

Original Article

An anatomical research of the anterior pelvic surgical approach and its clinical application in the treatment of pelvic and acetabular fractures

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Abstract: Objectives: To provide the anatomical basis via the anterior pelvis surgical approach to treat pelvic and acetabulum fracture. Methods: (1) Ten formalized cadavers were dissected, observed within the hypogastric region and pelvic anatomical position and variation. (2) On the basis of anatomical study, 20 patients with unstable pelvic fractures and 15 patients with acetabulum fracture were performed with the anterior pelvis surgical approach. Results: The separation could not separate and exposure of the spermatic cord/round ligament of the uterus; Separation of the rectus incision is located in the midline partial lateral 3 cm, is located in the inner side of arterio-venous cycle line position. Thus reducing the fire risk. And it helps to exposure corona mortis and vas deferens, etc. Dissection along the iliopectineal line, surgeon can exposure the operative field from the pubic symphysis to the sacroiliac joint and quadrilateral surface ahead. Clinical application of 35 patients, anatomic or satisfactory reduction was achieved. Conclusion: The anterior pelvis surgical approach provides excellent visualization to the anterior column, quadrilateral surface and permits good postoperative results for treatment of pelvic and acetabular fractures. It is an alternative and new surgical approach to access to the internal pelvis and medial wall of the acetabulum.

Keywords: Pelvic fracture, acetabular fracture, anatomical research, surgical approach, anterior pelvic surgical approach

Introduction

Clinically, significantly displaced fractures of pelvic and acetabular fractures are the best indications of open reduction and internal fixation. Many studies have revealed that a good anatomic reduction surgery of pelvic and acetabular fracture can significantly reduce time in bed and the incidence of traumatic arthritis in the articulation coxae in patients with unstable pelvic rings [1-3]. One of the key factors that determine the clinical effects of surgical reduction is the good exposure of the fracture site, because it provides the surgeon a wide field of view. Surgical approaches commonly used in clinic such as the limited or expanded ilioinguinal approach [4] and Kocher-Langenbeck approach (K-L approach) can all attain the exposure of a large area that the surgery requires [5]. However, complications that occur

after surgery should not be underestimated [6-8]. Therefore, the surgeon should comprehensively consider the patient's fracture site, reduction ease, application of fixation devices and other factors in selecting the optimal surgical incision.

The Stoppa approach, which is commonly used in clinic, was first reported and applied for abdominal hernia repair by R. stoppa *et al.* [9, 10]. In 1993, Eero Hirvensalo and Jane Lindahl *J. et al.* first proposed to modify the Stoppa approach [11], while Cole J.D. and Bolhofner B.R. *et al.* reported its clinical application in 1994 [12]. In recent years, as a surgical exposure approach with limited incision, this technique has been widely applied to pelvic and acetabular fractures such as anterior pelvic ring fracture, proximal sacroiliac joint fracture, sacroiliac joint separation, fracture of the ante-

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rior wall and anterior column of the acetabulum, transverse acetabular fracture, T-type fracture, acetabular column fracture combined with anterior wall fracture, and acetabular column fracture combined with transverse posterior half acetabular fracture.

We summed up a whole new surgical approach from our clinical experience in the clinical treatment of pelvic and acetabular fractures. Its longitudinal or transverse incision are all located 2 cm above the pubic symphysis, in which the longitudinal incision is in the affected side approximately 3 cm next to the abdominal midline, and the 8-9 cm long incision is located from 2 cm above the pubic support to the umbilicus. The main part of the transverse incision is located at the affected side approximately 2 cm crossing the abdominal midline. The lengths of transverse and longitudinal incisions are 8-9 cm, and are smaller compared with traditional surgical incision. Compared with the traditional Stoppa approach, this approach can quickly arrive at the surgical area with a clear and extensive exposure of the surgical site. In order to confirm the feasibility of this approach, we conducted an anatomic study. Furthermore, we underwent preliminary clinical practice on the basis of anatomical study and achieved good clinical results.

Materials and methods

Anatomical study

Formalin-fixed adult cadavers 20 sides in 10 cases, 12 sides in six male cases, and eight sides in four female cases. All specimens were perfused through the blood vessels and formalin-embalmed. All cadavers had no deformities, no history of tumor, and no history of abdominal or pelvic trauma surgery. All cadavers were provided by the Department of Anatomy, The Second Military Medical University. Gross level anatomy for formalin-embalmed specimens was conducted to observe the anatomic structure and variation situation in the lower abdominal wall and pelvic cavity. Superficial inguinal ring, spermatic cord/uterine round ligament, and traveling characteristics of the inferior epigastric artery and vein were observed. Anatomical locations of the obturator nerve, obturator vessels, and vas deferens/uterine round ligament were detected. The obturator foramen was observed to deter-

mine whether there are rami communicans between the obturator vessels and the inferior epigastric artery, as well as the relationship between this communicating vessels and linea iliopectinea.

Clinical study

General information: Twenty patients with pelvic fracture and 15 patients with acetabular fracture treated at Shanghai Changhai Hospital and Shanghai Pudong Hospital from January 2009 to June 2011 were selected as specimens. Among them, 23 were male and 12 were female; and the age of patients ranged from 21 to 60 years, with a mean age of 38.3 years. Pelvic fractures were classified by Tile classification: Tile B was 12 cases (B1 five cases, B2 seven cases) and Tile C was eight cases (C1.1 five cases, C1.2 three cases). Acetabular fractures were classified by Judet-Letournel classification, in which three cases were anterior column fractures, six cases were posterior column fractures, three cases were double-column fractures, and three cases were T-type fractures.

Surgical methods

Patients were placed in supine position. The operating table was adjusted to the head-end slightly lower by approximately 5° to locate the patient's pelvic organ as far away from the pubic symphysis as possible. Routine disinfection towels were placed at the lower abdomen, a longitudinal incision of 3.0 cm was made at the skin, and subcutaneous tissues were cut from 2 cm below the belly button to 3 cm above the pubic symphysis along the ventral midline, which was slightly biased toward the affected side. The rectus abdominis was longitudinally sliced apart, the abdomen of the rectus abdominis was retracted outward, separating at the posterior rectus sheath. Thus, the inferior epigastric artery and vein were revealed, and the artery and vein were ligated to prevent bleeding. The posterior rectus sheath and transverse fascia were cut apart, and the rectus abdominis was transversely cut off in the affected side. The incision was located at a point approximately 0.5-1 cm above the terminal of pubic symphysis, and the abdominal wall of the affected side was retracted outward in order to expose the peritoneal outer space. A blunt dissection of the peritoneum was con-

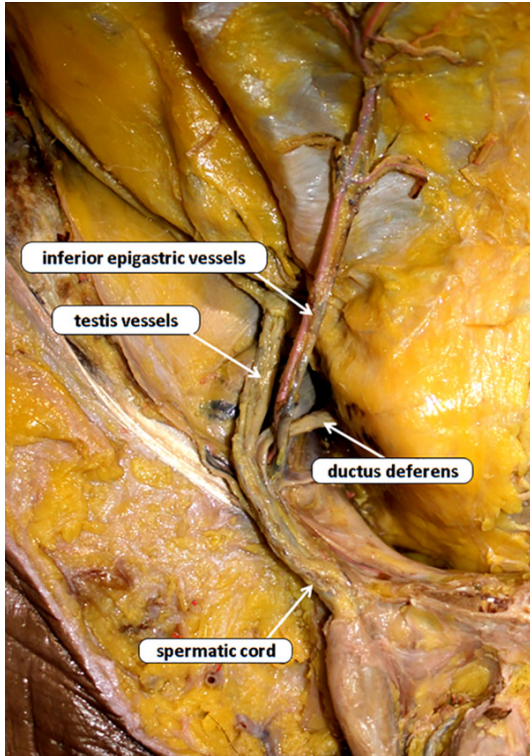


Figure 1. Anatomical features in the spermatic cord and inferior epigastric vessels.

ducted, while the bladder, peritoneum and pelvic organ were pushed toward the proximal end. The bladder was pushed off toward the direction of the head end by a moist gauze-wrapped intraperitoneal retractor instrument, revealing the posterior pubic space, rectus abdominis, joint tendon and external iliac neurovascular sheath underneath the abdominal wall; which were retracted directly outward by an intraperitoneal retractor. The edge of the true pelvis was exposed along the pubic superioris from front to back. A sharp dissection of the ligament of the pecten ossis pubis and ilio-pubic fascia was conducted, and a subperiosteal dissection was conducted along the pecten ossis pubis, revealing iliolumbar iliac artery branches above across linea iliopectinea. Care should be given in important anatomical structures along the line to avoid any harm. The surgeon carefully conducted the subperiosteal dissection along the pubic superioris, and was able to expose the true pelvis edge and body of squares along the line from the pubic symphysis to the sacroiliac joints. Excessive traction of the abdominal wall and pelvic organs toward both sides should be avoided during surgery, in

order to avoid damage to the vas deferens across and above the surgery field. Particularly, meticulous attention is required to probe whether there are communicating blood vessels connected to the obturator artery across the pubic superioris and external iliac artery. Plates may be placed for security reasons. Generally, the corona mortis needs to be ligated and cut off in order to avoid accidental injury and subsequent fatal hemorrhage. Periosteal stripping starts at the fracture end, and reduction by the instrument. After appropriate shaping, the titanium-reconstructed locking plate is placed above the pubic superioris, the squares and linea iliopectinea are fixed to the anterior pelvic ring and posterior acetabular columns, and staples or plates are set before the sacroiliac joint to fix the posterior pelvic ring. Regular follow-up was conducted after surgery to observe the effect of treatment.

Results

Anatomical study on anterior approach-related structures

Anatomical features in the spermatic cord and vessels underneath the abdominal wall: The spermatic cord arises from the perineum, travels along the pubic surface towards the proximal end, reaches the lateral line beneath the pubic tubercle, and enters into the inguinal canal at a point 32.16 ± 3.6 mm (29.5 - 37.6 mm) away from the pubic symphysis. The spermatic cord within the inguinal canal travels parallel to the pubic superioris, leaves the deep ring from the point 42.9 mm away the superficial ring and enters into the peritoneal outer space; then, divides into two parts: the vas deferens, and testicular artery and vein (**Figure 1**). The vas deferens turns to the inferior epigastric direction around the beginning part of inferior epigastric vessel, travels across and above the linea iliopectinea, enters into the pelvic cavity, then goes downward along the pelvic sidewall and the fascia of the urinary bladder, ending at the vas deferens ampulla. The total length of the pelvic portion of the vas deferens is 86.52 ± 8.95 mm (76.5 - 91.6 mm). In the pelvis, testicular arteries and veins travel along the fascia on the psoas major surface towards the proximal end.

The inferior epigastric vessel starts from the external iliac artery and vein located above the

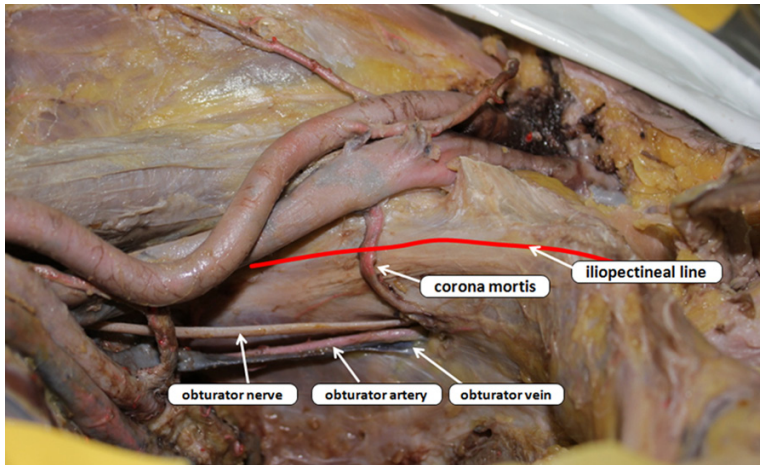


Figure 2. Peripheral structures of the obturator foramen: obturator nerve, obturator vessels, and corona mortis.

inguinal ligament, and diagonally travelling upward at a 70° angle with the longitudinal axis of the body along the pathway between the transverse fascia and posterior rectus sheath. When it reaches the location at a vertical distance of 30 mm from the pubic symphysis, it is 49.82 ± 5.87 mm (42.5-51.6 mm) from the midline of the abdomen. When it reaches the location at a vertical distance of 90 mm from the pubic symphysis, it is 50.85 ± 4.68 mm (43.8-54.7 mm) from the midline of the abdomen (**Figure 1**).

Anatomical characteristics of important peripheral structures around the linea iliopectinea

The obturator nerve arises from the lumbar plexus. When reaching the upper edge of the true pelvis, it goes through by the lower edge of the psoas major, and goes beneath the external iliac artery along the gap between the internal iliac artery and psoas major. Then, it goes across the linea iliopectinea into the true pelvis, and travels closely parallel to the obturator artery on the iliac fascia surface and enters into the obturator foramen (**Figure 2**). The pelvic segment of the obturator nerve has no branch. Its length is 96.94 ± 9.55 mm (93.8-107.3 mm) and is separated from the bony pelvic wall by the pelvic fascia and internal obturator muscle. The perpendicular distance from the midpoint of the pelvic segment of obturator nerve to the linea iliopectinea on the upper edge of the true pelvis is 12.5 ± 2.81 mm (10.8-17.3 mm). The inner side of the anterior seg-

ment of the obturator nerve is close beneath the outer wall of the bladder. The perpendicular distance from the part of obturator nerve going through the obturator foramen to the linea iliopectinea is 18 ± 3.1 mm (12.7-21.6 mm).

The topographical relationship between the obturator nerve and obturator artery and vein: the top-down order is nerve, artery and vein (**Figure 2**). The obturator artery arises from the internal iliac artery, while the obturator vein converges with the internal iliac vein.

The obturator artery is located close to the vein, runs medially along the inner surface of the pelvic sidewall, travels along the iliopubic fascia on the surface of squares, then runs through the obturator foramen from the upper rear to the lower front. Thereafter, it travels through the obturator canal to the thigh. The total length of the obturator vessel segment in the true pelvis is 47.8 ± 5.36 mm (40.8-52.3 mm), the perpendicular distance from the original end of the obturator artery to the linea iliopectinea is 16.08 ± 2.28 mm (13.7-19.8 mm), and the perpendicular distance from the middle of the obturator artery to the linea iliopectinea is 18.28 ± 3.48 mm (14.9-22.8 mm). The perpendicular distance from the converging terminal of the obturator vein to the linea iliopectinea is 12.0 ± 2.04 mm (9.7-15.8 mm), and the perpendicular distance from its middle to the linea iliopectinea is 21.6 ± 3.47 mm (18.7-26.7 mm).

In 14 sides of specimens, we found that the corona mortis connects to the obturator vessels and inferior epigastric vessels (**Figure 2**). Among them, 11 cases were venous corona mortis, while three cases were arterial corona mortis. When arising from the external iliac artery, the corona mortis vertically goes across the linea iliopectinea close to the fascia on the pubic superioris surface, and medially goes downward, entering the obturator foramen. Its total length is 42.66 ± 6.63 mm (39.7-49.4 mm). The distance from its crossing point with the linea iliopectinea to the pubic symphysis is 65.30 ± 8.04 mm (59.7-72.8 mm).

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Before outgrowing the obturator artery, the internal iliac artery outgrows the iliolumbar artery, which travels 22.0 ± 3.14 mm (19.2-25.4 mm) by the front of the sacroiliac joint; and goes across the linea ilipectinea into the iliopsoas. The iliolumbar artery outgrows two to three branches before entering the iliopsoas.

Clinical application of the anterior approach in pelvic and acetabular fractures

All patients did not suffer from preoperative and postoperative hemorrhage. Mean length of the anterior approach incision was 10 cm (9-12 cm), and mean blood loss was 225 ± 30.5 ml (170-350 ml). All patients were followed up for an average of 18 months (11-35 months). All patients attained bony union. On the imaging evaluation criteria developed by Matta *et al.* [13], the reduction of patients with pelvic and acetabular fractures were evaluated as good (a < 4 mm gap on the affected site in the pelvic fracture is good, and a reduction of < 3 mm is a satisfactory reduction). Twenty cases of pelvic fracture patients received follow-up for an average of 16 months (12-35 months), and scores of the Majeed pelvic fracture quantitative assessment system [14] of major patients (18 cases) were 80 points or more. Fifteen cases of acetabular fracture patients received follow-up for an average of 19 months (11-32 months). The scores of Harris hip joint assessment system of majority (13 cases) of patients were 85 points or more.

Two patients suffered from significant postoperative scrotum and penis bruising swelling; and five to seven days of swelling was relieved after magnesium sulfate wet dressing. All patients had no femoral nerve and sciatic nerve injury. All patients did not present deep vein thrombosis. All incisions of patients healed by first intention. In follow-ups, no patient experienced reduction loss, loosening and other complications.

Discussion

The pelvic surgical approach plays a pivotal role in the treatment of pelvic and acetabular fractures. It provides a good surgical field and facilitates fracture reduction operations for surgeons, reducing the heterotopic ossification rate in the fracture site. However, at the same time, anatomical structures in this site

are complex, while it has numerous nerves and blood vessels, and may grow anatomical variations; and a young doctor's learning curve for this is very long. Currently, the most common applied approach is the ilioinguinal approach, which is basically conducted by experienced surgeons; because this approach involves separating and exposing the iliac neurovascular sheath and the slightest mistake could lead to serious consequences [15]. Thus, many scholars have made improvements based on the ilioinguinal approach or tried to explore new surgical approaches [16-18] in order to reduce the risk of injury in important nerves and vessels.

The pelvic ring fracture, anterior acetabular wall fracture and anterior acetabular column fracture was first applied in 1993. It does not involve the dissection and separation of the iliac inguinal canal and neurovascular sheath, and has a relatively convenient operation and simple anatomical level, compared with the iliac inguinal approach. The Stoppa approach has been more widely applied [19, 20]. Although relevant studies have described the anatomical structures in this area, they all focused in narrating reduction treatment, which lack complete measurement data on the anatomical structures of this surgical approach. In this study, we proposed a new anterior surgical approach based on years of experience in clinical treatment of pelvic and acetabular fractures. The path into the lateral peritoneal region and into the true pelvis is 3 cm away from the abdominal midline, compared with the traditional Stoppa approach, reducing the traction force of the instrument, exposing the surgical field, as well as avoiding unnecessary interference of mechanical stress to the abdominal wall.

In this study, we focused on the anterior surgical approach, further elaborating the measurement of blood vessels, nerves, spermatic cord and other anatomical structures on the bony structure surface surrounding this approach.

Advantages and limitations of the anterior pelvic approach

The anterior pelvic approach in this study is located above the pubis in the lower abdomen, which is 3 cm near the affected side, compared with the Stoppa approach. Compared with the traditional approach, the anterior pelvic ap-

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proach can fully expose the true pelvis without incurring undue isolated stretch in the lower abdominal wall. For postoperative aesthetic considerations, female patients can choose a transverse skin incision. Based on anatomical measurement studies, it is confirmed that when applied to treatments of the anterior pelvic ring fracture, proximal sacroiliac joint fracture, sacroiliac joint separation, fracture of the anterior wall and anterior column of the acetabulum, transverse acetabular fracture, T-type fracture, acetabular column fracture combined anterior wall fracture, and acetabular column fracture combined transverse posterior half acetabular fracture, this approach has the following advantages. (1) Safe incision, less damage. The incision of this approach is located 3 cm above in the pubic superioris and the inner side of the superficial inguinal ring, there is no need to separate and expose the spermatic cord/uterus round ligament in the full-length, greatly reducing the chance of damage to the structure. The rectus dissection incision is located in the midline 3 cm towards the lateral side, in the medial side of the path where the inferior epigastric artery and vein travels through, reducing the risk of accidental injury to the blood vessel. (2) Adequate exposure range. This approach enters into the external peritoneal region in a location 3 cm towards the affected side, and is conducive for the retractor to expose the entire pelvic ring, the true pelvis, and the anterior part of the sacroiliac joints. A shorter exposure path significantly reduces the force that the assistant uses with a retractor to reveal the wound, and decreases the assistant's fatigue. (3) Safe exposure of the vulnerable corona mortis, as well as the vas deferens and the like. The surgeon conducts a sharp incision along the linea iliopectinea, and makes a blunt dissection close to the linea iliopectinea and the surface of squares, rendering the surgical field to extend from the pubic symphysis into the anterior part of the sacroiliac joints and squares. The operation that locates the dissection and exposure towards and above the linea iliopectinea and separation of the iliopsoas and iliac vessels by a retractor can also reveal the deep part of the iliac fossa and the anterior half of the top part of the acetabulum, which meet the clinical requirement of exposure for the treatment of fractures in this site.

At the same time, it should be noted that this approach also has some limitations. In the

external iliac artery sheath, the psoas major lay across the upper entrance of the true pelvis, but this approach does not involve the dissection of this structure. In this case, the iliac wing, front iliac spine and the top part of acetabulum cannot be directly exposed. Treatments of fractures in this site require a combination of part iliac femoral approach or the application of the posterior lateral hip approach, and so on. This approach that reveals squares can be applied for the treatment of acetabular column fractures combined with transverse posterior half acetabular fracture. However, for the treatment of acetabular posterior wall fracture, due to its inability to reveal the posterior wall of the acetabulum, the surgeon cannot directly see the operation of reduction, which requires the application of the posterior lateral hip approach, and so on. As for obese patients, since their skin and soft tissues within the pelvic cavity are relatively more, the vertical distance from the skin to the fracture site is long, which brings a certain degree of difficulty to the surgical operation.

Clinical significance of the surgical operation of the anatomical study on the anterior pelvic approach

Among many surgical approaches, it is impossible to meet the requirement of exposure for various types of pelvic fractures by a single approach. Clinically, commonly used surgical approaches can be classified into two categories: the internal pelvis approaches (ilioinguinal approaches), and external pelvis approaches or K-L approaches, extending iliac approaches, and so on. The K-L approach has shortcomings of interference with the abductor, easy to damage the sciatic nerve, and so on. On the other hand, the ilioinguinal approach is the standard anterior approach for acetabular and pelvic fractures [1]. Although there have been various improvements at present, all these improved approaches require the dissection of important anatomical structures such as the lateral femoral cutaneous nerve, iliopsoas, femoral nerve, external iliac vessels, lymph tubes, spermatic cord, or round ligament of the uterus. It has various disadvantages such as difficult to operate, technically demanding, time-consuming operation, long incision, serious damage, and so on. Thus, these have great surgical risks.

The anterior approach was applied in the clinical treatment of pelvic and acetabular fractures

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in this study, which employs only a longitudinal incision in the middle of the abdomen partial to the affected side, or a curved incision along the pubic symphysis that enters the external space of the peritoneum, passes by peritoneum rectus, pushes away the bladder, and retracts outward under the abdominal wall and the iliac neurovascular sheath. A sharp incision was applied in the iliopubic fascia along the pecten ossis pubis, and dissected and exposed along the pecten ossis pubis from front to back, ending in the marginal periosteum of the true pelvis, as well as a blunt dissection of the internal obturator muscle along the squares area. A special retractor device (such as Hoffman retractors) is placed in the great sciatic notch, which retracts apart the pelvic obturator nerve and the deep obturator muscle, the lumbosacral trunk in front of sacroiliac joint, etc. Thus, it can safely achieve effective exposure of the line from the pelvic pubic symphysis along the linea ilipectinea to the front part of the sacroiliac joint, the front wall and front column of the acetabulum, and the squares.

Compared with the traditional ilioinguinal approach, the anterior approach has no requirement of dissection and exposure of the external iliac neurovascular sheath bundles, as well as the spermatic cord; greatly reducing the risk of surgical injury and the risk of blood clots after surgery. Studies have revealed that a relatively large ratio of cases of postoperative femoral vein thrombosis occurred for the ilioinguinal approach. The group of patients in this study has reported no case of deep vein thrombosis. Some indices in this study such as average time, blood loss and surgical incision length are relatively superior compared with those in the traditional approach. Scores of postoperative reduction evaluation and postoperative functional marking in most fracture patients were excellent, indicating that the anterior approach meets the incision requirement in the pelvic and acetabular fracture surgery; and the clinical results were satisfactory. Patients could turn over in the early stage after surgery, could stand up with the aid of double crutches protecting the affected hip joint, and without weight-bearing after two weeks. After 4-12 weeks later, the patient could walk with the affected limb in part or full weight-bearing. As determined by X-ray imaging, results revealed good functional recovery. Therefore, a good,

stable, minimally invasive manner of internal fixation in pelvic acetabular fracture treatment is significant. Early exercise is beneficiary in accelerating the postoperative recovery of patients.

By anatomical study on specimens and clinical application research, we believe that in treating anterior pelvic ring fractures, proximal sacroiliac joint fractures, sacroiliac joint separation, fractures of the anterior wall, anterior column of acetabulum, transverse acetabular fractures, T-type fractures, acetabular column fractures combined anterior wall fractures, and acetabular column fracture combined transverse posterior half acetabular fractures, the anterior approach can meet these exposure requirements. It has several advantages such as clear anatomical structures and levels, safe operation, less damage, fully exposes the surgical field, fewer surgical complications, and so on.

Disclosure of conflict of interest

None.

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