Observational Study

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Biaxial reduction technique for the medially displaced quadrilateral surface in acetabular fracture through the modified iliofemoral approach

An observational study

Byung Hoon Lee, MD, PhD*

Abstract

Treatment of acetabular fractures is technically demanding injuries. The complex surgical approaches and special equipment have been introduced for achieving accurate anatomical reduction.

The aim of the study was to present our experiences of using a newly operative technique to achieve accurate reduction of articular dome impaction and of the quadrilateral surface without special equipment or traction device in reference to fracture reduction and fixation, technical aspects, and the incidence of complications.

Five acetabular fractures with involvement of the quadrilateral plate associated anterior column and posterior hemi-transverse fractures were treated with an anatomically curved reconstruction plate and 2 lag screws using a biaxial reduction technique with a modified iliofemoral approach. The impacted quadrilateral plate was reduced without special equipment with accurate reduction of the articular surface by direct digital palpation in an extensive working space.

Fracture reduction was assessed by Matta radiographic scoring as anatomic (within 1 mm) or satisfactory reduction (between 1 and 3 mm) in all 5 cases. Functional outcomes, according to the Harris hip score system, were greater than 90 points in all 5 patients. No loss of reduction, joint penetration, or visceral and neurovascular injury was documented at 1-year follow-up.

The biaxial reduction technique with a modified iliofemoral approach provides a versatile method for fracture fixation and greater surgical access in medial impacted dome injury with comminuted anterior AC fracture without special equipment or traction device.

Observational study, level IV

Abbreviations: 3D = three dimensional, AC = anterior column, AIIS = anteroinferior iliac spine, AIP = anterior intrapelvic, ASIS = anterosuperior iliac spine, CT = computed tomography, LFCN = lateral femoral cutaneous nerve.

Keywords: acetabular fracture, biaxial reduction technique, modified iliofemoral approach, quadrilateral plate

1. Introduction

Management of associated acetabular fractures is challenging. Complex surgical approaches and the difficulty of achieving anatomical reduction make the learning curve to high-quality patient care extremely steep.[1] Accurate reduction is required to prevent post-traumatic arthritis. Technique-related complications are common owing to pelvic anatomy, difficulty in surgical access, and infrequent exposure to acetabular fractures.[2,3] Misdirected or misplaced screws during internal fixation are documented in 4% of operatively treated acetabular fractures.[4–6]

There are several operative approaches to the acetabulum with an emphasis on visualization, which facilitates reduction and application of instrumentation.[7] Despite careful perioperative planning, accurate anatomic reduction is difficult in cases of displacements of both columns or hemitransverse fracture patterns. For this reason, different reduction techniques[8,9] and special equipment are used, including “Matta” forceps, “King Tong” clamp for quadrilateral surface reduction, and collinear clamp.

In the authors’ opinion, direct visualization and assessment is crucial for adequate quadrilateral plate reduction, as is the reduction maneuver. The iliofemoral approach can provide direct and extensive vision of the inside of the pelvic bone and quadrilateral plate and allows for the safe screw positioning. The operative field in this approach creates a wider working space and allows the surgeon to directly identify the entry and exit points of screws.

We treated 5 acetabular fractures associated with anterior column (AC) fractures and medialization of the femoral head (protrusio) and impaction of the superomedial acetabular dome using an anterior iliofemoral approach combined with a minimal Stoppa incision to gain direct vision of the displaced quadrilateral plate and anterior and posterior column. We also propose a safe and effective reduction technique, “biaxially purchasing

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Department of Orthopaedic Surgery, Kang-Dong Sacred Heart Hospital, Hallym University Medical Center, Seoul, Korea.

*Correspondence: Byung Hoon Lee, Department of Orthopaedic Surgery, Kang-Dong Sacred Heart Hospital, Hallym University Medical Center, Gil-dong, Seoul, 134-701, Korea (e-mail: oselite@naver.com).

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Table 1

A total of 5 consecutive cases of acetabular fracture were treated in our institution from March 2014 to August 2015.

	Sex	Age	Fracture type*	Time to surgery, days	Operative time, min	Blood loss, mL	Matta reduction score†	Complication	HHS (1 year after surgery)
1	M	54	AC+PHT	5	210	1800	Anatomic	Supf. wound infection	90
2	M	54	AC+PHT	5	90	800	Anatomic	None	93
3	M	41	AC+PHT	8	145	1200	Anatomic	Heterotopic ossification	91
4	M	50	AC+PHT	5	220	1000	Anatomic	None	92
5	F	48	AC+PHT+PC	6	170	1500	Satisfactory	None	98

HHS = Harris hip score.
* Letournels' classification: AC anterior column, PHT posterior hemi transverse, PC posterior column.
† Mattas' classification: 0–1 mm step/width = anatomic; 2–3 mm satisfactory; >3 mm unsatisfactory.

reduction," to achieve accurate reduction and we present the outcomes achieved. This study presented our experiences of using a newly operative technique to achieve accurate reduction of articular dome impaction and of the quadrilateral surface without special equipment or traction device in reference to fracture reduction and fixation, technical aspects, and the incidence of complications.

2. Methods

2.1. Patient selection

The present study was approved by the institutional review board, and signed informed consent was obtained from each participant (KANGDONG 2016-10-011). We enrolled retrospectively 5 consecutive patients treated in our institution for anterior column and posterior hemitransverse pelvic fractures from March 2014 to August 2015 (4 males, 1 female; average age: 49.4 years). The injuries were caused by traffic accidents in 3 cases, and 2 patients fell from a low height. Average time from injury to surgery was 5.8 days (range 5–8 days). Anteroposterior and Judet radiographs were taken for all patients, as well as pre- and post-operative 3D CT scans. The displacement of all fracture fragments was greater than 3 mm.

Skeletal traction was applied prior to the operation to reduce pain or maintain the reduction. Before the surgical procedure, vasculature was evaluated by Angio-CT. Follow-up for all patients was at 2 and 6 weeks, 3 and 6 months, and 1 year. Post-operative reduction was evaluated on all 3 views with the Matta radiographic scoring system; displacement of 1 mm or less was considered an anatomic reduction. Harris hip scores were used to assess functional outcomes. Peri-operative data and complications were obtained by retrospective chart review. Minimum follow-up was 12 months (Table 1).

2.2. Surgical technique

Our preferred technique is to operate on the patient in the supine position on a radiolucent table with a small lumbar roll on the side of the injured acetabulum. The ipsilateral limb is draped freely, so that hip and knee joints can be moved as required. A urinary Foley catheter is inserted for improved visualization, bladder protection, and monitoring of fluid balance. The fracture is exposed through an iliofemoral approach. The skin incision is along the iliac crest, extended up to the anterolateral aspect of the thigh, passing through the anterosuperior iliac spine (ASIS) (Fig. 1).

2.3. Surgical technique—ASIS osteotomy

During ASIS osteotomy surgical dissection was performed in the intrafascial plane to avoid injury of the lateral femoral cutaneous nerve (LFCN). After palpation of ASIS, sartorius fascia is dissected longitudinally, distal-to-proximal (Fig. 2A). Then, the sartorius muscle is bluntly dissected in the intrafascial space proximally and ASIS is palpated (Fig. 2B). ASIS is osteotomized vertically and horizontally including the insertions of the inguinal ligament, and the sartorius muscle is reclined inward and the

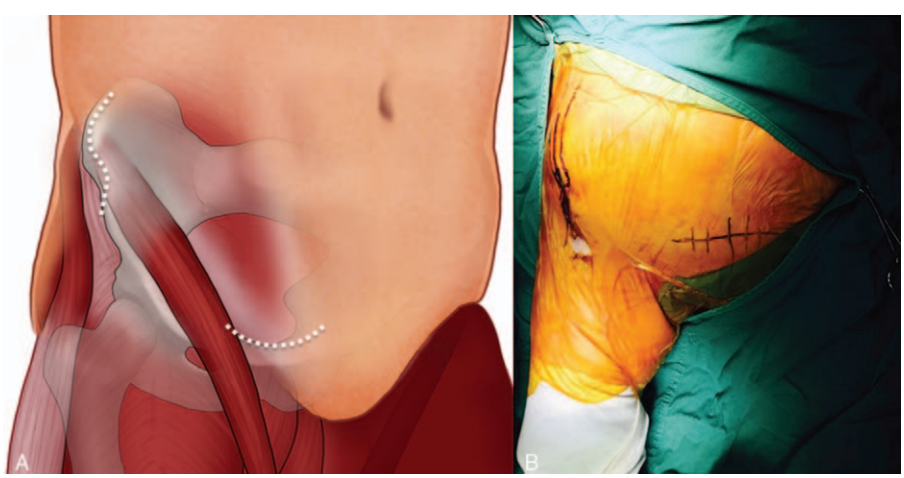

Figure 1. Skin incision for the iliofemoral and minimal Stoppa approach. (A) Schematic drawings (B) clinical photograph.

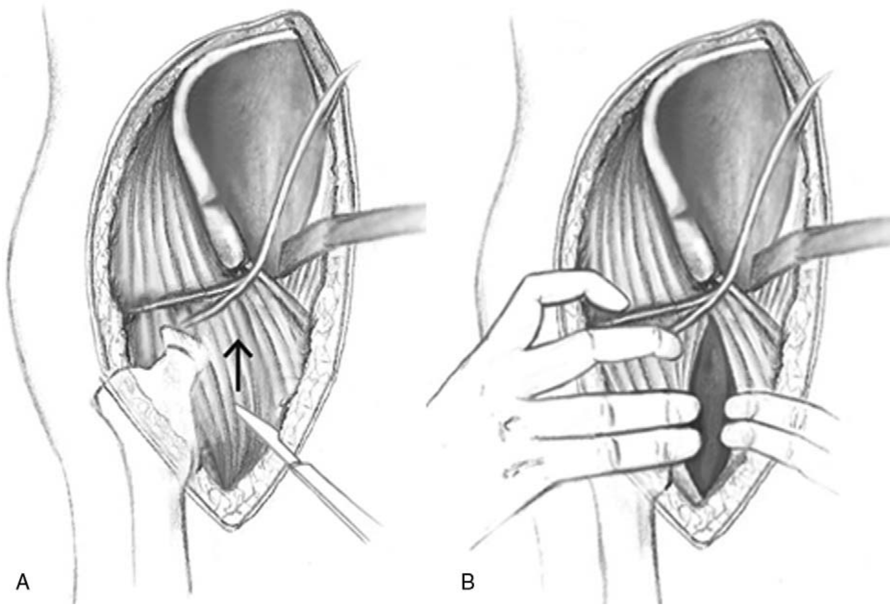

Figure 2. Schematic drawings of the osteotomy of ASIS. ASIS = anterosuperior iliac spine.

muscles of the endopelvic side of the iliac fossa are elevated. The osteotomized ASIS and attached sartorius muscle, LFCN, and femoral neurovascular bundles are retracted medially without iatrogenic injury. The anterior wall of the acetabulum can be accessed by pushing back the iliopsoas muscle medially and elevating its iliocapsularis head. Dissection is extended onto the origin of the rectus femoris. If necessary, the conjoint tendon of the rectus muscle is transected, leaving a tendon stump for later repair, to expose the hip capsule and visualize the hip joint. In our cases, there was no opening of the capsule to look at dome impaction. Then, the anterior column was exposed. The ilium and the quadrilateral surface of the pelvis are stripped subperiosteally. The sciatic notch is identified with a large Homan retractor. After irrigation and curetting of blood clots, we encountered the acetabular medial wall and the fracture site was identified (Fig. 3A).

2.4. Surgical technique—anterior columnar fracture reduction with minimal anterior intrapelvic (AIP) approach

A minimal AIP surgical approach was performed as previously described.[10] After a short "Pfannenstiel" incision, the rectus muscle is split at the midline, and soft tissues are elevated medially to laterally along the pelvic brim until the fracture lines along the AC are exposed. The periosteum and fascia adherent to the iliopectineal eminence are carefully lifted with a periosteal elevator. Then, subperiosteal dissection was performed with a curved, long Kelly clamp to introduce an anatomically curved plate along the iliopectineal line. The plate is inserted into symphysis pubis under direct visualization of the anterior columnar comminuted fracture through the lateral window. Anterior column fracture reduction is, thus, achieved by fixation of an anatomically curved reconstruction plate.

2.5. Surgical technique—biaxial reduction technique

Reduction of the medially impacted acetabular dome is achieved with 2 screws in the other direction. One is for posterior column fixation (longitudinal screw); the other is a supra-acetabular lag screw for lateralizing the quadrilateral surface (transverse screw). Initially, a 3.2 mm track for the longitudinal screw is drilled from a point 1 cm lateral to the pelvic brim and 2 cm anterior to the sacroiliac joint and posterior column, keeping in the direction in the posterior column. Then, the trajectory of a Kirschner wire for the transverse screw through the supra-acetabular region is verified under fluoroscopic control by digital palpation to ensure it reaches the posteromedial surface and is adequately captured. A 6.5 mm partially threaded cannulated screw is then inserted.

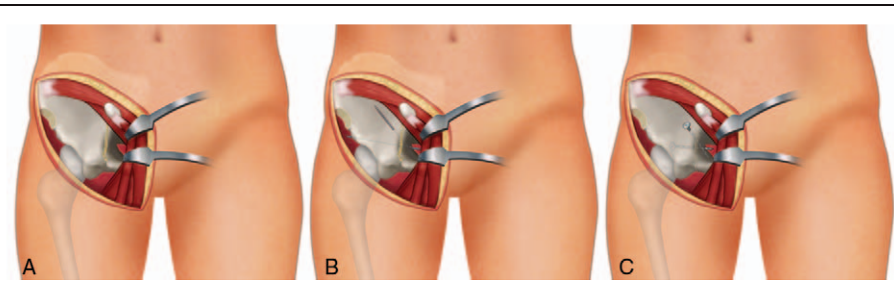

Figure 3. Schematic drawings of the modified iliofemoral approach and biaxial purchasing reduction technique.

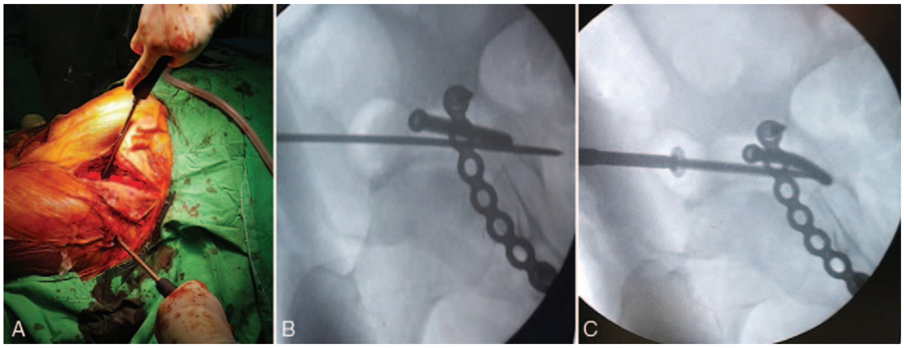

Figure 4. Biaxial reduction technique (A) involved insertion of a 6.5 mm cancellous screw to posterior column along medial and posterior column border or 6.5 mm partially threaded CCL screw (B) from the outer side of the iliac wing, 0.5–1 cm posterior and inferior to the an AIIS; (C) posterior columnar cancellous screw was bended with tightening of percutaneously inserted supra-acetabular lag screw. AIIS = anteroinferior iliac spine, AIP = anterior intrapelvic, CCl = cannulated screw.

Whether it also penetrates into the hip joint can be seen after capsulotomy and detachment of the rectus femoris muscle near anteroinferior iliac spine (AIIS).

Two biaxial screws purchase in this thick strut of bone (in the mid-portion of posterior column), as shown (Fig. 4). Space permitting, 2 screws may be placed in the posterior column through this safe corridor (Fig. 3B). As the biaxial lag screw is tightened, the displacement becomes smaller (Fig. 3C). It is important to ensure simultaneous biaxial reduction of the posterior column by digital palpation and intraoperative imaging.

The osteotomized ASIS is fixed back to the ilium with two 4.5 mm partially threaded cannulated screws. The wound is closed in layers after placement of a negative suction drain, which was used for 24 to 48 hours after surgery.

2.6. Postoperative management

Low-molecular-weighted heparin was routinely given for 3 weeks from the first post-operative day. Functional muscle contraction training began as early as 24 hours after surgery, with passive exercises after drain removal gradually extending to active flexion and extension of the hip. Patients were allowed to partially weight-bear after 4 to 6 weeks, and to fully weight-bear after 8 to 12 weeks.

3. Results

The average duration of surgery was 167 minutes (range 90–220 min). Mean blood loss was 1260 mL (range 800–1800 mL). Patient follow-up was for a minimum of 13 months (range 12– 19 months). Fracture reduction was assessed by Matta radiographic scoring as anatomic (within 1 mm) or satisfactory reduction (between 1 and 3 mm) in all 5 cases (Fig. 5). Functional outcomes, according to the Harris hip score system, were greater than 90 points in all 5 patients. No loss of reduction, joint penetration, or visceral and neurovascular injury was documented. Considerable surgery time could be saved and surgeons were confident about screw placement. No loss of reduction was seen until complete healing. All fractures were united after an average period of 2.8 months.

4. Discussion

The findings of our study relevant for the management of impacted acetabular dome injury associated anterior column are: (1) the iliofemoral approach with novel ASIS osteotomy technique does not disturb LFCN and creates sufficient visualization and workspace close to fracture lines involving the anterior column and quadrilateral surface, while sparing abdominal muscles and neurovascular structures within the femoral triangle. (2) Direct visualization and palpation of both columns and intra-articular control of reduction are decisive advantages that help achieve the best-possible screw trajectories, which reduce functional impact and morbidity. (3) The biaxial reduction technique does not require special instruments for accurate reduction of the articular surface and enables well-controlled and simultaneous reduction and fixation. (4) The modified iliofemoral approach enables accurate screw placement by digital palpation of exit and entry points, placement of the "posterior column–screw" more in line with the posterior column towards the ischial tuberosity, and plate anchoring into the sciatic buttress.

The ultimate goal of treatment for acetabular fractures is to achieve a "reduction parfaite" (Letournel), as the slightest defect (>1 mm) in the articular surface can lead to arthritis and poor functional outcomes.[1] As the presence of dome impaction and quadrilateral surface injury probably plays a decisive role in outcomes, optimal treatment of dome impaction is very important.

Given the difficulty of managing associated acetabular fractures, alternative approaches, such as AIP and modification of the traditional ilioinguinal approach,[11] have been proposed. The ilioinguinal approach does not allow intraarticular inspection and relies on apposition of visible extra-articular surfaces for joint congruence. AIP requires (1) less invasive dissection without exposure of the inguinal canal, and (2) allows direct visualization and access to the entire pelvic brim, the external iliac to obturator anastomosis, and the quadrilateral plate for reduction and plating.[12] This provides access to the impacted dome segment through the displaced AC fracture and wide visualization of the quadrilateral surface, which in turn allows direct reduction and optimal implant placement to neutralize deforming forces. The medial acetabular dome surface can be directly visualized through the lateral window over the brim onto the quadrilateral surface. However, if working space through the lateral window is small, reduction may be difficult, as may be visualization of the posterior column area.

In contrast to ilioinguinal and AIP approaches, the iliofemoral approach exposes the impacted articular surface, quadrilateral

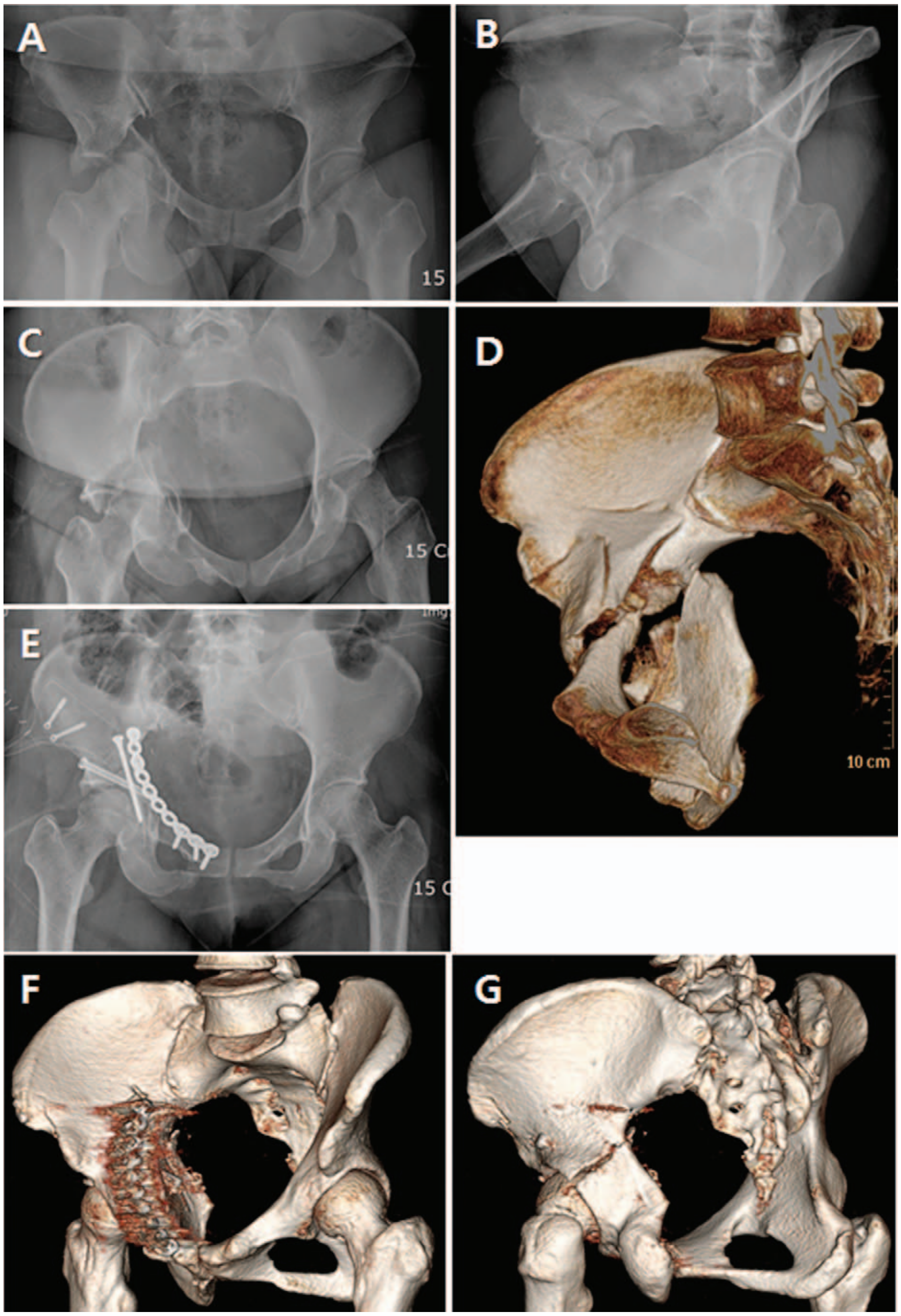

Figure 5. A 48-year-old woman suffered from acetabular fracture associated with both column fractures, which identified at the anteroposterior (A), oblique (B), pelvic inlet (C) radiograph. 3D-CT reconstruction image shows the acetabular fracture clearly (D). Postoperative anteroposterior radiograph (E) and 3D-CT reconstruction images (F, G) after the internal fixation of the acetabular fracture shows a good reduction of the acetabular fossa and both column and the ilium. 3D-CT = three dimensional computed tomography.

plate, and even the posterior column. It facilitates assessment of the reduction, provides more space for manipulation and safe positioning of the lateral supra-acetabular lag screw, and reduction can proceed in a centripetal direction towards the articular surface. Commonly used measures to avoid iatrogenic complications, such as intraoperative radiographs or fluoroscopy and auscultation of the hip joint during passive movement, are useful but cannot guarantee the safe placement of screws.[13–15] The iliofemoral approach by itself may not desirable when the iliopectineal eminence is comminuted. However, if combined with a minimal Stoppa approach, it would make ease to reduce and fix even a comminuted anterior columnar fracture with an additional pelvic brim plate.

The biaxial reduction technique is based on traction: lateral and longitudinal traction over the femur (with a Steinman pin inserted in the greater trochanter) applied in a semi-flexed position. Indirect reduction or reduction with special equipment for dis-impaction of dome is unpredictable, and reduction and stabilization can often be difficult.[10] And buttressing by longitudinal posterior columnar screws might achieve less fixation in a lateral direction than the combined effect of a direct lateralizing transverse screw and posterior columnar screw.

Compared to a conventional 3.5 mm cortical screw, we believe that the 6.5 mm partially threaded cancellous screw provides more rigid stability. In contrast to the modified Stoppa and Pararectus approaches, our approach and reduction technique is also less invasive, yet safe and effective for the fixation for acetabular fractures[16–17] and it allows reduction of quadrilateral plate.

4.1. Limitations

The findings of the present study are limited by its retrospective, single-center design with associated potential patient selection bias and influence by operator experience and interoperator technique variation. The study lacks a control group, which limits comparisons with alternate techniques. Larger, multicenter, randomized controlled studies are warranted.

5. Conclusion

The biaxial reduction with separated skin incision introduced in this study provided a versatile method for fracture fixation and greater surgical access in medial impacted dome injury with comminuted anterior AC fracture without special equipment or traction device.

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