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Research article

A novel approach for posterior acetabular fractures: Surgical technique

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Abstract: This article describes a novel approach, the Direct Posterior Approach (DPA) for the treatment of posterior acetabular fractures (posterior column, posterior wall, or both posterior column and wall). This technique allows direct visualization of the entire posterior wall, part of the hip capsule and the posterior column between the space of the gluteus medius and the piriformis superiorly. The approach spares the division of short external rotators, abductors, and hip capsule, thus preventing iatrogenic damage to the medial femoral circumflex artery, sciatic nerve, and superior and inferior gluteal neurovascular bundles, as well as protecting the vascularity of the fracture fragments. In addition to the low blood loss, short operative time and low risk of iatrogenic injury, patients who are treated by the DPA approach exhibit positive functional recovery in follow-up. DPA is an effective, safe and minimally-invasive technique for the treatment of posterior acetabular fractures.

Key words: Direct Posterior Approach; acetabular fractures; surgical technique; posterior column; posterior wall

1. Introduction

Posterior portion fractures of the acetabulum are the most frequent pattern of acetabular fractures, comprising approximately 19.4–35% of all acetabular fractures [1,2]. Based on the works of Judet and Letournel [3,4], accurate reduction and stable osteosynthesis with early mobilization have become the gold standard for the treatment of posterior acetabular fractures [5]. When faced with acetabular

fractures involving the posterior portion, the Kocher-Langenbeck (K-L) approach is regarded as the classic approach for its direct visualization of the entire posterior column and posterior wall as well as indirect access to the true pelvis [6,7]. However, the extensive incision of the K-L approach results in high risks of medial femoral circumflex artery (MFCA) and sciatic nerve (SN) injury intraoperatively, especially for inexperienced surgeons [8,9]. In addition, the sharpness damage of muscles used in the K-L approach usually results in formation of heterotopic ossification (HO) and decreased muscle strength post-operatively [10,11].

Over recent decades, minimally-invasive surgery has become a clinical trend because of its expected benefits including less tissue trauma and early rehabilitation. In the standard K-L approach, the gluteus maximus is split to expose the posterior patterns of the acetabulum, and the short external rotators (SER) are dissected; moreover, the capsule of the hip would be dissected if necessary. As a result, numerous surgeons have focused their views on a minimally-invasive modification of the K-L approach [12–16].

In the present study, a novel minimally-invasive posterior approach, the DPA, based on the classic K-L approach, was designed to treat posterior acetabular portion fractures and the clinical outcomes were evaluated over a 1 year follow-up.

2. **Materials and methods**

2.1 Inclusion and exclusion criteria

Inclusion criteria were: (1) acute acetabular fractures (<21 days); (2) acetabular fractures involving the posterior wall, posterior column, posterior wall and posterior column.

Exclusion criteria were: (1) open fractures; (2) acetabular fractures involving the anterior portion and quadrilateral plate which required an anterior approach; (3) follow-up for less than 1 year or loss to follow-up.

2.2 Patients

The study was approved by the Ethics Committee of the Third affiliated hospital of Southern Medical University, Guangzhou, China, and all procedures involving human participants were carried out in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Between January 2016 and June 2017, 22 consecutive patients with acetabular posterior portion fractures treated surgically in our trauma center using the DPA were retrospectively analyzed. Finally, 10 patients were included in this study according to our inclusion and exclusion criteria. Before surgery, all patients underwent radiographic examinations including X-rays (anteroposterior (AP) view and Judet view) and computed tomography (CT) scans (slice thickness of 1 mm) with three-dimensional (3D) reconstructions.

2.3 Surgical technique: Patient preparation

All surgical procedures were performed by the same senior surgeon in this study.

The patients with hip dislocation underwent a closed reduction and supracondylar traction as soon as possible after admission. All patients received routine antibiotic prophylaxis 30 min prior to operation. Under general anesthesia, the patient was placed in a prone position on the radiolucent operating table, with hip extension and knee flexion to avoid excessive tension on the SN. The feasibility of obtaining AP and Judet oblique views captured by C-arm fluoroscopy was verified for each patient before surgical draping. As shown in Figure 1, the posterior superior iliac spine and the posterior margin of the tip of the greater trochanter were treated as the landmarks for incision.

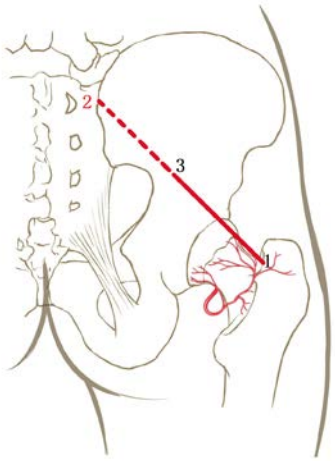

Figure 1. The landmarks for DPA. (1) Posterior tip of the greater trochanter. (2) Posterior superior iliac spine. (3) Midpoint between (1) and (2).

2.4 Surgical technique: Surgical procedure

Essentially, the skin incision of the DPA is similar to the proximal portion of the classical K-L incision [7]. A straight skin incision was initiated from the midpoint between the posterior superior iliac spine and the posterior tip of the greater trochanter, and extended towards the latter approximately 8–11 cm (Figure 2A,E). The gluteus maximus muscles were dissected bluntly along the muscle fibers. Neither the proximal part of the gluteus maximus attaching to the iliac crest nor the distal part inserting into the femur was detached. Holding the layers of the gluteus maximus apart using retractors, the piriformis and gluteus medius were exposed and the interval between these two muscles was identified (Figure 2B,F). The SN could be distinguished by its course anterior to the piriformis. With anterosuperior retraction of the gluteus medius muscle, the superior gluteal neurovascular bundle contiguous to the greater sciatic notch could be defined in the proximal direction (Figure 2C,G). Instead of dividing the SERs and abductors, the interval was further developed by retracting the gluteus medius anterosuperiorly and the piriformis posteroinferiorly. In this way, access to the entire acetabular posterior wall, partial hip capsule and the great mass of the posterior column (from the superior margin of the greater sciatic foramen to the sciatic spine) was achieved (Figure 2D,H). Nevertheless, in the region of the greater sciatic notch, the surgeon needed to manipulate carefully to avoid intraoperative damage to

the superior gluteal neurovascular bundle and the SN. This procedure created a space between the undersurface of the piriformis muscle and the posterior wall of the acetabulum, allowing reduction of acetabular posterior portion fractures under direct visualization.

For posterior column fractures with or without posterior wall fractures, fractures of the posterior column should be reduced and fixed first. On the other hand, for posterior wall fractures, any hematoma and hip capsule debris could be cleaned up directly by traction of the fragments, and soft tissue attached to the displaced fragments could be preserved. Capsulotomy of the hip joint was no longer necessary in this approach (Figure 3A). Moreover, as a benefit of the extensive exposure of the intra-articular surface, a marginal compressive fracture of the hip joint could be treated by bone grafting if necessary. After that, anatomic reduction and temporary fixation with K-wires of the posterior wall fragments was performed (Figure 3B). Finally, the appropriate reconstruction plates were chosen to contour adequately to accommodate the shape of the posterior wall and inserted to fix the posterior rim of the acetabulum (Figure 3C). A thorough irrigation was performed and closed suction drainage was placed before wound closure.

The whole procedure was performed between the space of the posterior column through windows between the gluteus medius and the piriformis muscles superiorly and between the SERs and retro-acetabular surface without dividing the rotators and abductors. The fractures of the posterior wall were appropriately stabilized with reconstruction plates. The reduction was assessed from the interlocking of the ragged fracture ends perioperatively without joint incision and division of rotators. The safe insertion of the screws was further assessed by confirming the fixation under an image intensifier.

2.5 Post-operative management

After surgery, the function of the SN was examined once the patient recovered from anesthesia. Routine antibiotic prophylaxis was administered for 24 h postoperatively. Low molecular weight heparin was administered daily for 2 weeks to prevent thrombosis. The suction drain was removed once the aspirated volume was less than 50 mL/d. X-ray examinations and CT scans with 3D reconstruction were performed in all patients postoperatively. Active and passive movement of the hip was started as soon as medically possible. Toe-touch weight bearing with the help of a walker or crutches was allowed at 4–6 weeks, and gradually full weight bearing was started 3–4 months after surgery.

2.6 Patient evaluation

Blood loss, operative time, time to surgery, reduction quality and complications were recorded. Patients received routine postoperative follow-up at 1, 3, 6, and 12 months, and annually thereafter. According to the Matta scoring system [17–19], the reduction of fractures was evaluated by measuring the postoperative residual displacements on postoperative radiographs, with reduction quality classified as anatomic (<1 mm), imperfect (1–3 mm), or poor (>3 mm). At the final follow-up the patients were evaluated clinically building on Merle d'Aubigne and Postel scoring which had been modified by Matta [17,18,20], ranging from excellent (18 points), good (15–17 points), and fair (14 or 13 points), to poor (<13 points).

2.7 Statistical analysis

Preoperative, intraoperative and postoperative data were recorded. Statistical analysis was mainly conducted using SPSS Statistics (SPSS Inc., Chicago, IL, USA). Patient characteristics and results are described by mean, standard deviation, and percentage. One sample T test was used to measure the significant of operative time and blood loss between our data and previous study of K-L approach.

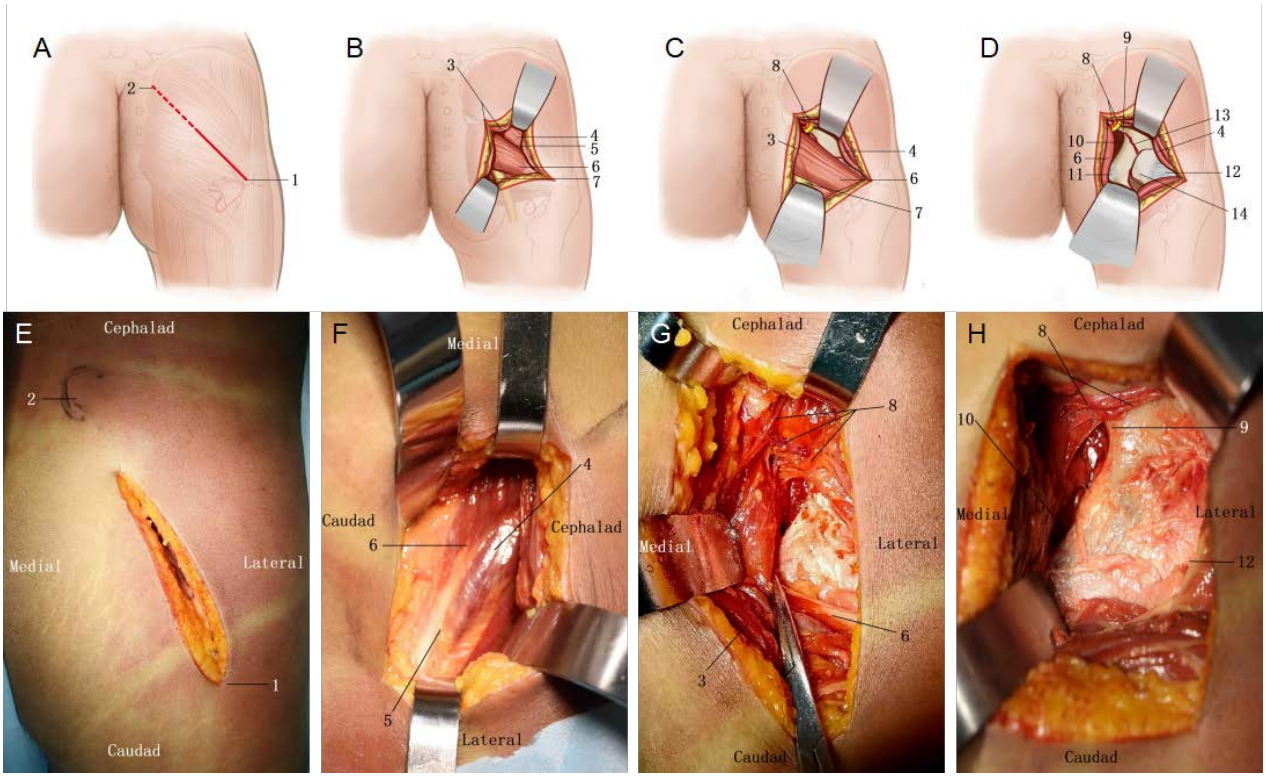

Figure 2. Scheme diagrams and intraoperative photographs of DPA. (A,E) DPA incision. (B,F) The layers of the gluteus maximus, piriformis and gluteus medius were exposed by blunt dissection and the interval between these two muscles was identified under retraction. (C,G) With anterosuperior retraction of the gluteus medius muscle, the superior gluteal neurovascular bundle contiguous to the greater sciatic notch could be identified in the proximal direction. (D,H) The manipulation space of the posterior acetabular fracture (the entire acetabular posterior wall, part of the hip capsule and the posterior column) was further developed by retracting the gluteus medius anterosuperiorly and the piriformis posteroinferiorly. (1) Posterior tip of the greater trochanter; (2) posterior superior iliac spine; (3) gluteus maximus; (4) gluteus medius; (5) interval between the gluteus medius and piriformis; (6) piriformis; (7) sciatic nerve; (8) the superior gluteal neurovascular bundle; (9) superior margin of the greater sciatic foramen; (10) greater sciatic foramen; (11) sacrospinous ligament; (12) capsule of hip; (13) fracture line; (14) displaced fracture fragment.

3. Results

Between June 2016 and June 2017, 22 consecutive patients with posterior portion fractures received surgical treatment through the DPA at our medical center. However, due to incomplete data, 12 patients were excluded from this study. Of the remaining 10 patients, seven were male and three were female, with a mean age of 37 years (range: 17–54 years; SD: 12.3 years). Six patients were injured in traffic accidents and four had a history of falling. According to the Judet and Letournel classification, six patients were diagnosed with isolated posterior wall fractures (60%), and four patients with posterior column and posterior wall fractures (40%). Additionally, in six (60%) patients, posterior wall fractures were associated with posterior hip dislocation. The dislocations were reduced as soon as possible. And preoperative supracondylar traction was performed, using weights up to 10 to 12 kg, until surgery. No abnormalities or deficits of the lower limbs were observed in any patients upon neurovascular examination. None of patients had associated injuries of the extremities or had fractures of the head of the femur. All patients were taken for operation as soon as their general medical condition permitted. The average time between injury and surgery was 6 days (range: 4–11 days; SD: 2.5 days) (Table 1).

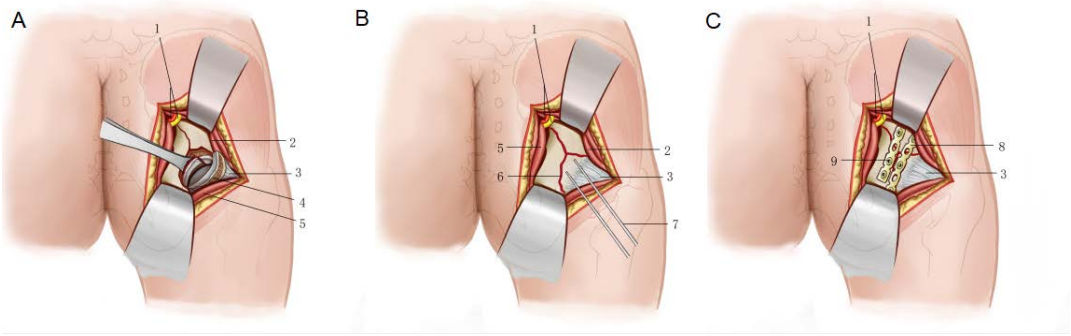

Figure 3. Schematic diagrams of DPA. (A) Hematoma and hip capsule debris could be cleaned up directly by traction of the fragments and the attached soft tissue of displaced fragments could be preserved. (B) Anatomic reduction and temporary fixation of the posterior wall fragments with K-wires. (C) Fixation with reconstruction plates. (1) The superior gluteal neurovascular bundle, (2) gluteus medius, (3) capsule of hip, (4) fracture fragments, (5) piriformis, (6) fracture line, (7) Kirschner wires, (8) reconstruction plate, (9) screw.

For all operations, the mean length of the incision was 9.6 cm (rang: 8–11 cm; SD: 1.4 cm) with a mean operative time of 50 min (range: 35–80 min; SD: 14.5 min). Mean blood loss during surgery was 310 mL (range: 200–440 mL; SD: 82.6 mL). As shown in Figure 4, the operative time and blood loss of DPA exhibited significant decline ($p < 0.01$) when compared that in previous report of traditional K-L approach [21]. All fractures exhibited radiological evidence of fracture union within 12 weeks after surgery (mean fracture union time, 9.3 weeks; range: 8–12 weeks; SD: 1.0 week). In the post-operative evaluations, the postoperative reduction quality was graded as anatomic in seven patients (70%), imperfect in three patients (30%), and poor in zero patients (0%) according to the Matta scoring system [17–19]. No patient exhibited loss of reduction at the end of the follow-up period (Figure 5).

The clinical outcomes based on the modified Merle d'Aubigné scoring system [17,18,20] were as follows: excellent in six patients (60%), good in two patients (20%), fair in two patients (20%), and poor in zero patients (0%) (Table 2).

Table 1. Patient demographic and injury data.

Variable	Value (mean ± SD)	Percent (%)
Gender		
Male	7	70
Female	3	30
Mean age (years)	37 ± 12.3 (range: 17–54)	-
Acetabular fracture type		
Posterior wall	6	60
Posterior column and posterior wall	4	40
Mechanism of injury		
Fall from a height	4	40
Traffic accident	6	60
Associated injury		
Posterior hip dislocation	6	60
Extremity fractures	0	0
Mean time from injury to surgery (days)	6 ± 2.5 (range: 4–11)	-

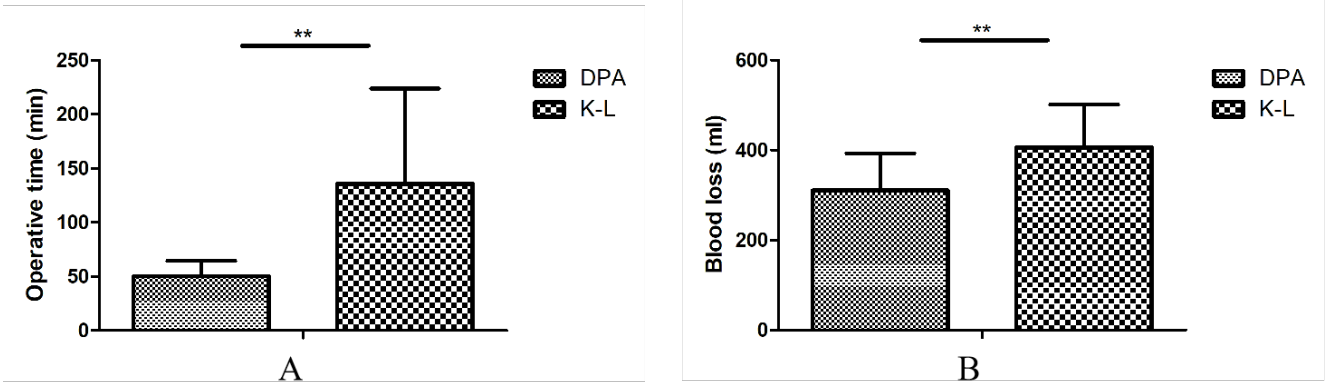

Figure.4. Parametric comparison of DPA and previous study of K-L approach. (A) Comparison of Operative time between DPA and previous study of K-L approach ("**" represented $p < 0.01$). (B) Comparison of Blood loss between DPA and previous study of K-L approach ("**" represented $p < 0.01$).

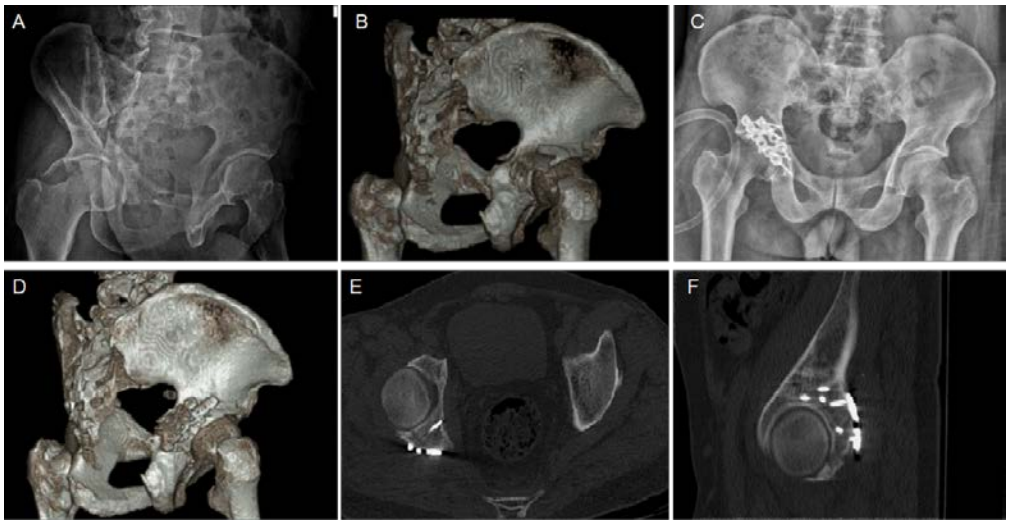

Figure 5. Representative radiographs of a 45-year-old man who sustained posterior column and posterior wall fractures and was treated by the DPA. (A) Pre-operative obturator oblique view; (B) pre-operative 3-dimensional CT scan; (C) post-operative anteroposterior view; (D-F) post-operative 3-dimensional CT scan.

Table 2. Postoperative outcomes and complications.

Postoperative data	Value mean ± SD	Percent (%)
Length of incision(cm)	9.6 ± 1.4 (range: 8–11)	-
Mean operative time (min)	50 ± 14.5 (range: 35–80)	-
Mean blood loss (ml)	310 ± 82.6 (range: 200–440)	-
Mean union time (weeks)	9.3 ± 1.0 (range: 8–12)	-
Reduction quality (Matta)		
Anatomic (<1 mm)	7	70
Imperfect (1–3 mm)	3	30
Poor (>3 mm)	0	0
The modified Merle d'Aubigné score		
Excellent	6	60
Good	2	20
Fair	2	20
Poor	0	0
Complications		
Heterotopic ossification	1	10
Femoral head necrosis	1	10

HO developed in one patient but the range of motion (ROM) of his hip recovered to a similar range as the uninjured hip by the end of the follow-up period. Femoral head necrosis occurred in one case at 9 months after surgery with the diagnosis of complicated posterior wall fractures associated with posterior hip dislocation. The patient received total hip arthroplasty at one year after surgery. Intraoperative radial measurements exhibited an accurate reduction in all patients and no screws were presented in the acetabular fossa. No iatrogenic damage to the SN or the superior gluteal neurovascular bundle and no posttraumatic arthritis was observed postoperatively. There were no instances of wound infection, implant loosening or breakage, recurrent dislocation, deep vein thrombosis, or revision fixation (Table 2).

4. Discussion

Over recent decades, based on the contributions of Judet et al. [3], treatment strategies for acetabular fractures involving the posterior portion have changed from non-operative treatments to surgical treatments. However, for most surgeons, operating on posterior acetabular fractures can be very challenging due to the complex adjacent arteries and nerves [8,22]. Consequently, conventional surgical approaches required extensive exposure and could result in severe trauma and high risks of complications such as HO or iatrogenic nerve or artery injury [8,10,23]. In this study, inspired by the traditional Kocher approach, we designed a novel minimally-invasive posterior approach to treat fractures of the posterior portion of the acetabulum. Satisfactory clinical outcomes were obtained with this reduced approach, with less soft tissue trauma and reduced risks of injury to the iatrogenic SERs, MFCA and SN.

In classic treatment of posterior acetabular fractures, the K-L approach is considered the ideal approach, with the benefit of remarkable exposure. Nevertheless, a 15–20 cm incision should be performed, and splitting of the SERs, abductors, and even the hip capsule is essential for this approach, therefore, extensive intra-operative blood loss and lengthy operative time are always involved [24]. Collinge et al. reported a 644 mL mean blood loss and 258 min mean operative time in 33 operations performed by the classic K-L approach [25]. In addition, for the trochanteric flip osteotomy associated with the K-L approach, although this can improve visualization of the superior acetabulum and enhance the protective on the MFCA, it is associated with increased blood loss and operative time, according to a recent study [16,26]. Furthermore, a rate of trochanter nonunion ranging from 2.1–2.4% is reported after trochanteric flip osteotomy [27,28]. In our study, the DPA provided direct visualization of the entire posterior wall, part of the hip capsule and the posterior column between the space of the gluteus medius and the piriformis, and yet required an incision of only 8–11 cm. Additionally, the mean operative time of surgery via the DPA was 50 min and mean blood loss was 310 mL. These data suggest that the DPA could be considered a minimally-invasive modification of the traditional Kocher approach.

Physically, the SERs, abductors and gluteus muscles contribute to the strength of hip joints, and intraoperative preservation of these components is related positively with post-operative rehabilitation. Matta and Ceylan proposed that the reduced muscular split is associated with improvement of hip abduction in their analyses [29,30]. Simultaneously, Borelli et al. reported a hip-muscle strength deficit post-operatively in 15 operations performed using the classic K-L incision [11]. Consequently, as the DPA utilizes blunt division of the SERs, abductors and gluteus muscles, the DPA can provide opportunities for stable and fast post-operative rehabilitation of the hip joint.

For most surgeons, protection of the MFCA is one of the vital key points for the posterior approach of acetabular fracture, since iatrogenic injury of the MFCA may result in avascular necrosis of the femoral head [31]. Meanwhile, recent investigations suggested that the gluteal artery is involved in the blood supply to the femoral head [32]. Moreover, iatrogenic injury of the SN can catastrophically destroy the functions of the lower limbs. According to recent analyses, a rate of 3–18% of SN injury was associated with surgery via the K-L approach with or without trochanteric flip osteotomy [33–35]. In our design, the manipulation space of the DPA was created through blunt separation of the piriformis muscle, and the gluteus medius, the MFCA, SN, superior and inferior gluteal neurovascular bundles could be well protected synchronously by retractors when compared to both the K-L approach and the osteotomy assistant K-L approach according to the anatomical characteristics of the posterior acetabulum. As a result, there were no instances of iatrogenic injury in our study. Nevertheless, one of our patients presented with femoral head necrosis; however, since the patient experienced extensive dislocation time before transfer to our medical center (11 days), it is our view that the major cause of femoral head necrosis may be the result of dislocation rather than iatrogenic injury of the supplying arteries.

HO is one of the unfortunate possible complications in orthopedics which result in chronic pain and unsatisfactory hip function [36]. Negrin et al. reported an HO rate of 37.9% post-operatively, in the analysis of 167 cases treated by the K-L approach [37]. Based on past investigations, HO is believed to be strongly related to the incision and split division of muscles [15,38]. Although there was one patient who presented with HO at 3 months post-operatively, the DPA approach may provide a low risk of HO due to the blunt division performed during surgery.

In recent reports, some minimally-invasive approaches similar to DPA have been described. SER-sparing modifications of the K-L approach for selected posterior portion fractures have been reported by Magu [13], Josten [14] and Sarlak [15]. A mean operative time of 73.2 min and mean blood loss of 187 mL in 14 cases were described by Magu and the reduction quality measurements showed an excellent outcome in ten patients (71%), good in three (22%) and fair in one (7%) [13]. In 2011, Josten et al. applied the same approach to stabilize nine patients with a mean operative time of 94 min, the reduction quality was classified as anatomic in five patients, imperfect in three, and poor in one patient [14]. In our results, the DPA resulted in similar operative time and blood loss; in addition, the modified Merle d'Aubigné scoring measurements presented approximate results when compared to the recent reported minimally-invasive approaches for posterior acetabular fractures. Our data suggested that the DPA may be a safe and minimally-invasive technique for the treatment of posterior acetabular fractures. Although the DPA exhibited advantages and excellent follow-up results in this study, the limitations of small case volume and short follow up time remain. Simultaneously, there are no data comparing the DPA and the K-L approach. Therefore, in further studies, a larger number of cases and longer follow-up time is necessary, while comparison of the DPA with other classic approaches for treatment of posterior acetabular factures will also be necessary.

5. Conclusion

In this study, a novel minimally-invasive approach for the treatment of posterior acetabular fracture was described and evaluated by 1 year follow-up. In addition to the low blood loss, short operative time and low risk of iatrogenic injury, the patients who underwent the DPA exhibited positive functional recovery in follow-up. Therefore, we conclude that the DPA is an effective, safe and minimally-invasive

technique for the treatment of posterior acetabular fractures.

Acknowledgments

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Conflict of interest

All authors declare no potential conflicts of interest.

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