, including one with heterotopic ossification affecting hip movement and two with femoral head necrosis.

Conclusions: Our study shows that single-column posterior fixation of transverse and posterior wall acetabular fracture through the Kocher–Langenbeck approach can obtain satisfactory radiological and clinical outcomes if there is adequate indirect reduction of the anterior column.

Key words: Acetabulum; Internal fixation; Kocher–Langenbeck approach; Single column; Transverse and posterior wall fracture

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Introduction

Complex acetabular fractures are often caused by high-energy injuries, which are severe injuries involving the pelvis and lower limbs. Because the position of the acetabulum is deep and difficult to expose, the management of such injuries is often a challenge for orthopaedic trauma surgeons. At present, open reduction and internal fixation has become a consensus for the treatment of displaced acetabular fractures.

Transverse and posterior wall fractures are a common pattern of complicated acetabular fractures, accounting for 24% to 32% of those lesions^{1,2}. The main fracture line of the transverse component usually passes through the acetabular dome. The mechanical force on the hip changes as the weight area displaces¹. Fracture malreduction or non-reduction would result in post-traumatic arthritis. Anatomical reduction and firm internal fixation are the main actions to achieve a good outcome. The surgical approach is critical to achieving the goal of anatomic reduction with minimum complications³.

While much progress has been achieved for transverse and posterior wall fractures, the choice of surgical approach is still controversial. Because these fractures involve both the anterior and posterior acetabular columns, some authors have suggested that the ilioinguinal (IL) and Kocher–Langenbeck (KL) approaches were indispensable. Although combined approaches have many advantages, they bring some thorny problems, such as a longer surgical time and a higher rate of surgical complications^{4,5}. In order to avoid greater surgical injury, some authors have attempted a single posterior approach with single-column fixation for this fracture type^{6,7}. Normally the choice of surgical approach depends on the amount of column displacement; however, the associated presence of the posterior wall makes the use of a posterior approach mandatory.

Giordano *et al.* treated transverse and posterior wall fractures with the posterior plate with or without anterior column lag screw by a single posterior approach. They found that it is not necessary to fix the anterior column of the transverse acetabular fracture if there is adequate indirect reduction of the anterior column⁶. Fahmy *et al.* also concluded that single-column posterior fixation in the transverse fractures (with or without posterior wall involvement) showed similar results to double-column fixation in terms of fracture stability, quality of reduction, and early functional outcomes⁷. Some biomechanical studies support the double-column fixed mode, but are not against single-column fixed module. Shazar *et al.* compared several constructs for transverse acetabular fractures using a synthetic hemipelvis model. The posterior plate with anterior column lag screw provided significantly stiffer fixation when anterior column displacement was assessed. If posterior column displacement was assessed, the anterior plate and posterior column lag screw provided significantly stiffer fixation⁸. Chang *et al.* compared double-column fixation with two lag screws *vs* a single-column fixation with a plate and screws in cadaveric pelvic specimens. This study showed there is greater strength

of fixation with a plate and screw construct. However, lag screw fixation provides relatively greater stiffness, which is a viable option for appropriate transverse acetabular fractures⁹.

Although these biomechanical studies have attempted to address this issue, there is currently limited clinical data to support single-column fixation in the management of transverse and posterior wall fractures. Therefore, we retrospectively analyzed the reduction quality, clinical outcomes, and postoperative complications of transverse and posterior wall fractures treated by the KL approach over a period of 8 years. The aims of this study were: (i) to explore the effectiveness of single-column fixation of transverse and posterior wall fractures using the KL approach; (ii) to compare the results with other studies reporting on radiological and clinical outcomes; (iii) to make a recommendation on choosing single-column fixation or double-column fixation in the treatment of transverse and posterior wall fractures.

Materials and Methods

Subjects

A retrospective evaluation was conducted of patients with a transverse and posterior wall fracture treated by the KL approach in a level-I trauma center between January 2009 and January 2018, with a minimum 12-month follow-up period. The inclusion criteria were as follows: (i) transverse and posterior wall fracture; (ii) time from injury to surgery ≤ 2 weeks; (iii) treated with single-column fixation by the KL approach; (iv) functional exercise and regular follow-up; (v) primary outcome parameters (quality of reduction and clinical outcomes) and secondary outcome parameters (time to surgery, surgical time, intraoperative blood loss, and postoperative complications) were evaluated. Exclusion criteria included: (i) manifestation of severe osteoporosis, pathological fractures, and previous history of hip injuries, as well as dementia and other disease processes; (ii) open acetabular fracture; (iii) those patients who were lost in follow-up, who suffered acetabular fractures with the major displacement occurring at the anterior column, and who suffered head trauma. This study was approved by the hospital ethics committee, and all patients signed the ethical informed consent after admission.

Preoperative Planning

All patients with acetabular fractures admitted to the emergency department started with a comprehensive physical examination. Anteroposterior pelvic and Judet oblique radiographic views and computed tomography images were the standard radiological protocol. According to Guyton and Perez¹⁰, indications for surgery included an acetabular fracture with 2 mm or more of displacement in the dome of the acetabulum, posterior wall fracture with more than 50% of the wall involved, and hip instability and incongruence. In addition, evaluation of the soft tissue around the pelvis was mandatory. Anticoagulation prophylaxis with low-molecular heparin was used preoperatively if there was no

contraindication. Ipsilateral skeletal traction was applied until surgery to reduce instability of femoral head, to avoid pressure necrosis on the femoral head cartilage, and to facilitate intraoperative reduction. All patients underwent surgery as soon as their general condition permitted.

Surgical Technique

Anesthesia and Position

All patients were administered antibiotics prophylactically with a first-generation cephalosporin 30 min before skin incision. The patients were all placed in a lateral position. All operations were performed by the same team led by a senior admitting orthopaedic surgeon under general anesthesia.

Approach and Exposure

The incision began 6 cm anteriorly to the posterior superior iliac spine and ran to the great trochanter with an externally convex curve. After the subcutaneous fat was incised, the ili-tibial band was encountered. Gluteus maximus and extorsion muscles were separated and protected. The sciatic nerve was identified over the posterior surface of the quadratus femoris muscle and was followed up to the greater sciatic notch. The greater ischial notch could serve as a reduction mark of posterior column fragments. The Hohmann retractor was placed medial to the ischial tuberosity to protect the sciatic nerve. Then, the entire posterior column and wall could be exposed and palpated.

Fracture Reduction and Fixation

In order to achieve stable column fixation and anatomical reconstruction of the articular surface, fixation of the column preceded reconstruction of the posterior wall. The steps were as follows: (i) the edges of the fracture fragments were debrided carefully; (ii) manipulation of the anterior column was accomplished *via* a clamp through the greater sciatic notch; (iii) a number of reduction devices, such as clamps, bone hooks, and joysticks, could be used to assist in reducing the posterior column; (iv) the posterior column was fixed with a properly contoured reconstruction plate, but care should be taken not to impede the placement of the second posterior wall plate; (v) restoration and stabilization of the posterior wall was achieved with ball-spiked pushers and Kirschner wires; (vi) the posterior wall plate in a buttress mode was applied from the ischial tuberosity to the retroacetabular surface. Then the screws can be inserted either independently or through the plate. It should be noted that in case of marginal impaction, the posterior wall should be treated before posterior wall reconstruction. A diagram was used to illustrate the procedures of reduction and fixation (Fig. 1).

Postoperative Management

Low-molecular heparin was restarted 6 h postoperatively, and after discharge, rivaroxaban was taken orally for 4 to 6 weeks. Antibiotics were stopped 48 h postoperatively

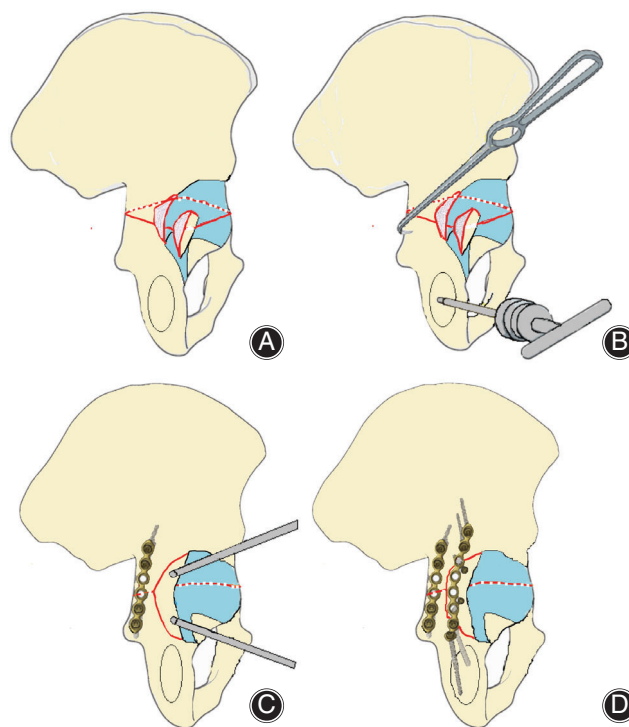


Fig 1 Schematic diagram illustrating the procedures of reduction and fixation. (A) The transverse and posterior wall fracture. (B) The manipulation of the column was accomplished by a number of reduction devices, such as bone hooks and joysticks. (C) After the fixation of the posterior column, restoration and stabilization of the posterior wall was achieved with ball-spiked pushers. (D) The posterior wall in a buttress mode was fixed with a properly contoured reconstruction plate.

unless another systemic or local infection was found. Drains were removed within 48 h postoperatively if the drainage did not exceed 50 mL/day. On the first postoperative day, the patients began physical therapy with isometric quadriceps and abductor strengthening exercises. Passive hip movement began at 2 to 3 days postoperatively, and active hip movement without weight-bearing began at 3 to 4 weeks postoperatively. For patients with posterior dislocation of hip before surgery, skeletal traction was conducted for 2 to 4 weeks before hip functional exercise. Partial weight-bearing was gradually initiated at 8 to 12 weeks according to fracture healing. Follow-up was performed at 2 and 6 weeks and then at 3, 6, 9, and 12 months postoperatively. Thereafter, patients were examined at 1-year intervals. The initial plain radiographs routinely obtained postoperatively included anteroposterior pelvic radiographs, Judet pelvic radiographs, and pelvic CT scans.

Outcome Measures

We mainly evaluated quality of reduction and clinical outcomes. The secondary outcome measures, including time to

surgery, surgical time, intraoperative blood loss, and postoperative complications, were also recorded.

Quality of Reduction

The quality of fracture reduction was graded as anatomic (0–1 mm displacement), imperfect (2–3 mm displacement), or poor (>3 mm displacement) according to the criteria described by Matta¹¹. All radiometric measurements were evaluated by an experienced radiologist and a study author, rather than by the surgical surgeon.

Clinical Outcomes

Clinical outcomes at last follow-up postoperatively were classified as excellent, good, fair, and poor by using the clinical grading system according to Merle d' Aubigne and Postel¹².

Statistical Analysis

Statistical analysis of the data was performed using SPSS version 20.0 statistical software (SPSS Inc., Chicago, Illinois, USA). The relationship between clinical outcomes and radiological outcomes was statistically analyzed using Fisher's exact testing. Chi-squared testing was used for categorical variables. Values less than 0.05 were considered statistically significant.

Results

Follow-Up

As a result, the mean follow-up time was 29.5 months (range, 12–96 months).

General Results

The study included a total of 24 patients (17 males and seven females), with an average age of 47 years. The mechanism of injury in all cases was a high-energy mechanism—motor vehicle collision (Table 1). These patients were treated with

open reduction and internal fixation by the single KL approach. The mean time from injury to surgery was 7.1 days. The mean surgical time was determined to be 135.8 min (range, 90–230 min). The mean intraoperative blood loss was 405.4 mL (range, 200–650 mL). All fractures healed within 5 months after surgery.

Radiographic Evaluation

Quality of reduction was graded as anatomic in 17 (70.8%) patients, imperfect in three (12.5%) patients, and poor in four (16.7%) patients.

Functional Evaluation

Clinical outcomes at last follow-up were excellent in 10 (41.7%) patients, good in six (25.0%) patients, fair in five (20.8%) patients, and poor in three (12.5%) patients. Excellent and good outcomes all occurred with anatomic reduction. The relationship between quality of reduction and clinical outcomes was statistically significant ($P < 0.05$) (Table 2).

Complications

No major intraoperative blood loss occurred in all patients. One patient had sciatic nerve injury due possibly to excessive intraoperative traction. His nerve function recovered remarkably after oral administration of methycobal for 6 months postoperatively. Two (8.3%) patients developed deep vein thrombosis (DVT) in the ipsilateral lower limbs and required antithrombotic treatment for an extended period of 3 months. No cases of pulmonary embolism were noted. One (4.2%) patient developed delayed healing of the incision due to infection and the patient healed within 3 weeks by prolonged local and systemic antibiotic use. Heterotopic ossification occurred in three (12.5%) cases, among which two cases were asymptomatic without treatment (Figs 2 and 3) and one case received ectopic osteotomy because of limited movement of the affected hip. Two (8.3%) patients developed avascular necrosis of femoral head at 6 months postoperatively and underwent hip replacement at 2 and 3 years postoperatively, respectively (Fig. 4). Five (20.8%) patients had traumatic arthritis and arthritis symptoms were relieved after taking aminodextran and celecoxib. All of them refused further surgical treatment (Table 3).

Discussion

Surgical Approach Selection

Although anatomical reduction significantly influences the clinical outcome¹³, a few authors have attempted the use of a single posterior approach for the management of transverse and posterior wall fractures^{6,7}. The KL approach is the most common posterior approach for the treatment of acetabular fractures, and it provides a wide view of the outer surface of the posterior column and posterior wall^{14,15}. The quadrilateral plate can be digitally palpated with the surgeon's index finger *via* the greater sciatic notch. The surgeon must recognize that this approach is not extensile and that a different

TABLE 1 The demographics of subjects

Variable	Value	Percent
Mean age (years)	47 (25–74)	—
Gender		
Male	17	70.8
Female	7	29.2
Side of injury		
Right	10	41.7
Left	14	58.3
Mechanism of injury		
Motor vehicle collision	17	70.8
Fall from height	3	12.5
Others	4	16.7
Associated injuries		
Limb fracture	1	4.2
Hip dislocation	2	8.3
Sciatic nerve injury	1	4.2
Pulmonary contusion	3	12.5
Traumatic brain injury	1	4.2

TABLE 2 Surgery-related variables

Variable	Value	Percent
Mean time to surgery (days)	7.4 (2–18)	—
Surgical time (min)	135.8 (90–230)	—
Blood loss (mL)	405.4 (200–650)	—
Quality of reduction (mm)		
Anatomic (0–1)	17	70.8
Imperfect (2–3)	3	12.5
Poor (>3)	4	16.7
Clinical outcome		
Excellent	10	41.7
Good	6	25.0
Fair	5	20.8
Poor	3	12.5

approach may be considered when a wider exposure is required, such as involvement of superior dome.

In our study, we were able to manage transverse and posterior wall fractures with a single posterior approach and achieve an acceptable reduction of the anterior column. Some scholars have achieved satisfactory results in the treatment of such injuries by a single posterior approach^{6,7,16}. Gansslen *et al.*¹⁶ reported that 90% of 104 patients with

transverse and posterior wall fractures were treated *via* a single KL approach. Anatomic quality of reduction in patients was rated as 76% and the excellent and good clinical outcomes were rated in 56%. Compared with these previous studies (Table 4), the patients in our study obtained similar radiological and clinical outcomes. In addition, no patients required a trochanteric flip osteotomy.

Options for Different Methods of Fixation

Because every fracture has a different personality, it is important to appreciate that if the reduction of the anterior column is not acceptable after fixation of the posterior elements of the acetabulum, the fixation of the anterior column should be considered. The anterior column may be fixed by the KL approach with an additional lag screw. Besides, an extra anterior approach or a trochanteric flip osteotomy may also be used to gain access to the anterior column.

Currently there are some biomechanical studies comparing different methods of fixation of transverse acetabular fractures, yet there is not enough clinical data to support these studies, particularly short- or long-term results^{8,9}. Shazar *et al.*⁸ evaluated various fixation methods for transverse acetabular fractures in a synthetic pelvic model. They

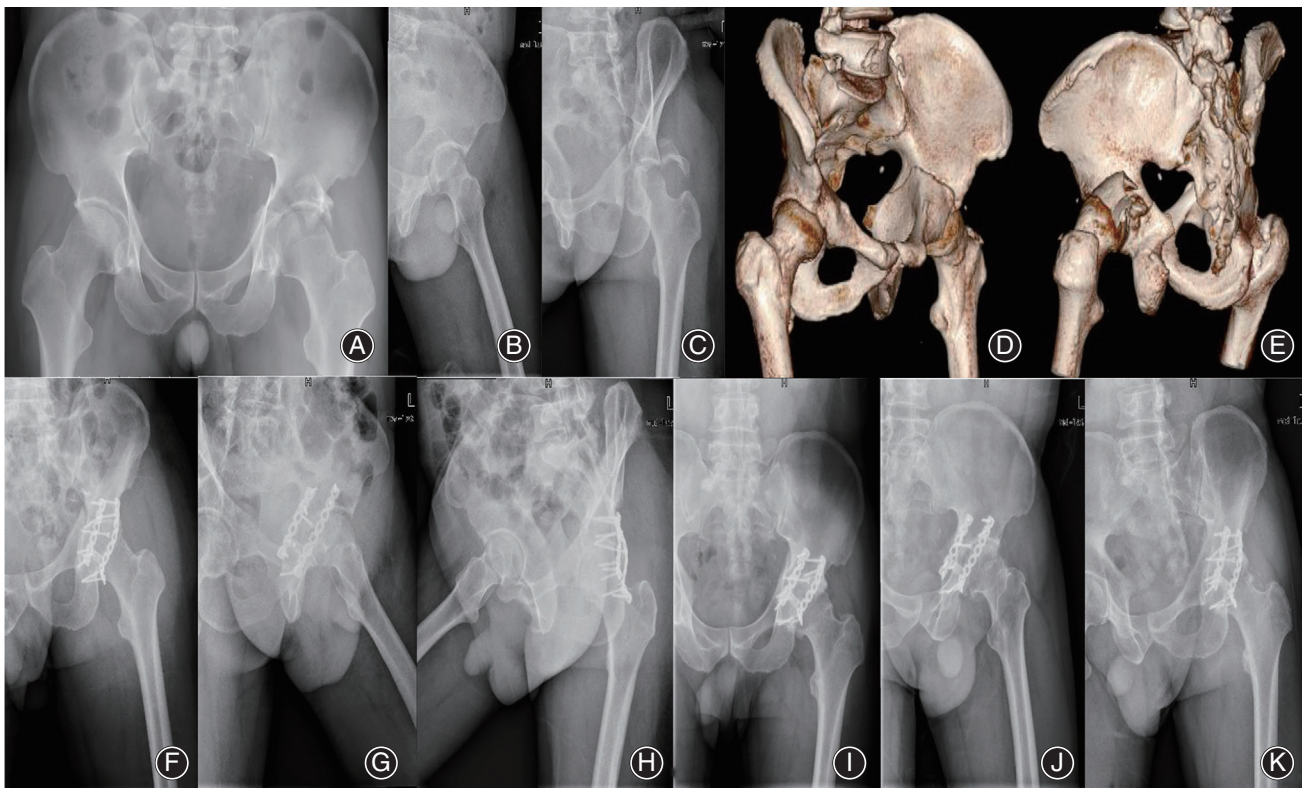


Fig 2 (A–E) A 55-year-old male patient sustained a fall injury. The fracture was diagnosed as a transverse and posterior wall fracture through X-ray images and three-dimensional reconstructions. (F–H) Immediate postoperative X-ray images confirmed satisfactory reduction of the fracture by single-column posterior fixation *via* the KL approach. (I–K) Postoperative radiographs at 2 years of follow-up showed a small amount of heterotopic ossification, but the patient was asymptomatic and the ossification did not affect hip function.

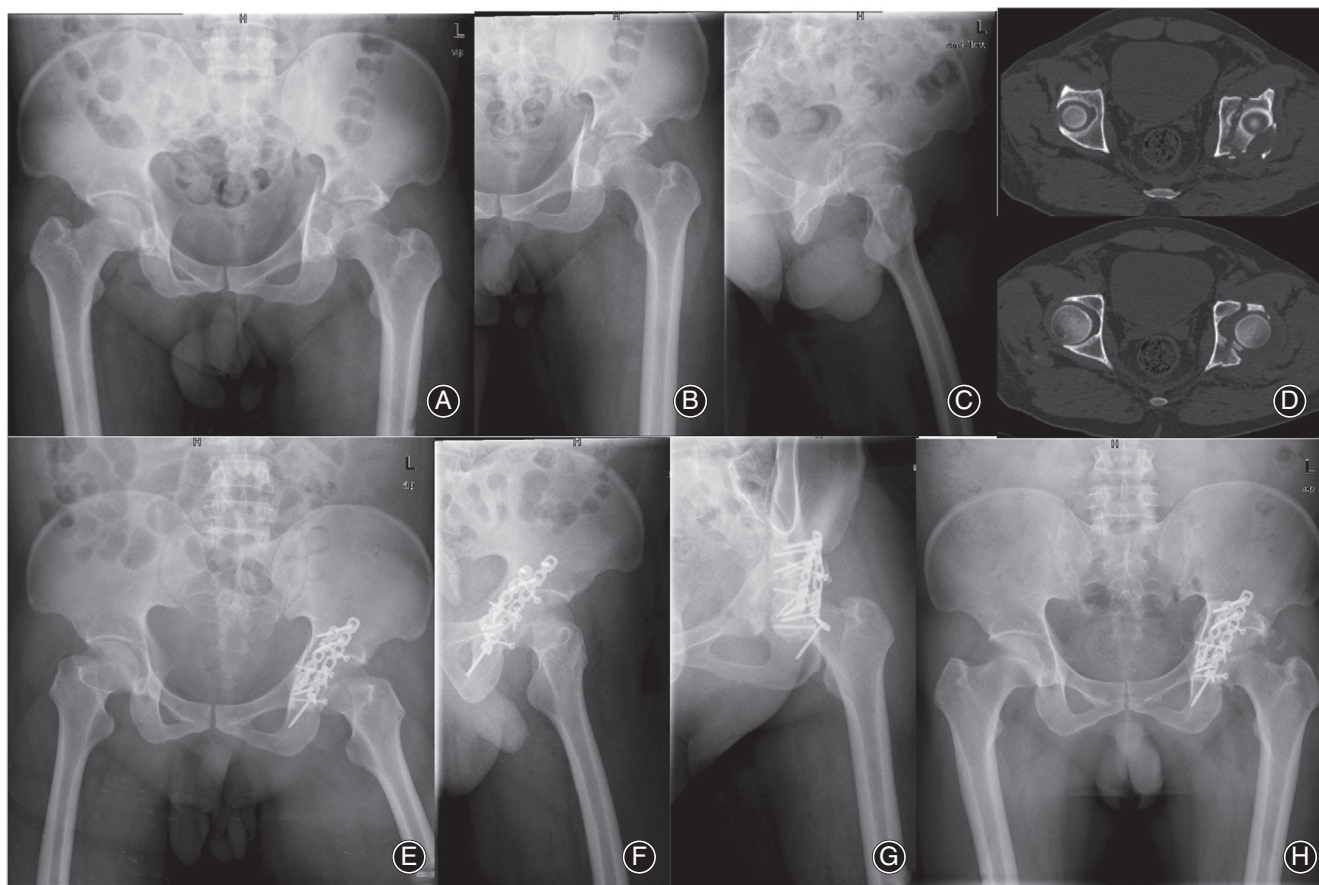


Fig 3 (A–D) A 34-year-old male patient sustained a road-traffic accident. Preoperative radiographs and CT scans showed a transverse and posterior wall fracture. (E–G) Immediate postoperative radiographs showed satisfactory reduction was obtained by single-column posterior fixation via the KL approach. (H) Postoperative radiographs at 8 years of follow-up showed heterotopic ossification, but the patient had a good functional hip outcome.

believed concurrent fixation of double columns of transverse acetabular fractures could provide the greatest resistance to postoperative loss of reduction. Chang *et al.*⁹ concluded that a single-column fixation of transverse acetabular fractures with a plate and screws had greater yield and maximum fixation strength compared to a double-column fixation with two lag screws. Giordano *et al.*⁶ reported on 35 patients with transverse and posterior wall acetabular fracture surgically treated by a single KL approach. Twenty patients were surgically treated with single-column plating and 15 patients had an additional lag-screw fixation from the posterior to the anterior column with an extra-long small-fragment cortical screw. They found there was no statistically significant difference between patients treated with and without fixation of the anterior component of the transverse acetabular fracture in terms of medial displacement of the femoral head. In another study⁷, the idea was also confirmed that there is no need for fixation of both transverse components provided that adequate reduction of the anterior column has been achieved. In our study, we fixed the posterior column with the reconstruction plate and screws in all patients. Because

the anterior column was satisfactorily reduced, no additional lag screws were used or surgical approach was added. In this way, the surgical injury was decreased, and overall, the patients obtained relatively satisfactory functional outcomes.

Complications

The major complications treated *via* the KL approach included infection, sciatic nerve injury, heterotopic ossification, post-traumatic arthritis, and avascular necrosis, which were consistent with findings in other previous studies on the posterior approach^{16–19}. One sciatic nerve palsy was observed in our study. He recovered remarkably at 6 months after oral administration of methycobal and thus this complication did not affect the clinical outcome. Therefore surgeons must be aware of the nerve position and tension or compression applied to it at all times. Hip extension and knee flexion help to avoid undue tension to the sciatic nerve. DVT occurred in two patients. Antithrombotic treatment was extended for 3 months in the patients, and no cases of pulmonary

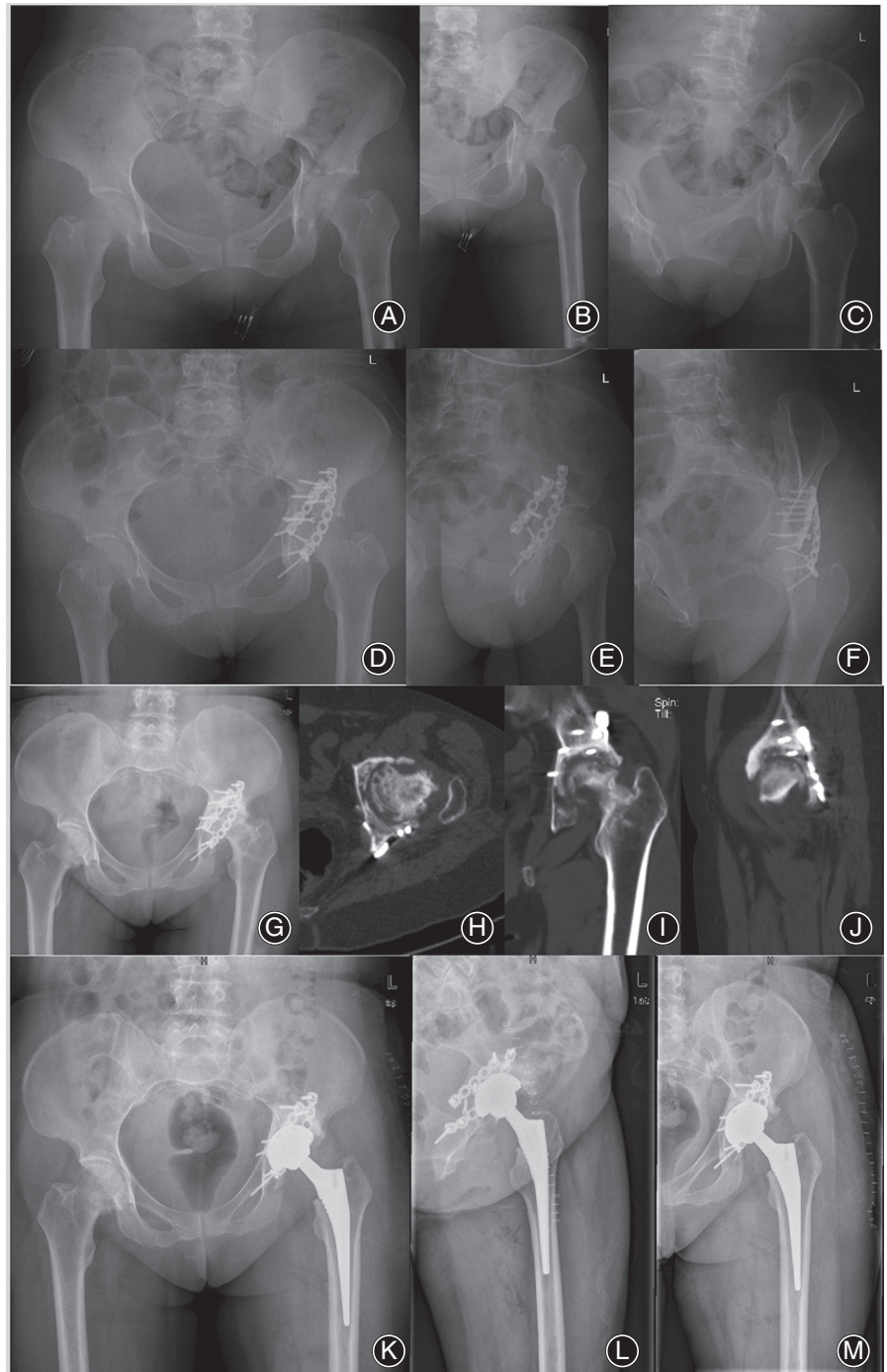


Fig 4 (A–C) A 49-year-old female patient sustained a fall injury. Preoperative radiographs showed a transverse and posterior wall fracture. (D–F) Immediate postoperative radiographs showed satisfactory reduction by single-column posterior fixation via the KL approach. (G–J) Postoperative radiographs and CT scans at 3 years of follow-up showed avascular necrosis of femoral head. (K–M) The patient underwent total hip replacement at the third year of the initial surgery.

TABLE 3 Postoperative complications

Complication	Value	Percent
Wound infection	1	4.2
Deep vein thrombosis	2	8.3
Sciatic nerve injury	1	4.2
Heterotopic ossification	3	12.5
Post-traumatic arthritis	5	20.8
Avascular necrosis	2	8.3

embolism occurred. Nonunion or malunion was not observed in our study.

Limitations

This study was subject to several limitations. Firstly, the study was of a small size from a single center. Secondly, the study was prone to various forms of bias due to its retrospective nature. Thirdly, statistical power was low due to lack of

TABLE 4 Different studies reporting on radiological and functional outcomes of transverse and posterior wall acetabular fractures

	Giordano <i>et al.</i> ⁶	Gansslen <i>et al.</i> ¹⁶	Fahmy <i>et al.</i> ⁷	This study
Case (n)	35	104	18	24
Percent of KL (%)	100	90	100	100
Mean follow-up (months)	47	43	19	29
Anatomic reduction (%)	No mention	76	80*	70
Excellent and good clinical outcomes (%)	88	56	86 [§]	66

* represents the overall anatomic reduction.
§ represents the overall excellent and good clinical outcomes.

a historical control group. The development of post-traumatic coxarthrosis requires 2–3 years of follow-up, which varies within the literature²⁰. Therefore, a relatively short follow-up duration was also a limitation of the study because it might be insufficient to assess the progression of postoperative osteoarthritis. In the future, long-term, prospective, randomized, controlled studies are warranted to compare the effectiveness of single-column posterior fixation with double-column posterior fixation.

Conclusions

Our experience shows that posterior column fixation alone in transverse and posterior wall fractures can obtain

satisfactory radiological and clinical outcomes. Direct reduction and fixation of the posterior wall and column components using the KL approach is an adequate option for these injuries if reduction of the anterior column is adequate.

Author Contributions

Yun Yang and Jiachen Sun wrote the draft of the manuscript. Yun Yang and Jiachen Sun were major contributors to study design and revision, and Zhou Xiang critically reviewed and revised the manuscript for important intellectual content. Yun Yang was involved in collecting data and design of the study. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

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