Short-segment fixation through a limited ilioinguinal approach for treating anterior acetabular fractures: a historical-control study

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Received: 6 March 2014 / Accepted: 7 April 2014 / Published online: 7 May 2014
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Abstract

Purpose We evaluated the potential advantages of short-segment fixation of certain anterior acetabular fracture patterns through a limited ilioinguinal approach.

Methods Two patient groups were studied. The first group comprised 22 patients (20 men, two women; average age 36 years) treated using the short-segment fixation protocol through a limited ilioinguinal approach. We modified the use of short pelvic brim plates, spring plates and posterior-column screws as reduction and fixation tools (leaving the distal end of the fracture unfixed) to keep the dissection entirely lateral to the iliac vessels. The second (control) group comprised 31 patients with matched fracture patterns fixed through the standard ilioinguinal approach. All patients were followed up for a minimum of two years. The estimated amount of blood loss (primary outcome measure), operative time, post-operative radiographic assessment of reduction quality and functional score assessment (secondary outcome measures) were compared between groups.

Results The short-segment-fixation group had significantly less blood loss ($p<0.0001$) and shorter operative time ($p=0.002$) compared with the control group. However, there were no significant differences in the quality of fracture reduction and functional scores between groups at the final follow-up. No major complications were encountered in either group.

Conclusion Short-segment fixation through a limited ilioinguinal approach is a safe and effective alternative for treating certain patterns of anterior acetabular fractures. Decreased blood loss and shorter operative time with less soft tissue dissection are the main advantages of this approach.

Keywords Ilioinguinal · Acetabulum · Fractures · Short segment

Introduction

Surgical treatment of acetabular fractures aims at anatomic reduction, restoring hip congruency and stable fixation through an approach that allows adequate exposure [6, 9, 11, 19, 21]. For anterior fracture patterns, this is usually achieved through the ilioinguinal approach. The standard ilioinguinal approach as described by Letournel and Judet [9] includes dissection around the external iliac vessels and development of three or four working windows. Recent approaches, e.g. the modified Stoppa and the pararectus approaches, also include retracting the vessels or dissecting around them [1, 7, 10], posing a risk of injury, especially in cases of neglected, displaced and/or comminuted fractures [4, 5, 7, 8, 18]. Furthermore, the standard approach has a potential risk of lymphatic injury, resulting in significant postoperative lymphedema [13].

Anterior-column fixation is usually achieved through the use of long reconstruction plates (≥ 12 holes) bridging both the proximal and distal extents of the fracture, which is believed to be important for ideal stabilisation. However, this technique may risk injuring vessels while passing the plate underneath them. Moreover, insertion of the pubic screws of the long reconstruction plate requires formal development of the medial window as well as retropubic dissection, which carries a higher risk of injury to the corona mortis with consequent increased blood loss [2, 20]. The increased morbidity and blood loss associated with development of the medial window is particularly evident in patients with prior inguinal surgery, such as hernia repairs [5]. In a trial to avoid development of the third window, Jeffcoat

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et al. [5] used the lateral two windows only for anterior acetabular fracture fixation. They used long pelvic brim plates with distal screws fixed to the superior pubic ramus, which limited their indications to a small group of patients with high distal extent of the fracture.

In this study, we described the short-segment-fixation concept. Through a limited approach, we included a larger spectrum of anterior fracture types. The intent was to fix the plate proximal to the fracture and buttress the anterior-column fracture fragment, leaving it unfixed distally, while developing the lateral $\pm$ middle windows only. We modified the use of short pelvic brim plates, spring plates and posterior-column screws as reduction and fixation tools to keep dissection entirely lateral to iliac vessels. The aim of this study was to evaluate the safety, efficacy and benefits of short-segment fixation versus the standard ilioinguinal approach. We hypothesised that the modified fixation concepts and limited exposure would result in a shorter operative time and less blood loss, with no adverse impact on functional and radiographic outcome.

Patients and methods

We began applying the short-segment-fixation protocol through a limited ilioinguinal approach in August 2009. Our

university hospital functions as a tertiary referral center for acetabular and pelvic injuries. Ethical committee approval was obtained prior to the study, and written informed consent was signed by all patients. Inclusion criterion was adult patients (>18 years) with displaced acetabular fractures of the following patterns: anterior column, anterior column with posterior hemitransverse and associated both-column fracture.

We excluded patients with anterior wall fractures, low-anterior-column fractures with the superior fracture limit below the anterior inferior iliac spine (AIIS), segmental anterior column fractures, neglected fractures (>21 days) and anterior-column fractures with the inferior fracture limit at or proximal to the iliopectineal eminence.

Between August 2009 and December 2011, 22 patients (study group) were treated using the short-segment-fixation protocol. The study group comprised 20 men and two women, with an average age of 36 years (range 20–80). All patients were followed up for a minimum of two years (mean 30 months; range 24–50 months). All patients sustained high-energy trauma (14 motor vehicle accidents, four pedestrian accidents and three falls from a height), except one elderly woman who had a minor fall resulting in a periprosthetic acetabular fracture on top of a bipolar hemiarthroplasty. Patient demographics, fracture types, associated injuries and time to surgery are shown in Table 1.

Table 1 Baseline characteristics of patients in both groups

	Group 1: short-segment fixation (<i>n</i> =22 patients)	Group 2: controls (<i>n</i> =31 patients)	<i>P</i> value
Age (years)	36 $\pm$ 14	34 $\pm$ 10	0.41
Gender (male/female)	20/2	25/6	0.45
Side (right/left)	13/9	17/14	0.78
Time to surgery (days)	7 $\pm$ 6	6 $\pm$ 4	0.57
Type of trauma			
Motor vehicle accidents	13	18	0.84*
Pedestrian injuries	4	7	
High-energy falls	4	6	
Minor fall	1	0	
Fracture type			
Associated both-column fracture	10	11	0.66*
Anterior with posterior hemitransverse	9	13	
Isolated anterior column	3	7	
Associated injuries			
Chest	1	2	0.95*
Abdominal	1	1	
Skeletal	11	14	
Multiple	2	4	
Spine	1	1	
Upper limb	4	3	
Lower limb	3	5	
Maxilofascial	1	1	

Data are mean $\pm$ standard deviation, or participant numbers

*Chi-square test (Monte Carlo method)

Historical control group

Retrospective review identified 78 patients who had internal fixation of displaced acetabular fractures through the ilioinguinal approach at our institution between January 2007 and July 2009. Forty-two patients did not meet our inclusion criteria, and five were excluded due to incomplete follow-up records. The remaining 31 patients who had matched fracture patterns with minimum follow-up of two years [3] comprised the historical control group. Control-group demographics, fracture types, associated injuries and time to surgery (Table 1) showed no statistically significant difference from the study group. The study met Pocock criteria [15] for the use of historical controls (control group inclusion and exclusion criteria, workup and evaluations were the same).

Surgical technique

Patients were positioned supine on a radiolucent table, and traction was applied manually by the assistant. Whenever needed, a corkscrew was placed into the proximal femur for lateral traction and reduction of femoral-head protrusion. Antibiotics were administered IV within 60 minutes of skin incision. As per the pre-operative plan, the lateral +/- middle windows of the ilioinguinal approach were developed. If the plan entailed the development of the lateral window only, the inguinal ligament was released from the anterior superior iliac spine (ASIS) after careful dissection of the lateral cutaneous nerve of the thigh to facilitate medial retraction of the iliopsoas muscle, hence improving exposure. If the two-window approach was planned, the entire dissection was kept lateral to the vessels after dividing the iliopectineal fascia and retracting the iliopsoas muscle laterally. This approach provided good access to the medial wall and posterior column.

Adopting the concept of the plate as a clamp described by Mast et al. [11], short brim plates were used to buttress and fix anterior-column fractures with superior extent located above the AIIS, leaving the inferior extent of the fracture unfixed. An undercontoured (or sometimes uncontoured) five- or six-hole 4.5-mm reconstruction plate was used and fixed with two screws proximal to the fracture. The first screw achieved reduction; the second prevented plate rotation. The fracture line being usually in the coronal plane with a large cancellous surface provided adequate stability despite using nonbridging buttress plates with no distal screws. In many cases, the fracture was incomplete laterally, with plastic deformation of the distal fragment (Fig. 1).

When the short-brim-plate technique was used, only the lateral window approach was needed for both fracture reduction and fixation. It was not always possible to reduce rotational displacement of the anterior-column fragment with the previous technique. In these cases, we partially loosened the plate screws, used a Shanz screw drilled in the fragment or a pointed reduction clamp across the fracture line at the iliac crest level to adjust rotation, and then retightened the screws. Reduction was maintained by inserting screws in plate holes distal to the fracture line passing into the posterior column. Aiming at more rotational control, a 4.5-mm screw or another plate close to the iliac crest was added. This limited approach was also enough to fix the posterior component of the fracture, which was reduced using the pointed pelvic-reduction clamps, and fixation was achieved using posterior-column screws and/or spring plates. The lateral window was usually enough for reduction and fixation of the high posterior-column fractures with column screws. In cases with low posterior-column fractures, tight lateral window, or when using a spring plate was planned, the middle window was developed (Fig. 2).

We also modified the concept of using the spring plate to buttress the medial-wall fracture and combined it with the

Fig. 1 A 37-year-old man sustained a motor vehicle accident. **a, b** Obturator oblique view and 3D computed tomography scan showing a displaced anterior-column fracture of the left acetabulum with central subluxation. This was treated through a limited ilioinguinal approach (lateral window). **c** Intraoperative fluoroscopic views (*upper*) after insertion of the first reduction screw through a six-hole, 4.5-mm reconstruction

plate. Incomplete reduction is noted. (*lower*) after insertion of the second reduction screw. Reduction was anatomical. Two interfragmentary screws inserted over a two-hole, 4.5-mm reconstruction plate were added for greater stability. **d** Obturator, oblique view, at the third postoperative month showing complete union, with no loss of reduction

Fig. 2 An obese 53-year-old woman sustained a pedestrian injury. **a** Plain X-ray showing associated both-column fracture of the right acetabulum. The patient was treated through the lateral two windows using the ilioinguinal approach. **b–d** Postoperative X-rays showing a 4.5-mm plate and a lag screw fixing the small, triangular fragment of bone at the iliac crest. Fixation of the anterior-column fragment was done using a five-hole, 4.5-mm reconstruction plate over the brim. A 4.5-mm lag screw was

inserted as an antirotation screw near the iliac crest. Following reduction of the anterior column, the medial-wall/posterior-column fragment was reduced through the middle window using the pointed pelvic reduction clamp. Two posterior-column screws inserted through the same plate were enough to fix the posterior column. **e** Follow-up X-ray at 3 months showing complete union

concept of using the plate as a clamp to reduce and fix the so-called medial-wall/posterior-column fragment. An overcontoured, inverted L-shaped 3.5-mm reconstruction plate was applied to the medial wall. Through the middle window, a 3.5-mm screw was inserted in the central hole near the pelvic brim and directed laterally to avoid engaging the posterior column. As the screw was being tightened, plate orientation reduced rotational displacement of the fragment. If a minimal gap was still present, an interfragmentary posterior-column screw was used to close it (Fig. 3).

Wounds were closed in layers over one or two drains, which were removed after 24–48 hours. Toe-touch-only weight bearing with a walker was started on the first postoperative day.

Intravenously administered antibiotics were continued for five days. Elastic stockings, dynamic compression devices and low-molecular-weight heparin (LMWH) were used for prophylaxis against deep venous thrombosis (DVT). LMWH was administered for four weeks postoperatively. No prophylaxis against heterotopic bone formation was used. Figure 4 illustrates our technique on a pelvic-bone model.

Follow-up

Detailed clinical and radiological assessment was carried out during the follow-up visits at two and six weeks, three and six months and one year postoperatively and then annually.

Fig. 3 A 52-year-old man sustained a pedestrian injury. **a–c** Plain X-rays and 3D computed tomography (CT) scan showing an anterior column with posterior hemitransverse fracture of the left acetabulum. Approach was through the lateral two windows. **d–f** Postoperative X-rays showing a short plate fixing the anterior column, and a spring plate with a posterior-

column screw fixing the posterior column. **g** Axial CT scan showing the buttressing effect of the spring plate on the medial wall, with anatomical reduction of the posterior column. The posterior-column screw is also seen down to the inferior part of the posterior column

Fig. 4 A pelvic model with anterior column with posterior hemitransverse fracture lines drawn over the left acetabulum. **a** A six-hole 4.5-mm reconstruction plate for buttressing the anterior fracture is positioned using a ballpoint pusher, and the first reduction screw is drilled. **b** Antirotation screw is inserted before pusher removal. **c** Pointed reduction clamp at the crest is used to control anterior-column-fragment

rotation before retightening screws. **d** Pointed pelvic reduction clamp is used to reduce the medial-wall/posterior-column fragment. **e** Posterior-column screw in place (*arrow*) and application of spring plate. **f** The first screw in the spring plate is inserted near the brim and directed laterally to avoid the posterior column. **g** Spring plate in place with an antirotation screw inserted (*arrow*)

Anteroposterior, iliac and obturator oblique radiographs of the pelvis were evaluated each visit. Fracture reduction was graded as anatomic (0–1 mm), imperfect (2–3 mm) and poor (>3 mm) based on residual displacements as defined by Matta [14]. Posttraumatic arthritis was defined as joint-space narrowing and/or the presence of osteophytes around the head–neck junction.

Outcome measures

The primary outcome measure was estimated amount of blood loss. Secondary outcome measures were operative time,

radiographic assessment of fracture reduction quality and loss of fracture fixation or any secondary displacements, complications, time to union, progression to arthritis and functional score assessment using the Harris Hip (HHS) and modified d'Aubigné scores.

Statistical analysis

PASW version 18 (Chicago, IL, USA) and PASS were used for statistical analysis. Descriptive analysis was conducted to explore the characteristics of the participants at baseline. Median, 25th and 75th interquartile percentiles of modified

Table 2 Comparison of the results of short-segment-fixation group with historical control group

	Group 1: short-segment fixation (<i>n</i> =22 patients)	Group 2: control (<i>n</i> =31 patients)	<i>P</i> value
Estimated blood Loss (cc)	710±250	980±210	<0.0001
Operative time (min)	85±19	107±28	0.002
Follow-up (months)	30±6	42±12	
Accuracy of reduction [14]			
Anatomical	19	25	0.86*
Imperfect	2	4	
Poor	1	2	
Harris Hip Score	90±8	91±7	0.82
Modified d'Aubigné score	16 (15–18)	15 (15–18)	0.85
Excellent	6	8	
Good	13	20	
Fair	2	2	
Poor	1	1	

Data are mean ± standard deviation, median (25th and 75th percentile) or participant numbers

*Chi-square test (Monte Carlo method)

d'Aubigné score; mean and standard deviation (SD) of age, duration to operation, HHS and percentages of the gender and side distribution were calculated. Continuous variables were tested for normality. For comparing groups, variables were analysed using two-tailed unpaired *t* tests or Mann–Whitney *U* test, as appropriate. Chi-square test was used for categorical data. The difference was considered statistically significant for *P* value <0.05. The primary end point was defined as the amount of estimated blood loss. An a priori power analysis of 0.8 demonstrated 17 participants were required to show a difference of 15 % in blood loss, with a 15 % standard error (SE) at a significance level of 0.05; thus, allowing for a 20 % dropout rate, each group comprised 21 participants. Finally, correlation analysis of the various characteristics with clinical outcome was done using the Spearman nonparametric rank-correlation test. Independent variables were accuracy of fracture reduction, time to surgery, type of fracture and estimated blood loss.

Results

In the study group, short pelvic brim plates were used to reduce the anterior-column fragment in all cases. Fixation of the posterior fragment was done using spring plates in nine cases (41 %) and/or posterior column screws in 18 cases (82 %). Reduction and fixation were performed through the lateral window in seven cases (32 %). The middle window was added in 15 cases (68 %) of low fractures, tight lateral window or when a spring plate was planned for. The mean estimated amount of blood loss was 710 ml (range 300–1,200), and mean operative time was 85 minutes (range 40–120). Cell-saver devices were not used. Intra-operative and/or postoperative blood transfusion was needed in eight cases (36 %).

The reduction was graded as anatomical in 19 hips (86 %), imperfect in two (9 %) and poor (>3 mm) in one (5 %). All patients achieved radiological evidence of fracture union at 12 weeks of follow-up, with no secondary displacements or loss of reduction. Median postoperative functional score at the final follow-up as graded by the modified d'Aubigné score was 16 (range 12–18). There were six excellent (27 %), 13 good (59 %), two fair (9 %) and one poor result (5 %). Mean HHS at the final follow-up was 90 points (range 69–100).

No complications were encountered in the perioperative period, except for breakage of a drill bit during drilling for a posterior-column screw. At final follow-up, one hip (5 %) showed decreased joint space, indicating cartilage loss; however, this was nonprogressive, and the patient had full and painless range of motion. Otherwise, no patient had evidence of arthritis or heterotopic ossification at the last follow-up X-rays. There were no local soft tissue complications, and no revisions were needed.

Comparison between groups is shown in Table 2. The short-segment-fixation group had significantly less blood loss ($p<0.0001$) and shorter operative time ($p=0.002$) than the control group. However, there were no significant differences in the quality of fracture reduction and functional scores between groups at final follow-up.

Reduction accuracy and clinical results correlated significantly ($p<0.001$), but fracture type ($p=0.62$), time to surgery ($p=0.86$), and blood loss ($p=0.53$) did not.

Discussion

Achieving good reduction of an acetabular fracture and satisfactory postoperative hip function is highly dependent on choosing the appropriate surgical approach and fixation implants [12]. In the study reported here, we present our experience with short-segment fixation of anterior acetabular fractures using a limited ilioinguinal approach. Short pelvic brim plates, spring plates and column screws were the main tools for reduction and fixation. None of these concepts is new; however, with some modifications, we used them to achieve reduction and fixation of the displaced columns through the limited approach. The short brim plates apply the concept of using the plate as a clamp [11]. We used a six- instead of a three-hole plate as a definitive fixation construct and not just as a reduction tool. This increased the lever arm of the reduction force and allowed insertion of more than one reduction screw.

The short brim plate had advantages over the conventional long pelvic brim plate. The long plate needed to be perfectly contoured in order to reduce and stabilise the fracture [22], and 3.5-mm reconstruction plates were thus used. In the case of short plates, stiffer 4.5-mm reconstruction plates were used, as plate contouring was not needed. The short plate affected reduction by the tension produced inside the plate as it touched the distal fragment. This continuous tension maintained fracture reduction till union. As stiffer plates were used, reduction force increased.

Spring plates were previously used to buttress medial-wall fractures [21]. We modified the use of spring plates to reduce rotational displacement and buttress the medial-wall/posterior-column fragment based on two observations: The first is that the posterior-column fragment usually has much of the medial wall attached to it; the second is that the posterior fragment cannot displace posteriorly without medial displacement. The vertical limb of the spring plate was far reaching posteriorly, thus providing the buttress effect provided by infrapectineal plates [16] inserted through the modified Stoppa or standard ilioinguinal approaches. However, spring plates are inserted using the lateral and middle windows only, thus protecting the iliac vessels.

The main advantage of short-segment fixation was significantly less blood loss and shorter operative time compared with historical controls ($p < 0.0001$ and $p = 0.002$, respectively). The decreased blood loss and shorter operative time could also be clearly appreciated comparing our results with other series of patients treated with the standard ilioinguinal, pararectus, modified Stoppa and even the proposed limited approaches [7, 9, 10, 14, 17, 18]. Moreover, in the nonrandomised control study by Jeffcoat et al. [5], significantly less blood loss and shortened operative time were found when using the limited two-window approach compared with the standard three-window approach. In addition to decreased blood loss and shortened operative time, benefits of short-segment fixation of anterior fractures include decreased tissue dissection. Using the lateral and/or middle windows avoids dissection around the external iliac vessels and development of the third window, which is associated with increased blood loss and risks the injury to the iliac vessels and/or corona mortis. The limited approach also avoids opening the inguinal canal and cutting the conjoint tendon, hence decreasing the incidence of reported postoperative hernias, especially in elderly patients with weak fascia [9, 18]. Moreover, it is easier and safer to perform the limited anterior approach in patients with previous hernia operations and resultant scarring. Short-segment fixation leaves the distal end of the fracture unfixed. Whereas this helped us expand the use of the limited approach to many anterior fracture patterns, it did not appear to affect fracture-reduction quality or fixation stability, as evidenced by the absence of secondary displacement or loss of achieved reduction.

Strengths of our study are the relatively large number of patients in a single institution, long-term follow-up and use of a control group, although it lacked randomisation and biomechanical analysis to support our hypothesis. It is worth mentioning that this technique does not apply to all patterns of anterior acetabular fractures. As we gain more experience with this technique, its benefits and limitations will be fully elucidated.

Conclusion Short-segment fixation through a limited ilioinguinal approach is a safe and effective alternative for treating certain patterns of anterior acetabular fractures. Decreased blood loss and shorter operative time with less soft tissue dissection are the main advantages of this approach.

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