A safe technique of anterior column lag screw fixation in acetabular fractures

Ramesh Kumar Sen • Sujit Kumar Tripathy •
Sameer Aggarwal • Tarun Goyal • Dharm S. Meena •
Santosh Mahapatra

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Abstract

Purpose Conventional anterior column lag screw fixation in acetabular fracture is a difficult technique that has potential risks of vascular injury, hip joint penetration and excessive radiation exposure. We propose a safe technique of anterior column lag screw fixation (in-out-in technique) and present the outcome.

Materials and methods Twenty-seven acetabular fractures were operated through an iliofemoral approach, where the ‘in-out-in technique’ of lag screw fixation was a part of the surgical procedure. The technique involved insertion of a malleolar screw (4.5 mm) or 6.5 mm partially threaded cancellous screw from the outer side of the iliac wing, 0.5–1 cm posterior and inferior to the anteroinferior iliac spine. The screw comes out of the bone surface to re-enter into the anterior part of iliopectineal eminence, and finally gains purchase in the lateral part of superior pubic ramus. The screw fixation procedure was under direct visualization without resorting to an image intensifier. The average follow-up of the patients was at 18.6 months (range 12–36 months).

Results No loss of reduction, joint penetration or visceral and neurovascular injury were documented. The average duration of surgery was 70 min and blood loss was 290 ml. All fractures were united after an average period of 2.8 months. Excellent to good functional outcome was observed in 24 patients (88 %), on evaluation with Merle D’Aubigne and Postel score at the latest follow-up.

Conclusion We conclude that the ‘in-out-in technique’ is a safe and effective method of anterior column lag screw fixation in acetabular fractures. It provides rigid stability and minimizes surgical duration, radiation exposure and intra-operative complications.

Introduction

Technique-related complications are common after acetabular fracture surgery, because of complex pelvic anatomy, difficulty in surgical access and infrequent exposure to acetabular fractures [8, 21]. A misdirected or misplaced screw during internal fixation of acetabular fractures may penetrate the hip joint or damage the neurovascular structures [9, 14, 18, 26, 27]. Intra-articular hardware placement has been documented in 4 % of operatively treated acetabular fractures [9, 14, 18]. Surgeons take several preventive measures to avoid such an iatrogenic complication. Intra-operative radiographs or fluoroscopy and auscultation of hip joint during passive movement are useful, but cannot assure the safe placement of screws [1, 4, 6, 11, 13]. Few danger zones in and around the acetabulum have been identified, where the surgeon has to be careful in hardware placement. The danger zone in the anterior column extends from the anterior border of iliopectineal eminence to the anterior

R. K. Sen • S. K. Tripathy • S. Aggarwal • T. Goyal • D. S. Meena
Department of Orthopaedics, Postgraduate Institute of Medical
Education and Research, sector-12,
Chandigarh 160012, India

S. Mahapatra
Department of Orthopaedics, Ispat General Hospital,
Rourkela, India

S. K. Tripathy (✉)
Department of Orthopaedics, Kasturba Medical College,
Manipal 576104 Karnataka, India
e-mail: sujitorho@yahoo.co.in

border of anterior-inferior iliac spine (AIIS) [20]. An anterior column lag screw passing through this danger zone may inadvertently penetrate into the hip joint or may cause femoral or external iliac vessels injury [20, 26].

Conventionally, an anterior column lag screw is inserted from the posterolateral surface of ilium (about 2–3 cm cranial to the joint margin along the posterior margin of the gluteus medius pillar), which passes through the narrow anterior acetabular rim to have final purchase in the superior pubic ramus (usually operated through the Kocher–Langenbeck approach) [2, 7, 15, 16, 25]. As the track of the screw remains completely intramedullary, the surgeon remains blind regarding the procedure and uses tactile feedback or fluoroscopy for accuracy of placement. The procedure becomes more cumbersome in obese patients, where radiographic findings may be misleading [21]. As a consequence, surgical duration and radiation exposure increases [12, 21]. Over the last three years, the authors have adopted a different track for screw fixation (in-out-in technique) in the anterior column (Fig. 1), operated through an iliofemoral approach [19]. The surgical technique and outcome of this modified anterior column lag screw fixation is described in brief.

Materials and methods

The senior author (RKS) has operated upon more than 600 acetabular fractures in last 14 years. The modified anterior screw fixation technique has been used in more than 50 cases, out of which 27 cases have completed at least 12-months of follow-up (mean follow-up of 18.6 months, range 12–36 months). The clinical and radiological data of these patients were retrieved from the trauma registry. Among these 27 patients, 16 had transverse fracture, eight had T-type fractures and the remaining three had both-column fractures. The acetabulum fractures in these cases were fixed with screws alone or screws and plate construct, depending on the fracture configuration. Anatomical reduction was

achieved in 20 cases (within 1 mm) and the remaining seven cases had satisfactory reduction (between 1 and 3 mm). The demographic profiles, acetabular fracture pattern, surgical approach, mode of fixation and outcome of these cases have been briefly outlined in Table 1.

Surgical technique

The anterior screw fixation technique is applicable for fixation of anterior column (low or very low anterior column fractures), in patients with transverse fractures, T-type fractures and both-column acetabular fractures, where the anterior fracture line passes lateral to iliopectineal eminence and the eminence is not comminuted. Presence of comminution at the fracture site may need an additional pelvic brim plate.

The patient is operated upon in the supine position on a radiolucent table with a sandbag beneath the affected hip. The ipsilateral limb is draped freely, so that the hip and knee joints can be moved as required during surgery. A urinary Foley catheter is inserted into the bladder for improved visualization, bladder protection, and monitoring of fluid balance. Prophylactic antibiotics are administered prior to the incision.

The fracture is exposed through the 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. 2a). The fascia lata is incised along the incision and a surgical plane is developed between the tensor fascia lata and the sartorius. The lateral femoral cutaneous nerve is preserved and retracted medially. The ASIS (1 cm depth and 2 cms length) is osteotomized and the iliacus muscle is carefully lifted up from the inner side of the pelvis (Fig. 2b). The osteotomized wafer of bone (ASIS), along with the iliacus muscle, lateral femoral cutaneous nerve and neurovascular bundles, are retracted medially with a Deaver retractor. The periosteum and fascia adherent to the iliopectineal eminence are carefully lifted up with a periosteal elevator (Fig. 2c). If required, the

Fig. 1 **a**, The entry point of an anterior column lag screw has been identified in the pelvic bone model. The point is 0.5 cm to 1 cm posterior, inferior and lateral to antero-inferior iliac spine. The screw track is drilled with a 3.5 mm drill bit; the drill bit comes out of the iliac wing to reenter into the anterior part of the iliopectineal eminence and finally gains

purchase in the lateral part of the superior pubic ramus (in-out-in technique). **b**, A 4.5 mm malleolar screw/6.5 mm partially threaded cancellous screw is fixed, which remains completely extraosseous in the middle danger zone, and passes almost perpendicular to the fracture surface, providing rigid stability (the blue shaded area indicates the fracture line)

Table 1 The demographic profiles, fracture pattern, surgical approach, mode of fixation and outcome of the acetabular fracture treated with the modified anterior column screw technique

Sr no	Age (yrs) / sex	Side	Acetabular fracture pattern	Associated pelvic/hip/femur injury	Approach	Ant. Acetabular screw fixation	Other implant	Follow-up (months)	Complications	Outcome	Clinical (Merle D'Aubigne and Postel)	Radiological (Matta's)
1	18/M	Rt	Both-column	Opp pubic rami fracture	Ilio femoral	Two screws	spring plate+brim plate	30	Nil	Very good	Very good	Good
2	44/M	Rt	Transverse	Nil	Ilio femoral	Two screws	Nil	12	Nil	Good	Good	Good
3	34/M	Rt	Transverse	Nil	Ilio femoral	Two screws	brim plate	12	Nil	Excellent	Excellent	Excellent
4	22/M	Rt	Both-column	Nil	Ilio femoral	Two screws	wing plate, post column screw	12	Nil	Very good	Very good	Excellent
5	25/M	Rt	Transverse with post wall	Sciatic nerve injury	Ilio femoral+KL	One screw	posterior plate	18	Nil	Very good	Very good	Good
6	30/M	Rt	Transverse	Ipsi femur fracture	Ilio femoral	One screw	posterior column screw	30	Nil	Excellent	Excellent	Excellent
7	24/F	Lt	T type	Opp. Pubic rami & symphysis disruption	Ilio femoral+extension outside ilium	Two screws	super acet outer plate+brim plate	12	Nil	Very good	Very good	Good
8	24/M	Rt	Transverse	Nil	Ilio femoral	Two screws	Nil	12	Nil	Excellent	Excellent	Excellent
9	32/F	Lt	T type	Opp pubic rami	Ilio femoral+KL	One screw	two posterior plates	24	HTO (Brooker Gr I)	Excellent	Excellent	Good
10	21/M	Rt	Transverse	Lt femur #, sciatic injury	Ilio femoral+KL	One screw	one brim plate+2 post plates	30	HTO (Brooker Gr II), complete sciatic recovery at 6 months	Good	Good	Fair
11	24/M	Rt	Transverse	Nil	Ilio femoral (no osteotomy)+Ganz	One screw	one screw post column	12	Nil	Very good	Very good	Excellent
12	34/F	Rt	T type	Nil	Ilio femoral+KL	One screw	posterior plate	30	Nil	Fair	Fair	Excellent
13	32/M	Lt	T type	Nil	Ilio femoral	One screw	post column screw+brim plate	12	Nil	Very good	Very good	Excellent
14	35/M	Lt	T type	Opp pubic rami fracture, sacrum	Ilio femoral	One screw	brim plate	12	Nil	Very good	Very good	Excellent
15	27/M	Rt	Transverse	Ipsi femur #	Ilio femoral	Three screws	Nil	12	Nil	Very good	Very good	Excellent
16	50/F	Lt	T type	Opp rami fracture	Ilio femoral+Pfannestiel	One screw	full ant column plate	30	Nil	Good	Good	Excellent
17	19/M	Rt	Transverse+post wall	Symph disruption	Ilio femoral+KL	One screw	post plate	36	Sec OA	Poor	Poor	Poor
18	23/F	Lt	Transverse	Femur head impaction	Ilio femoral	Two screws ant column	post column screw	30	Hip arthrosis	Poor	Poor	Poor
19	24/M	Lt	Transverse	Nil	Ilio femoral	One screw	brim plate	18	Nil	Excellent	Excellent	Excellent
20	25/M	Rt	Transverse	Nil	Ilio femoral	Two screws	Nil	12	Nil	Very good	Very good	Excellent
21	40/M	Rt	Transverse	Ipsi SI disruption, symphyseal disrupt	Ilio femoral+Pfannestiel	One screw	SI two plates, symphyseal fix., post screw	12	Nil	Good	Good	Excellent

Table 1 (continued)

Sr no	Age (yrs) / sex	Side	Acetabular fracture pattern	Associated pelvic/hip/femur injury	Approach	Ant. Acetabular screw fixation	Other implant	Follow-up (months)	Complications	Outcome	
										Clinical (Merle D'Aubigne and Postel)	Radiological (Matta's)
22	30/M	Rt	Transverse	Nil	Iliofemoral	One screw	Post column screw	18	Nil	Very good	Excellent
23	34/F	Rt	Transverse	Nil	Iliofemoral	Two screws	Nil	12	Nil	Excellent	Excellent
24	27/M	Lt	T type	Opp. rami fracture	Iliofemoral	One screw	Brim plate	12	Nil	Very good	Excellent
25	23/M	Rt	Both-column	Opp. both-column acetabulum fracture	Iliofemoral+ Pfannestiel	One screw	Anterior column plate	24	Nil	Good	Good
26	40/M	Lt	T type	Nil	Iliofemoral+ KL	One screw	Post plate	12	Nil	Good	Excellent
27	24/F	Rt	Transverse	Nil	Iliofemoral	Two screws	Nil	18	Nil	Excellent	Excellent

KL Kocher–Langenbeck approach

oblique head of the rectus femoris muscle can be detached from the anteroinferior iliac spine to expose the hip capsule. The anterior column is completely exposed, and the anterior fracture line of transverse, T-type or both-column fractures is visible. After cleaning the fracture plane, lateral and longitudinal traction over the femur (with a Steinman pin inserted in the greater trochanter) is applied in a semi-flexed hip position to pull the femur head under the acetabular roof. Simultaneous use of ball spike over the medial iliopectineal eminence usually reduces the fracture displacement (Fig. 2d). The reduction is maintained with a pointed reduction clamp or provisional K-wires fixation. The reduction is accessed by image intensifier.

The gluteal muscle on the outer side of iliac bone, just posterior and inferior (0.5–1 cm) to the anteroinferior iliac spine is stripped out to identify the position for placement of the anterior lag screw. The track for the screw is drilled with a 3.2 mm drill bit, keeping the direction in the line of the iliopectineal eminence and superior acetabular rim. The drill comes out of the iliac bone to re-enter again into the iliopectineal eminence and finally gain purchase into the junction of the superior pubic ramus and anteromedial acetabular wall (Fig. 3a and b). A 4.5 mm cortical or malleolar screw (AO, Synthes) or 6.5 mm partially threaded cancellous screw with washer is inserted into the track that purchases in this thick strut of bone (which is at the junction of the superior ramus and acetabular wall), and hence, compresses the anterior column (Fig. 3c and d). Two screws may be placed in the anterior column through this safe corridor, if room is available for it (Fig. 3).

It is important to ensure simultaneous reduction of the posterior column with digital palpation and intra-operative imaging. The posterior column is reduced (under image intensifier) with various techniques, including the use of pelvic clamp, ball spike, cob elevator, lag screws, or plate for reduction. Wherever required, the posterior column is reduced with a bone hook, and a 4.5 mm ilioischial screw is passed from a point 1 cm lateral to the pelvic brim and 2 cm anterior to the sacroiliac joint. (Fig. 4).

The wafer of osteotomized bone (of ASIS) is fixed back to the ilium with two small fragment screws. The wound is closed in layers after placing a negative suction drain. The important neurovascular structure must be protected during this surgical technique.

During the exposure, all precautions should be taken to preserve the lateral femoral cutaneous nerve around the ASIS. The tight adherent fascia from the superior pubic ramus should be lifted up subperiosteally with extreme caution, as there is a risk of damage to the femoral neurovascular bundle if the plane of dissection is not maintained strictly at the subperiosteal level. Excessive medial traction with Deaver retractor may cause femoral neuropraxia by compression over the iliopsoas muscle.

Fig. 2 **a**, Diagram showing the line of incision for the iliofemoral approach—along the iliac crest extending up to the anterolateral aspect of thigh passing through anterosuperior iliac spine. **b**, Hand diagram shows anterosuperior iliac spine (ASIS) osteotomy—2 cm length and 1 cm depth, the iliopsoas muscle is lifted up subperiosteally from the internal pelvic fossa. **c**, ASIS along with its attachments (sartorius and inguinal ligament) and iliopsoas retracted medially. **d**, Anterior column reduction using pelvic clamp and ball spike

Fig. 3 Right-sided transverse acetabular fracture fixed with two anterior column lag screws through the iliofemoral approach

Fig. 4 Radiograph (a) showing simple transverse acetabular fracture in a 30 year-old-man. Postoperative radiograph (b) showing fixation of screws in both columns (operated through the iliofemoral approach) after reduction

When posterior column is grossly displaced or posterior wall is also fractured, it is better to operate through Kocher–Langenbeck approach (single exposure) and fix the anterior column through conventional lag screw fixation technique (from posterior to anterior direction).

Results

There was no loss of reduction in any of these cases, and complete radiographic union was seen in all cases after an average period of 2.8 months (Figs. 4, 5, 6). None of the patients experienced infection, significant blood loss, or iatrogenic neurologic or vascular injury. Intra-operative assessment and postoperative radiological evaluation revealed accurate placement of screws in all of these cases, with no evidence of joint penetration. The average duration of surgery was 70 min with blood loss of 260 ml.

After mean follow-up of 18.6 months, clinical evaluation by Merle D'Aubigne and Postel score revealed excellent outcome in seven cases, very good in 11 cases, good in six cases, fair in one and poor in two cases. Matta's radiological scoring showed excellent outcome in 18 cases, good in six, fair in one and poor in two cases. Two patients developed heterotopic ossification of Brooker grade I and II, without any significant functional loss. Two patients had poor functional outcome because of development of secondary hip arthrosis (posttraumatic). One of them had only transverse fracture and the other one had transverse with posterior

acetabular wall fracture. Femur head impaction during initial injury was attributed for secondary arthrosis in these patients.

Discussion

Screw placement in the anterior column of acetabulum has a narrow margin of safety [5, 10, 27]. Several cadaveric studies have been published to provide the anatomic basis of lag screw fixation in the anterior column [5, 10, 27]. After anthropometric measurement of different dimensions in 44 cadaveric acetabuli, Hong et al. [10] established that the transverse section of anterior column is triangular in shape and the path for the lag screw placement is 10.5 ± 0.8 mm in diameter (fixation with a 6.5 mm lag screw allows only 2 mm space on either side of screw to err; a very narrow corridor). They proposed that the optimal entry point of a lag screw on the posterolateral ilium should be 9.2 ± 2.4 mm superior to the line between the anterior superior iliac spine and the greater sciatic notch, and 38.5 ± 3.8 mm superior to the greater sciatic notch. They also measured the distance from the entry point to the obturator groove, which was found to be 84.1 ± 6.2 mm. The inclination of the lag screw should be $54.2 \pm 5.5^\circ$ at the caudal direction in the sagittal plane and $40.7 \pm 3.8^\circ$ in the horizontal plane. Considering these angles and narrow track, the screw placement becomes difficult and risky (for hip joint violation and vascular injury).

Fig. 5 a. Right-sided acetabular fracture with sacroiliac and symphysis pubis disruptions in a 40-year-old man. b. One year after fixation with anterior column lag screw and reconstruction plate, the radiograph shows normal appearing hip joint

Fig. 6 Left sided T-type acetabular fracture with posterior sacrum injury in a 35-year-old male, fixed with one anterior column screw, brim plate and posterior transiliac reconstruction plate. One year after fixation, there is complete union and no evidence of any degeneration in the hip joint

In another study, Ebrahim et al. [5] concluded that the optimal entry point for lag screw fixation in the anterior column is located 16 ± 3.9 mm superior to the midpoint of the line connecting the apex of the sciatic notch with the notch between the anterior superior iliac spine and anterior inferior iliac spine, and 46 ± 5.9 mm superior to the acetabular rim; the mean inclination of the projected axis is $90.6^\circ \pm 5.0^\circ$ in the sagittal plane and $29.0^\circ \pm 4.4^\circ$ in the transverse plane. Despite these cadaveric studies, variations of anterior column dimensions in relation to age, sex, race and ethnicity cannot be substantiated, and even after consideration of these dimensions and use of intra-operative fluoroscopy, placing the screw in obese patients and in curved anterior column is challenging [21, 26].

Radiation exposure and surgical time in percutaneous anterior column lag screw fixation in minimally displaced or undisplaced fracture have been widely studied [3, 17, 23, 24]. Anterior column lag screw fixation through Kocher–Langenbeck approach (for fixation of transverse, t-type or both column fracture) is solely a fluoroscopy-dependent procedure, as the anterior column is not exposed and the screw track remains intraosseous; thus, radiation exposure and surgical time for this lag screw fixation is nearly equivalent to the percutaneous procedure. Mouhsine et al. [17] reported a mean fluoroscopic time of 62 s and a mean operative time of 30 min in percutaneous screwing by fluoroscopy only. Starr et al. [24] revealed a mean operative time of 75 min in percutaneous screwing of displaced fracture of the acetabulum. Crowl and Kahler [3] reported an average of 73 s of fluoroscopy in percutaneous screw fixation of anterior column acetabular fractures with fluoroscopy only, and the fluoroscopy time was less than 45 s with computer-assisted imaging. We never used an image intensifier for fixation of anterior lag screw in our study (but it was used for intra-operative fracture reduction evaluation), and the average total surgical duration was 70 min. Thus, considerable surgical time could be saved and the surgeons remained confident about the fixation without using fluoroscopy for screw insertion.

The proposed screw fixation technique as described in this article can be executed with any approach that

exposes the anterior column (ilioinguinal or iliofemoral approach). The screw remains extraosseous in the middle part of anterior column, which is the most vulnerable site for hip joint penetration. Shiramizu et al. [22] have already proved that the bone stock from the pelvic brim to the margin of the hip joint is minimal at the center of the hip joint. They found this thickness to be 14.0 ± 3.6 mm, and this section had smaller measurement than the anterior and posterior sections i.e. 18.5 ± 4.6 mm in posterior and 17.2 ± 3.5 mm in anterior half of the hip joint. The final purchase of the lag screw as per our technique remains in a thick strut bone anteriorly; thus, a rigid stability is achieved. Compared to a conventional 3.5 mm cortical screw, we believe that the malleolar screw (4.5 mm), or 6.5 mm partially threaded cancellous screw, provides more rigid stability. The malleolar screw has smooth shaft, it is partially threaded, but has a large diameter and large screw head for stronger fixation. The trephine tip allows insertion without tapping. No loss of reduction was seen in our series until complete healing. As the screw fixation was performed under direct observation, femoral vessels or external iliac vessel injury was easily avoided. The different combination of screws or screws and plate used for fixation in transverse, T-type and both-column fractures in this series have shown excellent to good clinical outcome in 88 % of patients. The duration of surgery and blood loss was also minimal. Few patients in our case series needed dual surgical approaches, which could easily have been done with single exposure. We suggest that patients with transverse fracture and posterior wall injury can be operated through the Kocher–Langenbeck approach, and that the traditional method of lag screw fixation should be adopted.

Anterior column lag screw fixation through an iliofemoral approach, as described in this study, is a safe and effective alternative to conventional technique of fixations for acetabular fractures. It minimizes radiation exposure, decreases surgical time and has a low complication rate. It also provides rigid stability until fracture healing, resulting in optimal functional outcome.

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