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Treatment of anterior column posterior hemitransverse fracture with supra-ilioinguinal approach

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Abstract

Objective: To report the feasibility and effect of the supra-ilioinguinal approach for treatment of anterior posterior hemitransverse fracture of the acetabulum.

Methods: Nineteen consecutive patients who underwent treatment for an anterior column posterior hemitransverse fracture of the acetabulum from January 2013 to June 2018 were retrospectively analyzed. All patients underwent treatment by the single supra-ilioinguinal approach with at least 1 year of follow-up.

Results: The mean time to surgery, operative time, incision length, and blood loss were 10.2 ± 3.8 days, 157 ± 125 minutes, 10.2 ± 0.6 cm, and 876 ± 234 mL, respectively. According to the Matta scoring system, the reduction quality was excellent in 13 patients, good in 6, and poor in 0. According to the Merle d'Aubigné scoring system, the outcome at the last follow-up was excellent in 12 patients, good in 5, fair in 1, and poor in 1. Postoperative complications occurred in three patients (deep vein thrombosis in one, lateral femoral cutaneous nerve injury in one, and both complications in one).

Conclusions: Use of the supra-ilioinguinal approach for treatment of anterior column posterior hemitransverse fracture of the acetabulum produced excellent clinical results because of the direct visualization of the anterior column and quadrilateral plate.

Keywords

Supra-ilioinguinal approach, anterior approach, acetabular fracture, anterior column posterior hemitransverse, treatment, clinical outcome

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Introduction

The incidence of acetabular fracture has changed with the continuous development of science and technology as well as changes in lifestyles and transportation.[1,2] Notably, however, the incidence of acetabular fracture varies with age because changes in hormone levels and bone mineral density affect the quality of bone, which determines whether an acetabular fracture can readily occur.[3–5] The elderly population is considered to represent the group at highest risk of sustaining acetabular fracture by a slight fall onto the greater trochanter,[6] which results in fracture of the anterior column, fracture of the quadrilateral plate, and central subluxation or dislocation of the femoral head.[7,8] Among the various types of acetabular fractures, the anterior column posterior hemitransverse (ACPHT) acetabular fracture is the main type that occurs in elderly patients. In this population, early open reduction and fixation has become the gold standard treatment to realize early rehabilitation, improve functional outcomes, and decrease the occurrence of complications.[6,9–12]

The main mechanism of acetabular fractures in elderly and young adults is similar; in elderly people, however, slight lateral forces applied to the greater trochanter of the femur can break the acetabulum, resulting in a different type of acetabular fracture.[6,9] Previous reports of acetabular fractures in young and elderly people have indicated that the main fracture types are significantly different; those in elderly people are mostly ACPHT acetabular fractures, and they are often associated with subluxation or dislocation of the femoral head and even compression of the articular surface.[7,8,13] Hence, adequate intraoperative fracture localization and exposure are crucial for successful treatment of this type of fracture. However, the various fracture sites and loose bone make reduction and fixation difficult.[14] It is important to select a single or combined surgical approach, especially an intrapelvic approach, for the treatment of ACPHT acetabular fractures.

In 1993, Letournel[15] described the use of the ilioinguinal approach to treat anterior acetabular fractures with good results. This method is only clearly indicated when the entire internal side of the ilium, quadrilateral plate, and superior pubic ramus can be seen from the anterior and superior views; it does not provide a good view of the fracture from inside to outside of the pelvis as effectively as other intrapelvic anatomical approaches.[16,17] In 1994, Cole and Bolhofner[18] achieved direct exposure of pelvic fractures by modifying the Stoppa approach, but it was still necessary to make an additional incision along the iliac wing to facilitate placement of the anterior column lag screw and to treat some ACPHT acetabular fractures associated with fractures in the high iliac wings.[18]

Various anterior approaches can reportedly be used to treat anterior fractures of the acetabulum, but non-special surgical methods can also provide a whole view of the inside of the pelvis. Hence, based on the ilioinguinal approach, our team retained the middle window of the ilioinguinal approach and moved the incision upward and inward.[19,20] In 2010, our novel approach was first applied in clinical patients with acetabular fractures. In 2014, our team reported this modified approach and named it the supra-ilioinguinal approach.[20] In 2018, our team published a report describing the effect of treatment for both-column fractures of the acetabulum.[19]

A few reports have described the concrete treatment of ACPHT acetabular fractures within the past decade; therefore, we treated this type of acetabular fracture using a single supra-ilioinguinal approach. The purpose of this study was to evaluate the feasibility of using a single supra-ilioinguinal incision for the treatment of

ACPHT acetabular fractures and to provide a standard score for postoperative function and fracture reduction.

Materials and methods

We collected the data of consecutive patients who underwent treatment for ACPHT acetabular fractures at our traumatic center from January 2013 to June 2018. All patients were treated in the Department of Orthopedics, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology. The exclusion criteria were combination with a femoral head fracture, combination with fractures (excluding sacral fractures) requiring an additional approach for treatment, double acetabular fractures, non-ACPHT acetabular fractures, and $\leq$1 year of follow-up. All patients with an ACPHT acetabular fracture in this study underwent treatment with the single supra-ilioinguinal approach for reduction and fixation, and all procedures were performed by the same surgeon. The patients' general data, time to surgery, causes of injury, blood loss, and operative time were recorded.

Each patient was required to undergo postoperative radiographic examinations such as radiographs in the anteroposterior and Judet positions as well as computed tomography (CT) with three-dimensional (3D) reconstruction. The Matta scoring system was used to evaluate the quality of reduction.[21] According to this system, reduction of $\leq$1 mm is excellent, 2 to 3 mm is good, and $>$3 mm is poor. At the last follow-up, the patients were re-examined for evaluation of pain, walking ability, and hip range of motion and function using the Merle d'Aubigné scoring system.[22,23] According to this system, 17 to 18 points indicates an excellent outcome, 15 to 16 points indicates a good outcome, 13 to 14 points indicates a fair outcome, and $<$13 points indicates a poor outcome.

This study of our novel anterior approach for the treatment of acetabular fractures was approved by the Ethics Committee of Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China. All patients provided written informed consent.

Preoperative preparation

Each patient was required to undergo complete conventional examinations before the operation, including pelvic radiographs, CT with 3D reconstruction, pelvic CT angiography, and color Doppler ultrasound of both lower extremities regardless of the presence or absence of vessel injury and thrombogenesis (Figure 4(a), (b)). Three-dimensional printing technology was used to mirror-print a contralateral healthy hemi-pelvic model to simulate placement of the lag screw and plates, and a whole pelvic model was also printed to simulate the process of reduction. Antibiotics, enemas, blood for transfusion, and intraoperative autologous blood transfusion devices were prepared using conventional methods.

Surgical technique

The patient lay on a fluoroscopic operating table in the supine position. The operating side of the acetabulum was slightly raised, and the operative surgeon stood on the contralateral side. We depicted a triangle using three body markers: the navel, anterior superior iliac spine (ASIS), and pubic symphysis (Figure 1(b)). The beginning point was the junction located on the lateral and the middle one-fourth of the line connecting the ipsilateral ASIS with the navel, and the ending point was the junction seated on the middle and the medial one-third of the line connecting the ipsilateral ASIS with the pubic symphysis. If an iliac fracture was present, the surgical incision could be extended (Figure 1(a), (b)). Conventionally, the length of the entire surgical incision was about

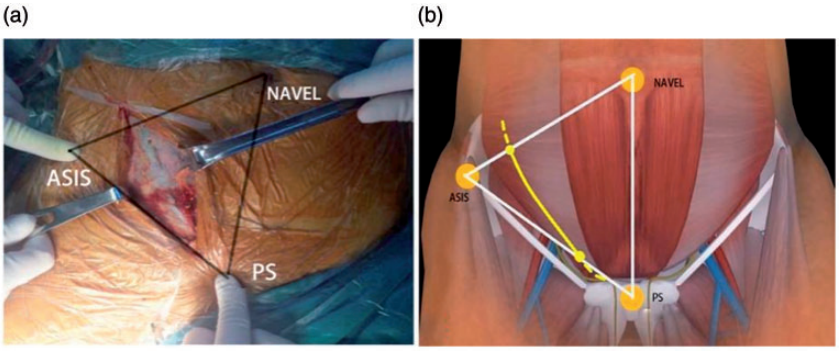

Figure 1. Incision. (a) We depicted a triangle using three body markers: the navel, ASIS, and PS. The incision began at the junction of the lateral and the middle one-fourth of the line connecting the ipsilateral ASIS with the navel, and the incision ended at the junction of the middle and the medial one-third of the line connecting the ipsilateral ASIS with the PS. (b) Diagram showing a virtual incision of the supra-ilioinguinal approach.
ASIS, anterior superior iliac spine; PS, pubic symphysis; N, navel.

10 cm; if necessary, however, the incision could be extended to both sides to facilitate the treatment according to whether a pubic symphysis separation or a fracture of the upper iliac wing was present.

A surgical incision of approximately 10 cm was routinely made along a preset body surface trajectory. The length of the incision was determined by the fracture site. If an iliac wing fracture was present, the incision could be extended upward along the original surgical incision. If the fracture was close to the pubic symphysis or pubic symphysis separation was present, the incision could be extended downward. First, the external oblique, internal oblique, and transverse muscles were incised, and the inferior epigastric artery was identified under the transverse abdominal fascia and ligated. Downward continuous blunt separation of the spermatic cord (male) or the round ligament of the uterus (female) was performed, and the cord or uterus was marked with a red rubber tube. Second, the retropubic space was bluntly exposed from the medial side, and an electric knife was used to peel off the muscles attached to the superior ramus of the pubis. Attention was paid to the presence or absence of a corona mortis, which is an anastomosis between the obturator artery and the external iliac artery or the inferior epigastric artery. If present, the corona mortis was ligated to prevent blood loss from the injury and the placement of plates. Third, the iliopsoas muscle and external iliac vessels were separated. The iliopsoas muscle fascia was incised to expose the iliopsoas muscle, which is convenient for stretching. At this time, attention was paid to the femoral nerve within the iliopsoas muscle to prevent damage. The external iliac blood bundle was then bluntly separated to prevent accidental injury to the branch during the operation, which may cause unnecessary massive bleeding. Finally, separation of the quadrilateral plate and the sacroiliac joint was continued along the pelvic brim, achieving clear, direct visualization of the sacroiliac joint and the quadrilateral plate. The lateral and medial windows were connected below the iliac vascular bundle.

The iliopsoas muscle, spermatic cord or round ligament of the uterus, and external iliac artery were three important anatomical landmarks located at the entrance of the

entire incision. Therefore, the entire incision was divided into four windows according to these three landmarks (Figure 2). The first window was located between the ilium and the iliopsoas (Figure 3(a)) and could be used to treat fractures of the ilium. The second window was located between the iliopsoas and the external iliac vascular bundle (Figure 3(b)) and could be used for placement of the posterior column lag screw. The third window was located between the external iliac vascular bundle and the spermatic cord or the round ligament of the uterus (Figure 3(c)) and could be used to treat fractures of the anterior column and the quadrilateral plate. The fourth window was located between the spermatic cord or the round ligament of the uterus and outside of the rectus abdominis (Figure 3(d)) and could be used to treat fractures of the anterior column, suprapubic ramus, and quadrilateral plate. We used this incision to treat the ACPHT acetabular fractures. For fractures of the anterior column, we placed an anatomical reconstruction plate at the arcuate edge and inserted the screw through the second and fourth windows. The treatment of hemitransverse fractures was mainly based on whether the fracture was combined with comminuted fractures in the quadrilateral plate. It was necessary to decide whether to block and fix the quadrilateral plate or simply fix it with a lag screw or an iliosciatic plate.[24]

Postoperative follow-up

All patients were requested to take oral anticoagulant drugs for at least 3 weeks to prevent deep vein thrombosis. All patients also underwent pelvic radiographs in three positions as well as CT with 3D reconstruction for evaluation of the reduction quality (Figure 4(c), (d), (g)). Weight-bearing activities, such as passive and active ipsilateral hip flexion or extension motions, were not allowed within 4 weeks postoperatively. The patients were allowed to walk with a pair of crutches 4 to 6 weeks postoperatively and with a single crutch 6 to 12 weeks postoperatively. The patients were requested to

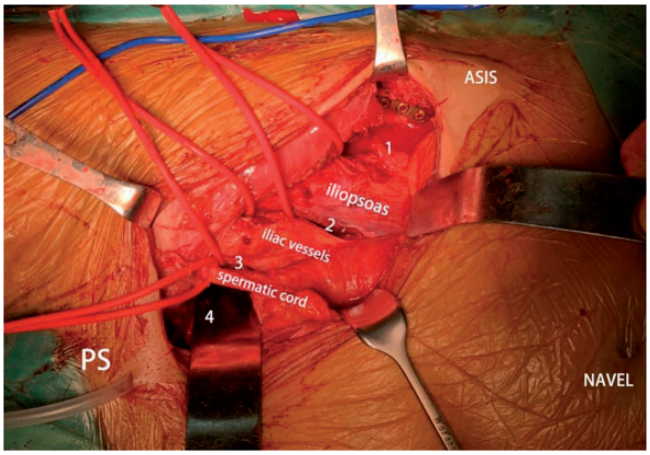

Figure 2. Intraoperative view showing the four anatomical windows of the incisions of the supra-ilioinguinal approach. 1, The first window consisted of the iliac bone and iliopsoas. 2, The second window consisted of the iliopsoas and iliac vessels. 3, The third window consisted of the iliac vessels and spermatic cord (male) or round ligament of the uterus (female). 4, The fourth window consisted of the iliac vessels and spermatic cord (male) or round ligament of the uterus (female) and the outside of the rectus abdominis. ASIS, anterior superior iliac spine; PS, pubic symphysis; N, navel.

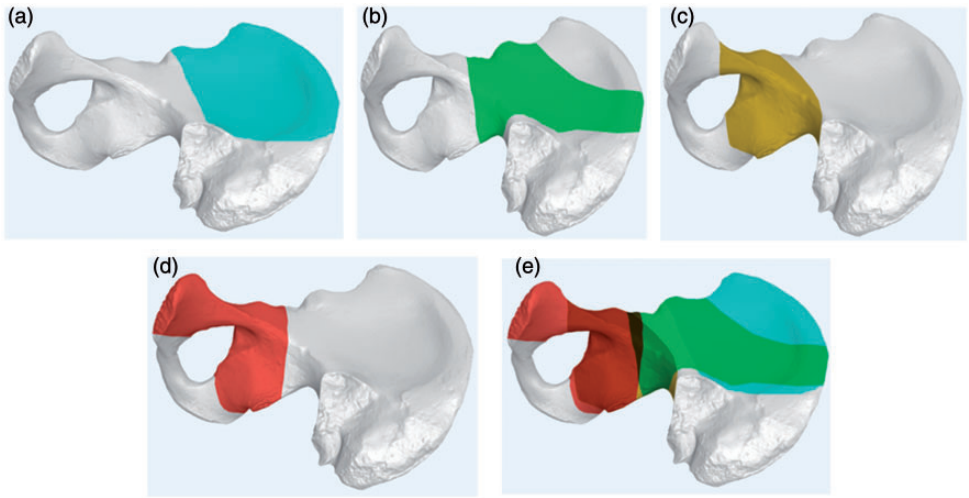

Figure 3. Diagrams showing direct visualization of the four windows of the supra-ilioinguinal approach. (a) First window. (b) Second window. (c) Third window. (d) Fourth window. (e) Visualization of entire incision.

undergo a pelvic radiograph at 1, 3, 6, and 12 months postoperatively to evaluate the rehabilitation of the fracture site.

Statistical analysis

Data were analyzed with IBM SPSS Statistics for Windows, Version 19.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation.

Results

Nineteen consecutive patients were included in this study. Among these 19 patients, 4 (21%) had fractures involving the ipsilateral iliac wing, and the incision was extended to fix the iliac wing. The mean time to surgery was 10.2 ± 3.8 days. The mean operative time was 157 ± 125 minutes. The mean incision length was 10.2 ± 0.6 cm, and the mean blood loss was 876 ± 234 mL (Table 1). According to the Matta scoring system,[21,22] the reduction quality was excellent in 13 (68%) patients, good in 6 (32%), and poor in 0 (0%). The clinical outcomes were evaluated at the last follow-up using the Merle d'Aubigné scoring system,[23] revealing that 12 (63%) patients had an excellent outcome, 5 (26%) had a good outcome, 1 (5%) had a fair outcome, and 1 (5%) had a poor outcome. Postoperative complications occurred in three (16%) patients (deep vein thrombosis in one, lateral femoral cutaneous nerve injury in one, and both of these complications in one). No other complications occurred, such as obturator nerve or vascular injury, inguinal or abdominal wall hernias, or atrophy of the rectus abdominis (Table 1).

Discussion

Since Letournel[15] applied the ilioinguinal approach to the treatment of acetabular fractures, many surgeons have begun to pay attention to the application of this approach, especially in the treatment of anterior acetabular fractures.[25–27] This surgical approach is applicable to all fractures involving the anterior acetabulum, including simple anterior column or wall fractures, associated anterior column and wall fractures, ACPHT acetabular fractures, and

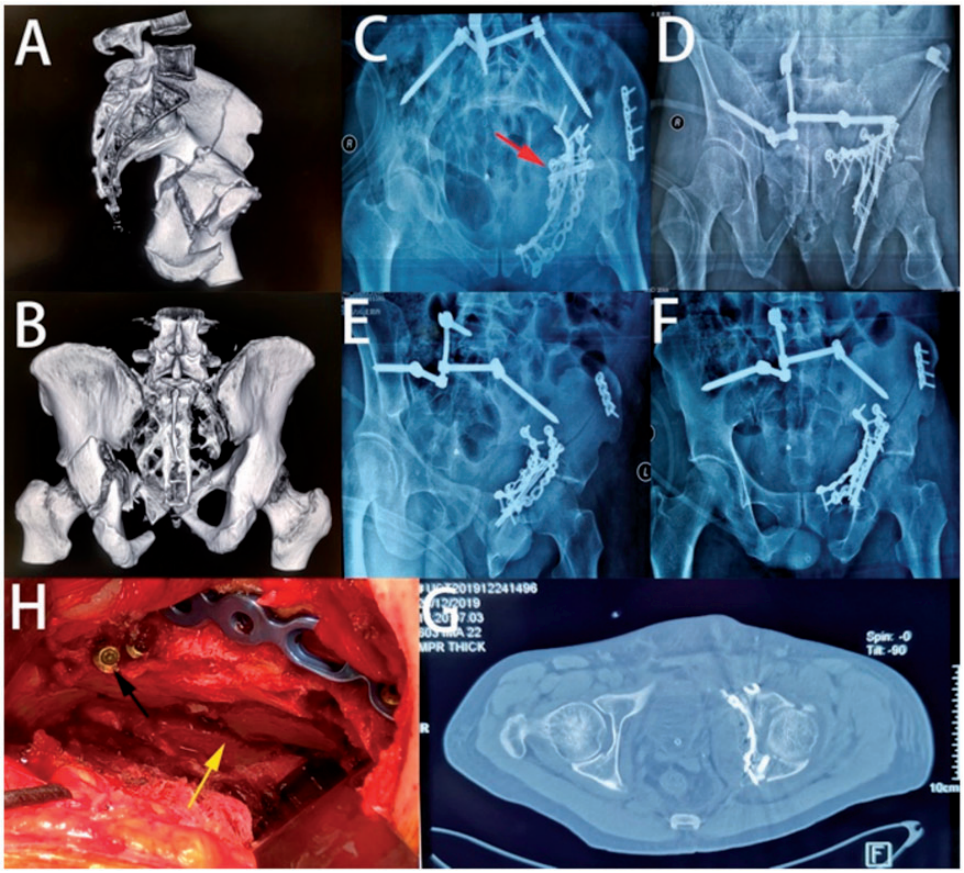

Figure 4. Diagram showing a 54-year-old man with an ACPHT acetabular and sacral fracture caused by a transport accident. The patients' radiographic data included (c, d) postoperative X-rays in four positions, (g) a computed tomography scan, (a, b) preoperative three-dimensional reconstruction, and (h) an intraoperative image. Visualization of the entire quadrilateral plate and placement of the lag screw in the posterior column was achieved with this incision (yellow arrow, broken quadrilateral plate; black arrow, lag screw). We placed a curved supra-pectineal plate and a quadrilateral integrated infra-pectineal buttress plate (red arrow).

T-shaped fractures. However, it also has some drawbacks. For example, it cannot be easily performed in the treatment of some highly separated posterior column fractures because of unclear visualization of the posterior column. Moreover, this approach invades the inguinal canal and requires separation of the iliac and femoral vascular bundles and femoral nerves, which can easily lead to iatrogenic neurovascular injury.[28]

In 1973, Stoppa[29] first reported a novel surgical approach, namely a subperitoneal approach for the treatment of inguinal hernias, which was subsequently named the Stoppa approach. In 1994, Cole and Bolhofner[18] modified the Stoppa approach to treat acetabular fractures. Review articles were published thereafter to describe the evolution of the technique.[30,31] Using this approach, the medial wall, dome and quadrilateral plate of the acetabulum,

Table 1. Patients' data during hospitalization.

Patient No.	Age, years	Time to operation, days	Operative time, minutes	Length of incision, cm	Blood loss, mL	Matta score	Merle d' Aubigné score	Complications
1	51	5	110	9.3	450	Excellent	Excellent	
2	47	13	170	11.1	850	Excellent	Excellent	
3	38	6	165	10.5	900	Excellent	Excellent	
4	63	14	185	9.7	1100	Good	Fair	
5	53	10	130	9.5	800	Excellent	Good	LFCNI
6	44	8	140	9.2	750	Excellent	Excellent	
7	34	7	160	10.3	800	Excellent	Excellent	
8	31	4	115	10.1	450	Excellent	Excellent	
9	27	6	120	10.3	600	Excellent	Excellent	
10	66	17	165	9.6	1050	Excellent	Good	DVT
11	45	11	190	11.5	1350	Good	Good	
12	56	8	155	10.4	900	Excellent	Excellent	
13	53	9	145	10.3	800	Excellent	Excellent	
14	46	12	170	10.5	900	Good	Good	
15	57	10	185	9.8	1050	Good	Excellent	
16	65	19	155	11.2	750	Excellent	Good	LFCNI, DVT
17	49	12	195	9.7	1250	Good	Poor	
18	42	11	160	9.8	900	Excellent	Excellent	
19	30	12	170	10.4	1000	Good	Excellent	

LFCNI, lateral femoral cutaneous nerve injury; DVT, deep vein thrombosis.

and even the sacroiliac joint were exposed and directly visualized without dissecting the external iliac vessels. However, this approach was not feasible for treatment of iliac wing fractures and the placement of posterior lag screws, requiring the creation of an additional lateral iliac window. Because the external iliac vessels were not separated, it was difficult to operate on the quadrilateral plate. Although the traditional Stoppa approach has been modified to change the vertical incision into a transverse incision along the pubic symphysis, it still requires a combined iliac fossa approach to treat iliac wing fractures and placement of posterior column lag screws. Additionally, because of the extra incision, complications of this approach are not rare and may include hernias, vascular complications, and especially postoperative infections.[28,32]

In 2012, Keel et al.[33] reported a novel anterior intrapelvic approach to treat acetabular fractures. This approach followed the advantages of the ilioinguinal approach with the medial view of the anterior intrapelvic approach and was less invasive. Additionally, using this approach, some complex acetabular fractures could be addressed by applying a single incision. However, because the beginning point of the incision was slightly far from the ASIS, placement of the reduction clamps and lag screws or plates for high anterior column fractures was difficult.

After considering the advantages and disadvantages of various anterior surgical approaches for anterior acetabular fractures, our team proposed a high supra-ilioinguinal approach based on an ilioinguinal incision and used it to treat ACPHT acetabular fractures. This modified novel approach continuously uses the middle window of the ilioinguinal approach, and the incision is moved upward and inward.

Compared with the ilioinguinal and modified Stoppa approaches, this novel approach is nearly located on the quadrilateral plate. Anterior acetabular fractures can be conveniently treated through a single incision; such fractures include anterior wall, anterior column, both-column, associated anterior column and posterior hemitransverse, transverse, and "T"-shaped fractures (excluding simple posterior acetabular fractures). For some ACPHT acetabular fractures associated with high anterior column fractures, the incision can be extended, allowing lateral exposure of the iliac wing without a second incision; this decreases the risk of infection. Additionally, the novel approach does not involve dissection of the inguinal canal, which avoids injury to the vessels and nerves. Because the incision is located on the lateral side of the rectus, it is unnecessary to cut the rectus and expose the bladder; this avoids the risk of certain complications such as atrophy of the rectus and iatrogenic injury of the surrounding tissues.

Compared with the pararectus approach, the rectus sheath does not need to be dissected in the supra-ilioinguinal approach; only the three layers of the abdominal muscle must be cut. This avoids peritoneal injuries and postoperative abdominal wall hernia formation. Because the incision in the supra-ilioinguinal approach is more lateral than that in the pararectus approach, it is convenient to expose and treat high anterior column fractures exiting the iliac crest without an additional incision; this also decreases the risk of wound infection.

In the present study, 19 patients with ACPHT acetabular fractures were treated through a single supra-ilioinguinal approach. We obtained excellent reduction in 68% of patients and good reduction in 32%. Evaluation of the clinical results using the Merle d'Aubigné scoring system at the last follow-up showed good or excellent outcomes in 89% of the patients.

Our study has several limitations. First, when using our approach, the iliac vascular bundle and spermatic cord must be dissected. Although the spermatic cord and vessels can be protected under direct visualization, injury is still possible during the separation process. Second, our study was retrospective in nature. Third, this study focused only on the effect of surgical treatment of ACPHT acetabular fractures with the single supra-ilioinguinal approach; it lacked postoperative evaluation of other anterior fractures. Therefore, it is necessary to collect additional data on other types of anterior fractures and comprehensively evaluate the advantages and disadvantages of this surgical approach.

Conclusions

Treatment of ACPHT acetabular fractures using our ilioinguinal approach produced a favorable clinical effect because of the clear, direct view of the anterior column and quadrilateral plate. This surgical technique affords a selective anterior approach for the treatment of ACPHT acetabular fractures and even other fractures associated with anterior acetabular fractures.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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