Fixation of Superomedially Displaced Acetabular Fractures Using an Anatomical Suprapectineal Quadrilateral Surface Plate Through Modified Stoppa Approach

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Research Article

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Abstract

Treatment of superomedially displaced acetabular fractures including a quadrilateral surface (QLS) is challenging. We present a surgical technique using an anatomical suprapectineal QLS plate through the modified Stoppa approach and report the availability of this plate to treat this fracture type along with the surgical outcomes. Thirteen consecutive patients (11 men and 2 women) who underwent surgical treatment using an anatomical suprapectineal QLS plate through a modified Stoppa approach for superomedially displaced acetabular fractures between June 2018 and June 2020, were enrolled retrospectively. These fractures included 10 both-column fractures and 3 anterior-column and posterior hemitransverse fractures, which were confirmed on preoperative 3-dimensional computed tomography. Surgical outcomes were clinically assessed using the Postel Merle d'Aubigné (PMA) score and visual analog scale (VAS) score at the final follow-up, and radiological evaluations were performed immediately after the operation and at the final follow-up. The follow-up period was longer than 1 year in all patients with a mean 22.9 months. The mean operation time was 103 min. Anatomical reduction was achieved in 11 (84.6%) patients, while imperfect reduction was achieved in the remaining two (15.3%) patients. At the final follow-up, radiographic grades were excellent, fair, and poor in 11 (84.6%), one (7.6%), and one patient, respectively. The mean PMA score was 16.3 (range, 13-18) and the mean VAS score was 1.0 (range, 0-3). No secondary reduction loss or implant loosening was observed. However, two patients underwent conversion to total hip arthroplasty due to post-traumatic arthritis and subsequent joint pain. No other complications were observed. Simultaneous reduction and fixation using an anatomical suprapectineal QLS plate through the modified Stoppa approach can provide satisfactory outcomes in superomedially displaced acetabular fractures, resulting in shorter operation times and fewer complications.

Introduction

Superomedially displaced acetabular fractures generally involve two main column fragments. Although they are not specifically classified under a single type according to the established classification systems, these fractures involve both a superiorly displaced anterior column fragment and a medially displaced posterior column fragment including a quadrilateral surface (QLS)[1,2]. The treatment of these fractures is challenging because of the two-directionally displaced column fragments and their proximity to neurovascular structures[3,4]. Therefore, the use of appropriate surgical approach and reduction methods is very important for achieving satisfactory outcomes in patients with these fractures.

Traditional ilioinguinal and/or Kocher-Langenbeck approaches do not provide a sufficient surgical field for the medially displaced QLS fragment in these fractures; therefore, anatomical reduction and secure fixation of these fractures using these approaches is not easy[5–9]. Meanwhile, the modified Stoppa approach offers direct access to the medial aspect of the posterior column, including a QLS from the ischial spine to the greater sciatic notch[10]. Thus, this approach can facilitate the acquisition of adequate reduction and fixation in superomedially displaced acetabular fractures, even with fracture extension into the iliac wing and sacroiliac joint.

The choice of an appropriate reduction method and tool is as important as the appropriate approach for the treatment of superomedially displaced acetabular fractures[11,12]. Several reduction methods using various clamps and reduction forceps have been used to treat these complex fractures. However, because of the displacement of the two column components into two separate directions and their location in the true pelvis, satisfactory reduction is difficult to achieve in these fractures. Furthermore, plate-and-screw fixation may be difficult due to the small space under the reduction devices, and the subsequent delay in fixation may lead to prolonged operation times and more bleeding[13–15]. An anatomical suprapectineal QLS plate (Stryker®, Selzach, Switzerland) was recently introduced and has been widely used in complex acetabular fractures (Fig. 1). This plate may also be a good option for the treatment of superomedially displaced acetabular fractures. We have performed reduction and fixation simultaneously using this plate via the modified Stoppa approach in these two-directionally displaced fractures and could reduce operation time and bleeding while yielding favorable outcomes.

This study aimed to report our surgical technique using an anatomical suprapectineal QLS plate through the modified Stoppa approach in superomedially displaced acetabular fractures and to demonstrate the viability of this plate along with the favorable surgical outcomes.

Materials And Methods

This study was approved by the institutional review board of Hallym University Sacred Heart Hospital (2021-04-007). The institutional review board waived the informed consent for this study owing to its retrospective nature. All methods were carried out in accordance with the relevant guidelines and regulations.

Between June 2018 and June 2020, 17 superomedially displaced acetabular fractures were treated at our institute by using an anatomical suprapectineal QLS plate through the modified Stoppa approach. None of our patients received conservative treatment for this fracture type during the same period. Of the 17 patients, two had periprosthetic acetabular fractures, one was lost to follow-up, and one died 3 months after the operation due to cause unrelated to the index surgery. Finally, 13 patients (11 men, two women; mean age, 62.2 years; range, 46-86 years) were enrolled in the current study.

Three-dimensional computed tomography (3D-CT) was performed in all patients before surgery to ensure accurate assessment of fracture pattern and obtain a detailed preoperative plan. The specific fracture pattern of superomedially displaced fractures, which included a superiorly displaced anterior-column component and a medially displaced posterior-column component involving a QLS, was confirmed on preoperative radiographs and 3D- CT. On the basis of the Letournel and Judet classification, 10 patients had both-column fractures while three patients had anterior-column and posterior hemitransverse fractures (Table 1). The average time from injury to surgery was 4.2 days (range, 2-8 days).

Table 1
Data for 13 patients with acetabular fracture with quadrilateral surface fragments.

Case	Gender	Age	Fracture type	Accompanying fracture	Injury mechanism	Associated injuries
1	Male	46	BC	Posterior wall	Fall more than 3 meter	Traumatic pneumothorax
2	Male	80	ACPH		Fall less than 3 meter	
3	Male	52	BC		Fall less than 3 meter	Ipsilateral pisiform fracture
4	Male	46	BC		Fall more than 3 meter	Lumbar compression fracture
5	Male	53	ACPH	Anterior wall	Motorcycle road traffic accident	
6	Male	86	BC		Fall less than 3 meter	
7	Male	52	BC		Fall more than 3 meter	Contralateral scapular fracture
8	Female	67	BC	Anterior wall	Fall less than 3 meter	Ipsilateral distal radius fracture
9	Male	54	BC	Anterior wall	Fall less than 3 meter	Skull base fracture
10	Male	58	BC		Fall less than 3 meter	
11	Female	80	BC	Anterior wall	Fall less than 3 meter	
12	Male	67	ACPH	Anterior wall	Pedestrian road traffic accident	
13	Male	70	BC	Posterior wall	Crush by heavy objects	Multiple compression fractures

BC: both column fracture; ACPH: anterior column and posterior hemitransverse fracture

Surgical techniques and procedures

Surgery was performed with the patient in the supine position on a radiolucent table and with the ipsilateral hip in a flexed position, which was maintained throughout the procedure to relax the tension of the femoral neurovascular bundle. The modified Stoppa approach, as described by Cole and Bolhofner[10], was used in all patients. In cases with complete iliac wing fractures, direct reduction and fixation with a 3.5-mm reconstruction plate or cortical screws was first performed through the additional lateral window. Next, the insertion of the rectus in the ipsilateral anterior pubic body was partially released to reduce the tension of the muscle and obtain sufficient visualization. To reduce the medially displaced QLS component more easily, the Schanz screw was inserted into the femoral head for lateral traction (Fig. 2). Subsequently, separation of soft tissues including the obturator vessels and muscles from the pelvic brim and QLS, was subperiosteally performed with a periosteal elevator. After obtaining a sufficient surgical field, an anatomical QLS plate was placed appropriately on the pelvic brim under fluoroscopic guidance so that its medial margin was close to the symphysis pubis while attaching the plate to the QLS using a ball-spike pusher, and the frontmost screw was inserted to fix the plate to the pubic body (Fig. 3). Next, indirect reduction of the medially displaced posterior column fragment including a QLS was achieved by pushing it laterally with a ball-spike pusher on the infrapectineal portion of the plate along with lateral traction of the femoral head using a Schanz screw (Fig. 4). While maintaining the reduction of the posterior column fragment, the superiorly displaced anterior column was reduced by pushing it inferiorly with another pusher on the suprapectineal portion of the plate (Fig. 5). After confirming satisfactory reduction of the anterior and posterior columns under direct visualization and fluoroscopic guidance, one screw was inserted toward the posterior column in the third hole from the back of the suprapectineal portion of the plate while the pushers were maintained on the plate for reduced anterior and posterior column fragments (Fig. 6). Depending on the fracture pattern and bone quality, additional screws were inserted in the anterior and posterior holes of the suprapectineal portion of the QLS plate: poorer-quality bone necessitated the insertion of more screws for secure fixation. Finally, simultaneous indirect reduction and fixation of superomedially displaced acetabular fractures using this plate was achieved, which was followed by compression between the anterior and posterior column components by screws inserted toward the posterior column. In patients with a relatively large anterior wall fragment or comminution, a 3.5-mm reconstruction plate was additionally inserted as a buttress plate on the anterior wall right outside the QLS plate. Meanwhile, in patients with an unreduced large posterior wall fragment through the anterior approach and fixation, additional fixation was performed using the Kocher-Langenbeck approach 1 week after anterior fixation. Correct reduction and implant positioning were carefully confirmed using fluoroscopy prior to wound closure.

After surgery, non-weight-bearing on the operated side was maintained for approximately 4 weeks; thereafter, tolerable weight-bearing with a pair of crutches was allowed. Full weight-bearing was permitted approximately 10 weeks after surgery, depending on the degree of radiographic fracture consolidation. Throughout the postoperative period, isometric quadriceps contraction exercises with the leg in extension were encouraged.

Postoperative assessments

The quality of reduction of the articular surface and the congruency of the hip joint were evaluated on postoperative plain radiographs by using the Matta classification system, and the findings were categorized as anatomic (0–1 mm), imperfect (1–3 mm), and poor (> 3 mm)[11].

At the final follow-up, the Postel Merle d'Aubigne (PMA) score and visual analog scale (VAS) score were used to rate the final clinical outcome. The radiological evaluation performed on the basis of the Matta criteria was as follows[11]: excellent (normal-appearing hip joint), good (mild changes with minimal sclerosis and joint narrowing < 1 mm), fair (intermediate changes with moderate sclerosis and joint narrowing < 50%), and poor (advanced changes). During the follow-up period, complications such as reduction loss, infection, nerve palsy, post-traumatic arthritis, venous thromboembolism, and heterotopic ossification were investigated.

Results

All patients were followed up for a minimum of 1 year with a mean follow-up period of 22.9 months (range, 12-33 months), (Table 2). Assessments using plain radiographs showed that anatomical reduction of the acetabular fracture was achieved in 11 patients, and imperfect reduction was achieved in two patients.

Table 2
Surgical outcomes of 13 patients

Case	Follow-up period (month)	Surgical approach	Additional fixation	VAS score	PMA score	Time to operation (day)	Operation time (min)	Intra-operative bleeding	Time to union (month)	Quality of reduction	Radiographic grade	Complicat
1	33	MS & KL	Iliac crest and posterior wall plate	1	17	3	155	1000	4	Anatomical	Excellent	
2	32	MS		2	15	4	145	1000	4	Anatomical	Excellent	
3	31	MS		0	18	2	90	500	3	Anatomical	Excellent	
4	33	MS		0	17	5	105	900	3	Anatomical	Excellent	
5	31	MS		0	18	2	60	750	4	Imperfect	Poor	THA conversior
6	27	MS	Iliac crest plate	1	16	3	75	1000	3	Anatomical	Excellent	
7	17	MS		0	18	7	70	800	3	Anatomical	Excellent	
8	22	MS	Anterior wall screw fixation	3	13	2	85	500	4	Poor	Fair	THA conversior
9	18	MS	Anterior wall screw fixation	0	17	8	120	800	4	Anatomical	Excellent	
10	16	MS		0	18	4	115	1500	3	Anatomical	Excellent	
11	15	MS	Anterior wall screw fixation	1	14	5	75	300	4	Anatomical	Excellent	
12	13	MS	Anterior wall buttress plate	2	14	4	135	800	3	Anatomical	Excellent	
13	12	MS & KL	Posterior wall plate	0	17	6	180	1500	4	Anatomical	Excellent	

M-S: Modified Stoppa, K-L: Kocher-Langenbeck, VAS: visual analogue scale; PMA: Postel Merle d'Aubigné.

At the final follow-up, radiographic grades were excellent in 11 patients (84.6%), fair in one, and poor in one. The mean PMA score was 16.3 (range, 13-18), while the mean VAS score was 1.0 (range, 0-3).

Postoperative follow-up radiographs showed no secondary reduction loss or implant loosening. However, mild protrusion of the femoral head along with joint space narrowing were observed in two patients who eventually underwent conversion to total hip arthroplasty due to post-traumatic osteoarthritis and subsequent joint pain. Complications such as deep infection, surgical site infection, venous thromboembolism, or heterotopic ossification were not reported. Moreover, none of the patients showed iatrogenic lesions in the obturator neurovascular bundle. All patients could ambulate without external support at the last follow-up.

Discussion

Superomedially displaced acetabular fractures are generally caused by the medial impact of the femoral head into the QLS and superior dome, which displaces the anterior column superiorly and the posterior column including the QLS medially[1]. These acetabular fractures involving a QLS are complex fractures that are not regarded as a parameter in the gold standard Judet-Letournel classification system. However, these fractures are mostly associated with anterior-column and posterior hemitransverse or both-column fractures, as shown in our study.

The appropriate approach and reduction method is of paramount importance for achieving satisfactory results in these two-directionally displaced fractures[9]. In the past, these fractures were fixed mainly with reconstruction plates through the ilioinguinal or combined approach with Kocher-Langenbeck approach[4,7]. However, conventional approaches cannot yield sufficient direct access to the posterior column component including a QLS, and secure stabilization is difficult to obtain using conventional fixation methods, especially for a medially displaced QLS fragment. Moreover, intraoperative reshaping of the conventional plates may be required to improve the buttress effect on the QLS fragment, which can prolong the operative time and reduce the buttress intensity of the plate. Anterograde lag screws may be inserted from an anterior approach to fix the posterior column involving a QLS fragment, and an additional posterior incision may be unnecessary[15,16]. However, lag screws can reduce the stability of the fragments, especially in osteoporotic elderly patients or those with comminution of the pelvic brim or QLS, and the insertion technique is demanding[17,18]. As a result, complications including screw loosening and secondary reduction loss leading to protrusion of the femoral head may occur[9,19].

Several authors have developed new fixation strategies for medial infrapectineal buttress plates in medially displaced QLS fractures[20,21]. However, this solution does not provide adequate support for superiorly displaced anterior-column fracture components in superomedially displaced acetabular fractures and can often hinder direct reduction of these components unless simultaneous reduction of the two-directionally displaced fracture components is performed. Meanwhile, as shown in our technique, the method using an anatomical suprapectineal QLS plate via a large medial window through the modified Stoppa approach can enable simultaneous indirect reduction and fixation of the posterior column component, including a QLS fragment along with the anterior column component. This anatomical QLS plate simultaneously serves as a reduction tool and fixation device in our technique; therefore, no additional reduction device or temporary fixation is necessary. This technique also avoids additional reshaping of the plate due to its anatomical contour, and sufficient stability of the QLS fragment can be achieved with this plate because of its excellent buttress effect. Accordingly, we achieved satisfactory reduction and surgical outcomes along with shorter operation times and fewer complications in almost all cases using our technique. No fixation failures, such as screw loosening or secondary reduction loss leading to protrusion of the femoral head, were observed in the current study. Nevertheless, iatrogenic injuries of the obturator nerve and corona mortis may accompany placement of this plate because it is much larger than the conventional plate. However, these injuries can be avoided by timely ligation of the corona mortis and careful protection of the obturator nerve, as shown in our study.

When indirect reduction of the medially displaced posterior column including a QLS is performed using this anatomical QLS plate and a ball-spike pusher according to our technique, the intact greater sciatic notch can serve as a reference mark for reduction of displaced posterior column fragment. However, in cases with an impacted dome fracture, which is often present concomitantly in elderly patients, reduction of the dome fracture using a Cobb’s elevator should be performed first through the fracture site between the anterior and posterior columns under direct visualization or fluoroscopic guidance. While maintaining the reduction of the posterior column component after its reduction, the superiorly displaced anterior column component is pressed using another ball-spike pusher on the plate; thus, compressive fixation between the anterior and posterior column components can be obtained by inserting screws toward the posterior column. In cases with relatively large unreduced anterior or posterior wall fragments, additional fixation should be performed for more anatomical reduction and firm fixation, as in our study. However, as shown in the current study, the two patients who underwent conversion to total hip arthroplasty due to inadequate reduction and subsequent arthritis, showed a large fragment or comminution at the anterior wall on preoperative 3D-CT. In one patient with comminution of the anterior wall, no additional fixation was performed except for the anatomical QLS plate. Meanwhile, in the other patient with a large fragment of the anterior wall, two lag screws were inserted to fix this fragment additionally. Similar to posterior wall fracture, this anterior wall fracture affecting joint stability and congruency can also be considered as a poor prognostic factor. Accordingly, more careful attention is required for accurate reduction and firm fixation for this anterior wall fragment, and additional buttress plate is needed for this fragment to obtain more favorable outcomes (Fig. 7).

The present study had some limitations. The number of patients was relatively quite small, and no control group of patients treated with conventional fixation methods was included for comparison. These factors may limit the clinical applicability of the plate. However, fixation of this anatomical suprapectineal QLS plate using the modified Stoppa approach could serve as a minimally invasive treatment for superomedially displaced acetabular fractures with a QLS fragment.

The current study demonstrates that superomedially displaced acetabular fractures can be treated successfully by simultaneous reduction and fixation using an anatomical suprapectineal QLS plate through the modified Stoppa approach along with satisfactory outcomes and fewer complications. On the basis of our results and the literature[3,13–15], we believe that our technique is very effective in the treatment of these fractures with a medially displaced QLS fragment. However, large cohort comparative studies are needed to confirm our results.

In conclusion, superomedially displaced acetabular fractures involving a QLS can be treated more easily and effectively by simultaneous reduction and fixation using the anatomical suprapectineal QLS plate through the modified Stoppa approach, leading to shorter operation times and fewer complications. Our technique and outcomes suggest that the approach and anatomical QLS plate used in this study are viable for treating superomedially displaced acetabular fractures.

Declarations

Data availability

Data is available from the corresponding author on reasonable request.

Authors’ contributions

DKK: study design, data analysis, drafting manuscript. SHL: study design, data collection and analysis. YML: data analysis and interpretation. JHH: data collection and analysis. JHY: study design, data analysis and interpretation, drafting manuscript, approving final version of manuscript.

Competing interests

The authors declare no competing interests.

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Figures

Figure 1

Image of anatomical suprapectineal quadrilateral surface plate.

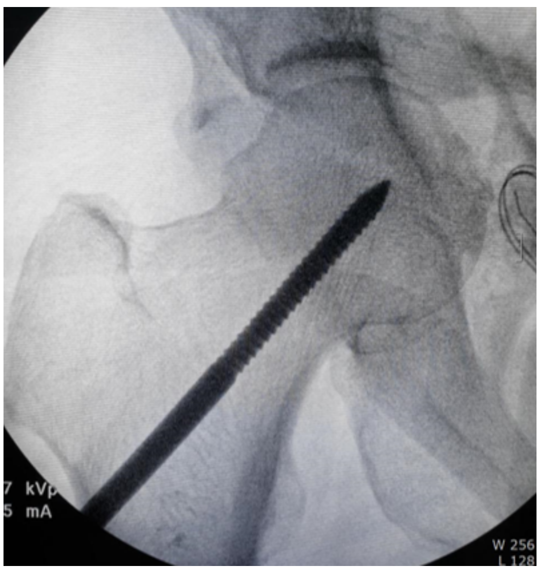

Figure 2

A fluoroscopic image of the insertion of the Schanz screw into the femoral head on operating side.

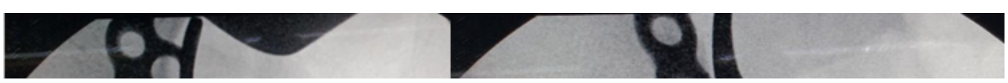

Figure 3

Fluoroscopic images of attaching the quadrilateral surface plate to quadrilateral surface using a ball spike pusher.

Figure 4

Indirect reduction of the medially displaced posterior column fragment using a ball spike pusher on the infrapectineal portion of the quadrilateral surface plate.

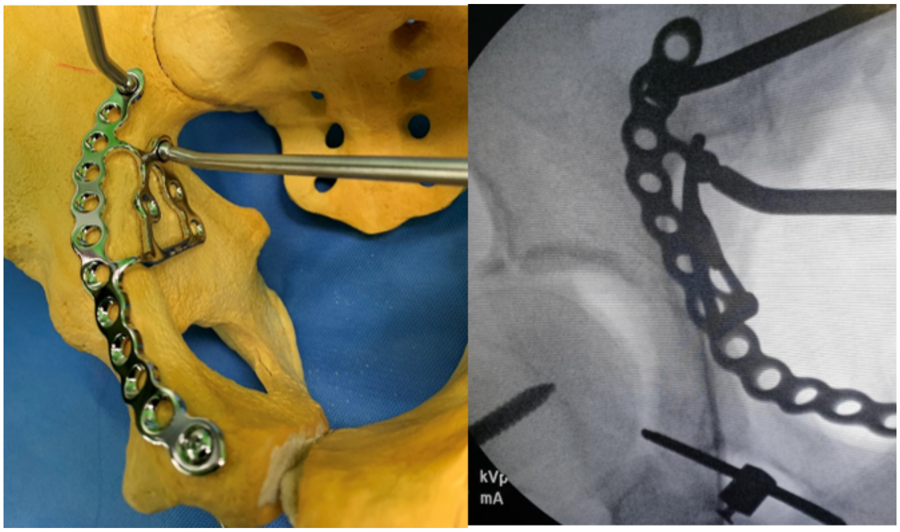

Figure 5

Reduction of the superiorly displaced anterior column using a pusher on the suprapectineal portion of the plate.

Figure 6

Insertion of the screw in the third hole from the back of a suprapectineal portion of the plate while the pushers were maintained on the plate.

Figure 7

a) pelvis anteroposterior radiograph and b) 3D-CT of a 67-year-old male, superomedually displaced acetabular fracture with anterior wall fragment. C) immediate posteoperative and d) 18 months after surgery radiograph, after fixed with quadrilateral surface plate and additional buttress plate.