CLINICAL ARTICLE

Is Plating Fixation Through the Kocher–Langenbeck Approach for Associated Posterior Wall Fragment Indispensable in Both-Column Acetabular Fractures?

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Abstract

Objective: The treatment methods for posterior wall (PW) in both-column acetabular fractures are controversial. The purpose of this study was to compare reduction quality, clinical outcomes, and complications of nonfixation for posterior wall fragment and plating via the Kocher–Langenbeck (KL) approach after anterior surgical procedures in both-column acetabular fractures.

Methods: Forty-nine patients with both-column acetabular fractures associated with PW fixed *via* iliac fossa and Stoppa approaches from October 2012 to October 2017 were recruited into this study and were divided into two groups: Nonfix group (nonfixation for PW) and KL group (PW plating through the KL approach). Operation duration, intraoperative blood loss, reduction quality, fracture healing, and relevant complications of patients were reviewed. Merle d'Aubigné scores were used for assessing functional outcome.

Results: The mean blood loss and operation durations were lower in Nonfix group than in KL group (both $p < 0.05$). The mean hospital stay durations were (18.54 ± 6.42) days and (21.17 ± 7.32) days in groups Nonfix and KL, respectively ($p = 0.186$). All fractures healed well with no significant difference in union time between the two groups ($p = 0.210$). The rates of satisfactory reduction were 84.62% (22/26) in Nonfix group and 86.96% (20/23) in KL group ($p = 1.000$). The mean Merle d'Aubigné scores were 15.62 ± 2.28 in Nonfix group and 16.17 ± 2.19 in KL group ($p = 0.388$). The complication rates were 7.69% (2/26) in Nonfix group and 34.78% (8/23) in KL group ($p = 0.046$).

Conclusions: For both-column acetabular fractures associated with PW fragment, although fixation of PW was not performed after anterior surgical procedures, satisfactory outcomes could also be obtained. However, nonfixation was a less invasive choice with a lower complication rate.

Key words: both-column fracture; injury mechanism; Kocher–Langenbeck approach; nonfixation; posterior wall

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Introduction

The posterior wall (PW) of the acetabulum is an important structure for maintaining the stability of the hip joint[1,2]. It has been reported that PW fracture may be isolated or associated with other acetabular injuries such as transverse, posterior column, or T-shape fractures[3,4]. These types of PW fractures are caused by a direct strike posteriorly and are frequently accompanied by posterior dislocation of the femoral head[5,6]. Hip stability is usually destroyed in this fracture pattern[4,7]. Thus, open reduction and internal fixation through the Kocher–Langenbeck (KL) approach is necessary to restore the stability of the hip joint[6].

Both-column fractures are defined as entire acetabular articular surface detachment from the axial skeleton by the Judet–Letournel classification system, with fracture lines involving multiple planes[7,8]. According to the previous literature, both-column acetabular fractures are also commonly associated with PW fracture[9]. Moreover, unlike the PW mentioned above[10,11], the PW detachment in both-column fractures can be caused by an anterior "pull-type" force of the hip joint capsule and the PW fragments are often undisplaced or minimally displaced[3,12]. In the past decade, the idea that main fragments of both-column fractures can be managed through a single anterior approach has been accepted by most surgeons[13,14]. However, the disposal techniques of associated fragmented PW remain controversial. Some authors have suggested that an additional posterior KL approach should be performed simultaneously to accomplish the fixation of the PW fragment[15,16], but these could be associated with higher rates of complications[17]. Moreover, Wang *et al.* reported that good clinical results were gained through using a lag screw for PW detachment in associated both-column fractures[3]. Shin *et al.* also reported that the PW associated with both-column fractures can be successfully ignored if the PW fragment is adequately attached to the acetabulum through the labrocapsular complex of the hip joint[10].

Initially, the PW was fixed by KL approach in our surgical team. However, with the increasing understanding of the injury mechanism, clinical and radiological studies, the PWs were no longer extra fixed. The purpose of the study was to: (i) reveal fracture characteristics of both-column fractures with PW involvement; (ii) to evaluate the posterior stability of the PW associated with both-column fractures; (iii) to compare the therapeutic results of nonfixation *vs* plating fixation for the PW fragment (anterior approach *vs* anterior plus posterior incisions) after anterior surgical procedures.

Materials and Methods

Patients

The study was approved by the institutional internal review board of the participating institution. Patients with both-column acetabular fractures associated with PW detachment from October 2012 to October 2017 in our institution were retrospectively analyzed in this study. The inclusion criteria were as follows: (i) acute both-column fractures with PW detachment (<21 days); (ii) patient age in the range of 18–65 years; and (iii) management of the main fragments through an anterior approach and nonfixation or plating fixation through the KL approach for the PW fragment. The exclusion criteria were as follows: (i) bilateral acetabular injuries; (ii) pathologic fractures; (iii) preexisting ipsilateral hip diseases; and (iv) noncompletion of the 1-year follow-up. According to the inclusion and exclusion criteria, 49 patients were included in this study. All patients included in this study received surgical management through iliac fossa and Stoppa approaches firstly. For the associated PW fragment, nonfixation was performed in recent 26 patients (Nonfix group) and plating through the KL approach was performed in another early 23 patients (KL group).

Surgical Technique

For patients in Nonfix group, iliac fossa (lateral window of ilioinguinal approach) and Stoppa approaches were performed in the supine position to manage the main displaced fragments (Figure 1A). A curved incision (iliac fossa approach) starting from the anterior superior iliac spine to the middle of the iliac crest was performed. Soft tissues and abdominal contents were retracted medially to directly expose the displaced fragments in the iliac wing. With the help of assistant traction of the lower extremity, the cephalad displaced iliopubic fragment could be reduced with a ball-spike pusher and reduction forceps through the iliac fossa approach (Figure 1B). Provisional stabilization of the iliac fragment could be accomplished by Kirschner wires (Figure 1C). A reconstruction plate was placed to accomplish the fixation of the iliopubic fragment (Figure 1D). Then, a Stoppa incision was made in the area 1–2 cm superior to the pubic symphysis. The retropubic space, between the pubic symphysis and the bladder, could be exposed after the linea alba was split longitudinally. Outward force from a ball-spike pusher and traction of the affected limb were essential to reduce the medially displaced ischiadic fragment (Figure 1E). A clamp was employed to hold the reduction of the posterior column (Figure 1F). Then, an anatomic quadrilateral surface plate was placed to stabilize the fragments in the quadrilateral surface after satisfactory reduction quality was achieved (Figure 1G, H). Dynamic stress examination under anesthesia was performed to confirm posterior hip stability[18]. The suture procedure was performed in layers over drains, which should be removed 24–48 h postoperatively (Figure 1I).

For patients in KL group (Figure 2), relevant surgical procedures were conducted in floating position. Similarly, the main fragments were also managed through anterior (iliac fossa and Stoppa) approaches. The associated PW fragment could be indirectly reduced after the anterior surgical procedures. A 15–18-cm KL incision starting from 4 cm anteriorly

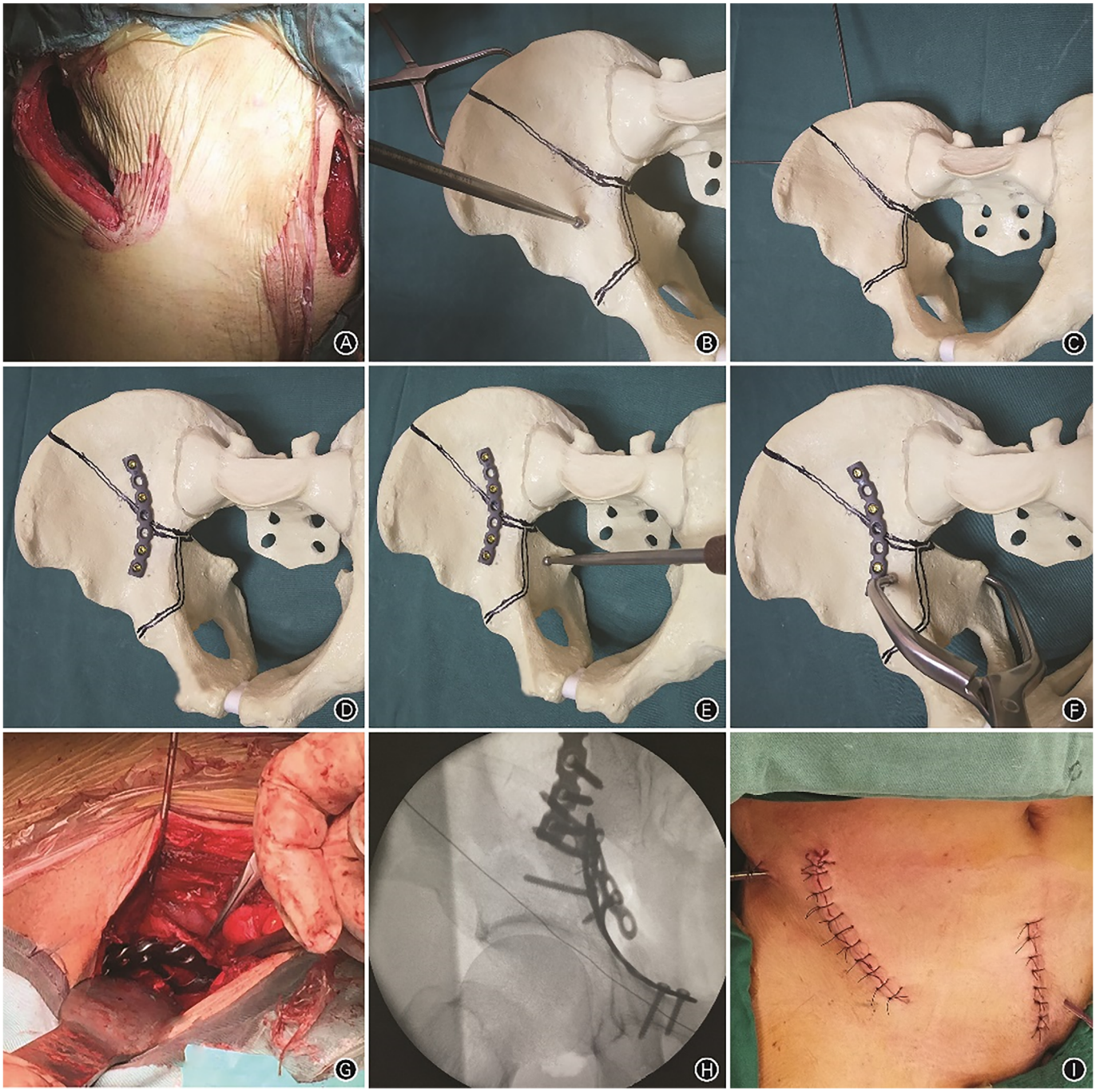

Fig. 1 Surgical procedures of Nonfix group. (A) surgical incision (iliac fossa + Stoppa); (B) reduction process of iliopubic fragment; (C) temporary fixation of iliac fragment; (D) plating fixation of iliopubic fragment; (E) reduction of ischiadic fragment; (F) a clamp was employed to hold the reduction of posterior column; (G) intraoperative view of plating fixation for ischiadic fragment; (H) intraoperative fluoroscopy; (I) sutured incision

to the posterior superior iliac spine to the posterior edge of the femoral greater trochanter was made. Subcutaneous soft tissues were dissected, and the tensor fasciae latae was split along the gluteus maximus fibers. The insertion of the extorsion muscle group was partially cut from the greater femoral trochanter. Retractors were applied to provide access to underlying structures. The tendon of piriformis was separated to expose the PW fragment. The sciatic nerve should be identified and

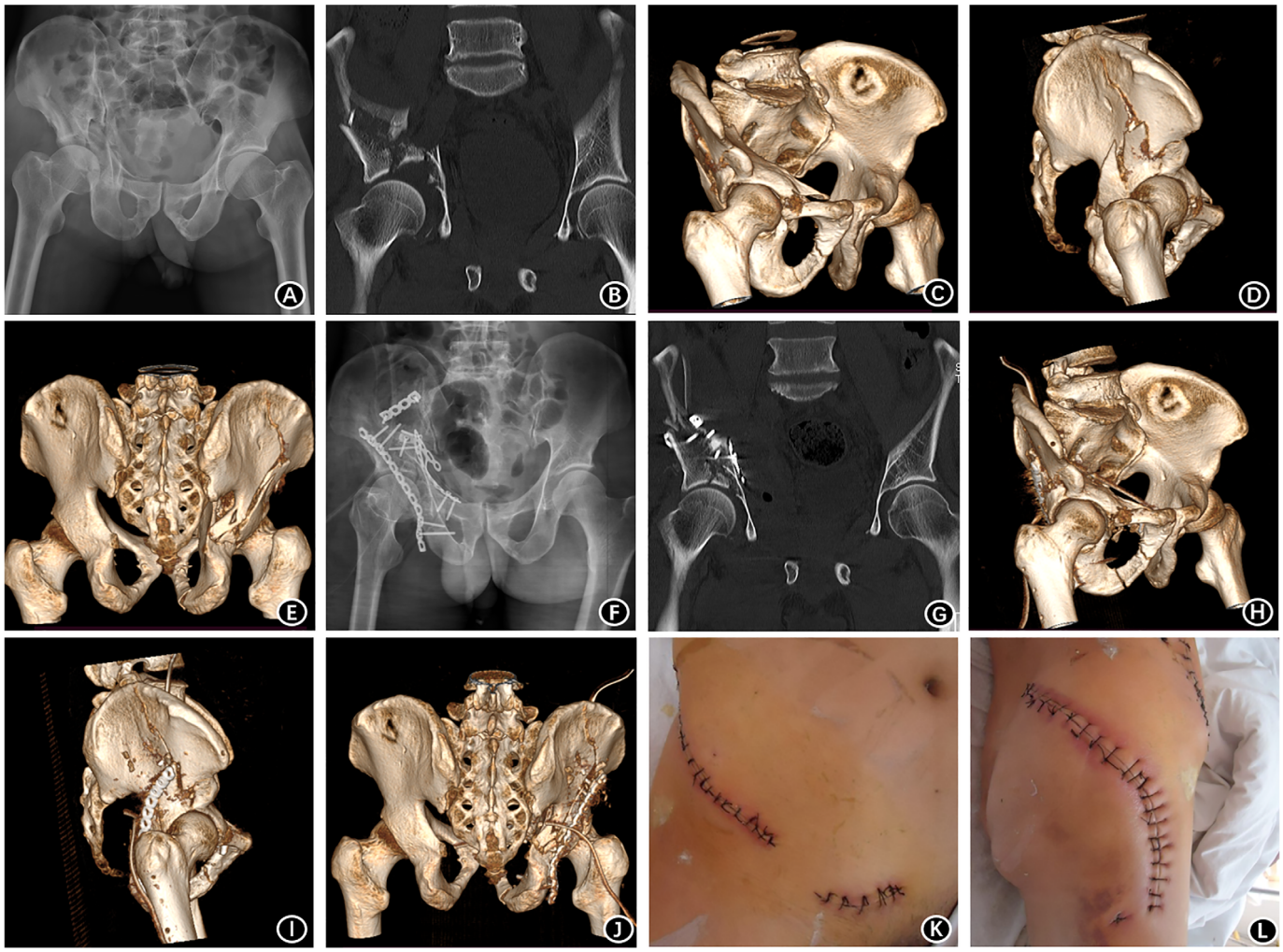

Fig. 2 A patient in KL group was presented. (A) preoperative anteroposterior (AP) view; (B) preoperative CT scan; (C–E) preoperative three-dimensional reconstructions; (F) postoperative AP view; (G) postoperative CT scan; (H–J) postoperative three-dimensional reconstructions; (K–L) sutured incision (iliac fossa + Stoppa + KL)

protected throughout the surgical procedures. A reconstruction plate could be placed to accomplish the plating fixation of the PW fragment. Then, surgical incisions were sutured after the drainage tubes were placed.

Postoperative Management

Identical postoperative therapeutic strategies were implemented for the patients in the two groups. Standard antibiotic prophylaxis was 1–3 g Cefazolin intravenously 24 h postoperatively to prevent infection. Low-molecular-weight heparin sodium (LMWHS, 4250 IU, once daily) was employed 24 h postoperatively to prevent deep venous thrombosis of the lower limbs until patients were discharged from the hospital, followed oral anticoagulant (rivaroxaban, 10 mg once daily) after discharge until postoperative day 35. Early active exercise of the hip joint in bed was encouraged to avoid ankylosis and peripheral tissue atrophy. Gradual partial weight-bearing exercise with crutches was permitted at 6–8 weeks. Full weight-bearing exercise should begin when the fracture line disappeared in the radiographs (which typically occurred at 12–14 weeks).

Outcome Assessment

Follow-up was routinely conducted at 1, 3, 6 months and 1 year postoperatively, and then annually thereafter. Radiographic results and functional outcome were assessed at each follow-up. Complications including infection, thrombosis, hematoma, sciatic nerve injury, and lateral femoral cutaneous nerve were also recorded as well.

Matta Grading Score

The Matta grading score was used to evaluate the reduction quality[19]. The reduction was graded as anatomic (<1 mm displacement), imperfect (2–3 mm displacement), or poor

(>3 mm). Anatomic and imperfect reductions were regarded as satisfactory reductions in this study.

Modified Merle d'Aubigné Score

The modified Merle d'Aubigné scores was used to evaluate the functional outcomes at the final follow-up. The score system mainly includes three aspects: pain, walking, and range of activity. The score standard had a maximum of 18 points (best possible outcome). The results were graded as excellent (18 points), good (15–17 points), fair (13–14 points), or poor (<13 points)[20].

Statistical Analysis

The relevant data were processed using SPSS (version 23.0; SPSS, Chicago, IL, USA). Measurement data including operation time and blood loss in the two groups were compared using the *t*-test. Differences in categorical variables such as gender, injury mechanism, and complication rates were determined using the chi-square test or Fisher's exact test. A value of $p < 0.05$ was regarded as significantly different in this study.

Results

Follow-up

All patients were followed up in the outpatient department or by telephone with standard questionnaire survey. The mean follow-up time of Nonfix group was 25.69 ± 7.28 months and for the KL group was 28.78 ± 6.18 months ($p = 0.118$). Patient demographics and characteristics were recorded and shown in Table 1. There were no statistically significant differences in all variables ($p > 0.05$).

General Results

The mean blood loss levels of groups Nonfix and KL were (784.62 ± 302.91) ml and (1056.52 ± 487.88) ml, respectively ($p = 0.022$). The average operation times were (174.81 ± 35.59) min in Nonfix group and (219.57 ± 73.22) min in KL group ($p = 0.012$). The mean hospital stay durations in the two groups were (18.54 ± 6.42) days for Nonfix group and (21.17 ± 7.32) days for KL group ($p = 0.186$). All fractures healed well with no significant difference in the union times between the two groups ($p = 0.210$) (Table 2).

Radiographic Improvement and Functional Evaluation

Redisplacement of fragments was not observed during follow-up. The rates of satisfactory reduction were 84.62% (22/26) in Nonfix group and 86.96% (20/23) in KL group ($p = 1.000$). The mean Merle d'Aubigné scores in Nonfix and KL groups were (15.62 ± 2.28) points and (16.17 ± 2.19) points, respectively, ($p = 0.388$) (Table 2).

Complications

The complication rates were 7.69% (2/26) in Nonfix group and 34.78% (8/23) in KL group ($p = 0.046$) (Table 3). Hematoma developed in one case in Nonfix group and two cases in KL group; relevant symptoms disappeared after immediate puncture drainage. Lateral femoral cutaneous nerve (LFCN) palsy occurred in one case in Nonfix group and two cases in KL group. Skin numbness of the lateral thigh faded away gradually after 2 months' conservative treatment. Incision infection was observed in two cases in KL group, whose symptoms disappeared after a thorough debridement. Thrombosis developed in one patient in KL group, which disappeared after active anticoagulation treatment. Sciatic nerve

TABLE 1 Patient demographic characteristic

Characteristics	Nonfix group	KL group	t/X^2	*P* values
Age (year)	46.12 ± 11.78	45.52 ± 11.18	0.180	0.858
Gender (M/F)	21/5	18/5	0.000	1.000
Injury severity score	12.62 ± 4.76	13.30 ± 5.51	−0.470	0.641
Preoperative displacement (mm)	3.51 ± 1.04	3.90 ± 0.94	−1.370	0.177
Time to surgery (day)	7.04 ± 3.67	7.26 ± 3.02	−0.230	0.819
Follow-up time (month)	25.69 ± 7.28	28.78 ± 6.18	−1.590	0.118
Injury mechanism (falling/crushing/traffic accident)	9/11/6	5/8/10	2.442	0.295
AO classification (C1.3/C2.3)	20/6	19/4	0.019	0.890

TABLE 2 Clinical results of two groups

Characteristics	Nonfix group	KL group	t/X^2	*P* values
Blood loss (ml)	784.62 ± 302.91	1056.52 ± 487.88	−2.373	0.022
Operation time (min)	174.81 ± 35.59	219.57 ± 73.22	−2.666	0.012
Union time (month)	3.46 ± 0.65	3.26 ± 0.45	1.273	0.210
Hospital stay (days)	18.54 ± 6.42	21.17 ± 7.32	−1.343	0.186
Satisfactory rate of reduction quality	22/26	20/23	/	1.000
Merle d'Aubigné score	15.62 ± 2.28	16.17 ± 2.19	−0.872	0.388

injury occurred in one case in KL group, and early exploratory surgery was conducted. Relevant symptoms including hypoesthesia of the ipsilateral foot disappeared gradually after 2 months of neurotrophic treatment.

Discussion

Our results demonstrated that the reduction quality was similar with or without an additional KL approach. Even through the PW detachment was not especially fixed during the surgical procedures, the stability of the hip joint was restored through anterior surgical procedures, and redisplacement was not observed in the follow-up. Compared with plating through the KL approach in KL group, the nonfixation of the PW fragment performed in Nonfix group was a less invasive technique with a lower complication rate.

Fracture Characteristics of Both-Column Fractures with PW Involvement

The morphological characteristics and injury mechanisms of the PW associated with both-column fractures and in isolated PW fractures are completely different[5,21–23]. Central dislocation of the femoral head frequently accompanies both-column fractures because of the strike on the anteromedial part of the acetabulum[21]. Then, anteromedially displaced main fragments may be separated from the PW fragment, which usually present as minimally displaced and noncomminuted with a large fracture surface[3,24]. Meanwhile, the associated femoral head fracture and hip capsule avulsion are seldom observed in this injury pattern. The fracture line of the PW frequently extends proximally to the higher proportion of lateral ilium with "pull force" from hip joint capsule[3,12]. Regarding the PW fragment as a lever, the anteromedial detachment in distal proportion can lead to a contrary displacement of the proximal part. For patients with severe medial displacement of the entire acetabulum, the posteriorly displaced proximal tip of the PW fragment is prone to form an "anti-spur" sign in the obturator view, which can serve as an auxiliary method for the diagnosis of this fracture type (Figure 3)[24]. As for isolated PW fracture, it is caused by the femoral head striking the PW posteriorly. The fracture fragment frequently is comminuted and displaced visibly and involves posterior dislocation of hip. Posterior dislocation of the femoral head, meaning instability of the hip joint, is a common symptom[5,6,22].

TABLE 3 Complications of two groups

Characteristics	Nonfix group	KL group
Infection	–	2
Thrombosis	–	1
Hematoma	1	2
Sciatic nerve injury	–	1
LFCN injury	1	2

The complication rates were 7.69% (2/26) in Nonfix group and 34.78% (8/23) in KL group ($X^2 = 3.972$, $p = 0.046$).

Posterior Stability of the PW Associated with Both-Column Fractures

The main indication for fixation of the PW fragment is hip instability[1,4,25]. The anterior displacement tendency of the PW and femoral head were eliminated for the block of fixed main fragments. In addition, Shin *et al.*[10] reported that the PW associated with both-column fractures did not accompany posterior hip joint instability in contrast to isolated PW fractures. And no case of posterior instability was found on the intraoperative dynamic assessment, which was the same as our results. Moreover, the integrality of the capsule and surrounding soft tissues contributes greatly to the stability of the hip joint[26]. Avulsion of the capsule and posterior soft tissues maintaining the hip stability is seldom involved in both-column fractures because the injury mechanism was not a direct strike on the PW. In such cases, this is confirmed by

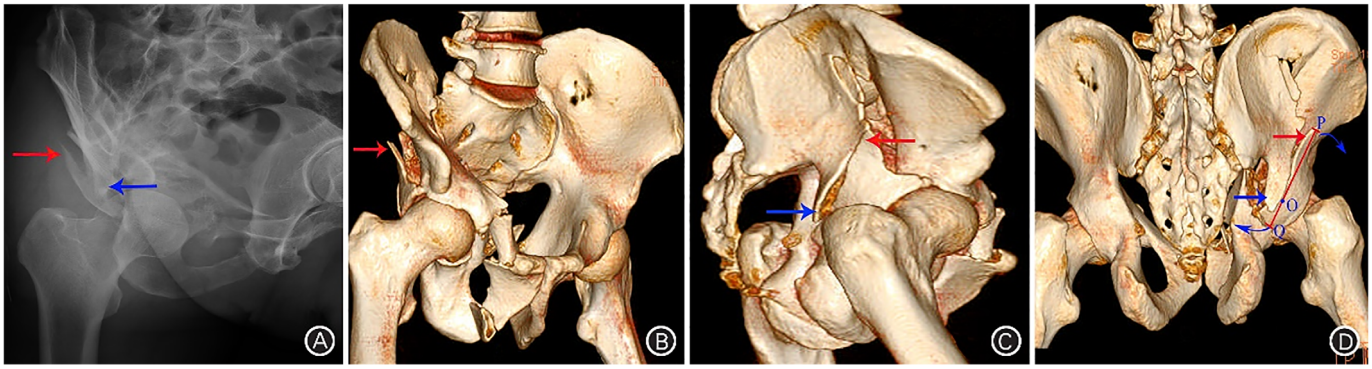

Fig. 3 Radiographic characteristics of both-column acetabular fractures associated with PW fragment. Spur sign and "anti-spur" sign were marked with blue and red arrows, respectively. (A) obturator view; (B, C) obturator and lateral view of three-dimensional reconstruction; (D) the displaced tendency of PW fragment was marked with curved arrows in the posterior view of three-dimensional reconstruction, P, proximal part of PW fragment; O, the "fulcrum" of the lever; Q, distal part of PW fragment

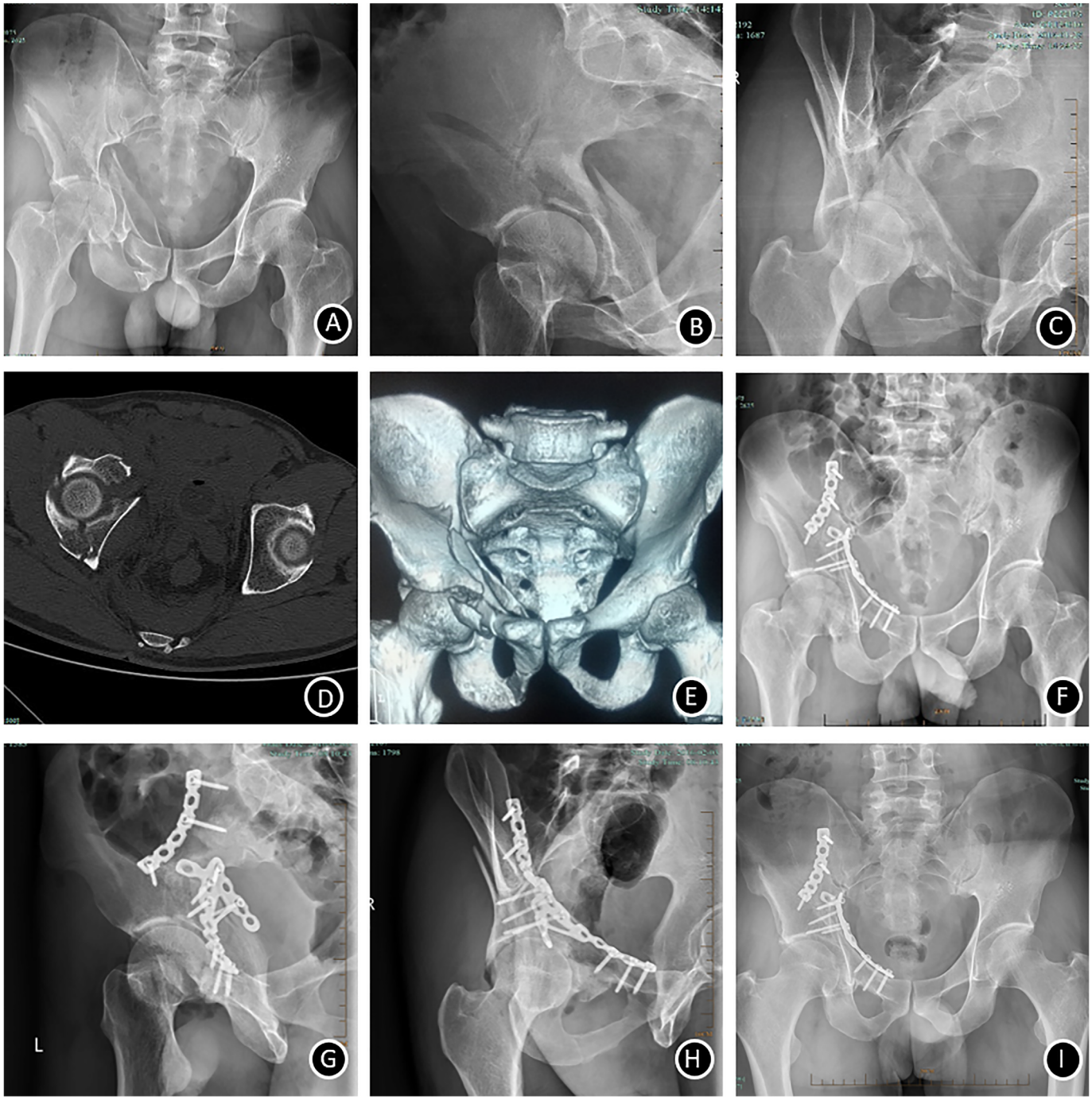

Fig. 4 A male patient in Nonfix group was presented. (A–C) preoperative AP and Judet views; (D–E) preoperative CT scan and three-dimensional reconstruction; (F–H) postoperative AP and Judet views showed satisfactory reduction and congruency of hip joint; (I) fracture lines disappeared and redisplacement was not observed in the follow-up

the fact that postoperative redisplacement of Nonfix group was not observed in the follow-up (Figure 4). Thus, additional fixation for PW fragments in both-column fractures may be unnecessary.

Advantages of Nonfixation for the PW Fragment

It has been reported that acceptable reduction quality for main fragments of both-column fractures can be obtained through a single anterior technique[3,13]. Secondary congruence

of the acetabulum and femoral head is a characteristic of both-column fractures, meaning that joint contact stresses are evenly distributed throughout the articular surfaces[13,21]. Then, the femoral head and the PW detachment can be indirectly reduced by the compression role of main fragments during the anterior reduction procedure. Moreover, the PW fragment can also be indirectly reduced with the traction of the uninjured capsule and the surrounding soft tissues after the femoral head reduction[3]. Chen *et al.*[11] also demonstrated that the clinical outcomes were similar regardless of whether or not the PW associated with both-column fractures was reduced and stabilized. Therefore, although KL incision had not been especially performed in Nonfix group, postoperative radiographic examination showed that a satisfactory reduction effect similar to that of KL group was obtained.

Regarding our results, accepted reduction quality and stability of fragments were achieved for the patients in both groups. Standard postoperative rehabilitation treatment was performed for all patients; therefore, there was no significant difference in the functional outcomes between the two groups. However, a posterior KL procedure was routinely conducted in KL group; thus, their mean blood loss, operation time, and complication incidence were higher than those of Nonfix group. Infection and hematoma were more prone to occur in KL group because of a longer operation time and additional soft tissue exposure. Iatrogenic injury of the LFCN may occur during the iliac fossa approach because of its highly variable branches and course[13]. However, peripheral cutaneous nerves may gradually grow to replace the function of the injured LFCN during the rehabilitation process. Thus, LFCN injury can be a self-limiting complication, and relevant symptoms, including skin numbness of the lateral thigh, may disappear after conservative treatment[27]. A flexed knee should be maintained during the surgical procedure to reduce the tension on the sciatic nerve and decrease the risk of developing deep venous thrombosis in the lower extremities[28]. There may be anatomic variation in the course of the sciatic nerve, which may be injured during the extensive exposure in the KL approach[29]. Moreover, additional KL incision would increase the nursing difficulty in the process of rehabilitation.

Limitations

The study had several limitations. First, as a retrospective study, the patients in two groups were not randomly recruited but according to differences in time. Second, this study had a limited sample size with a relatively short follow-up time. Third, the patients with PW fragments in both-column fractures fixed with lag screws were not recruited as a control group. In future clinical study, a prospective randomized controlled trial (including PW fragments fixed with lag screws) incorporating a longer follow-up should be performed to explore the best management method for PW fragments in both-column fractures.

Conclusion

In conclusion, the effective reductions in both-column fractures with PW detachment could be obtained through a single anterior technique. Although the PW fragments of both-column fractures were not fixed, acceptable stability of the fragments and satisfactory clinical outcomes could be achieved.

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