

APACHE—Anterior Plating of the Acetabulum in Hemi-Endoscopic Technique: An Alternative Method for Internal Fixation of the Acetabulum



Koroush Kabir, M.D., Kristian Welle, M.D., Philipp Lingohr, M.D., Max Jaenisch, M.D., Jonas Roos, M.D., and Martin Gathen, M.D.

Abstract: Injuries of the acetabulum are often challenging in treatment and aftercare. One reason is the required surgical approach, which has high complication rates, including vascular lesion, hernias, and wound infection. We present an alternative endoscopic-assisted approach for the internal fixation of acetabular fractures to avoid the Pfannenstiel incision. An endoscopic approach similar to that used for endoscopic hernia surgery was used. The ilioinguinal approach's lateral window was used to achieve reduction and insertion of a reconstruction plate. The purpose of this study is to describe a minimally invasive technique as a possible method to reduce hospitalization and complications. Another goal is to give detailed technical recommendations and to assess the potential pitfalls of this surgical approach. The APACHE technique is a safe and suitable minimally-invasive approach for the successful treatment of complex acetabular fractures and can be considered in similar cases.

Open reduction and internal fixation are the preferred therapy in displaced acetabular fractures in the elderly with reported good to excellent results.¹ The operation is challenging, starting with an approach that is associated with blood vessel or nerve injuries, and it is mostly performed in specialized centers.^{2,3} The worldwide gold standard for the treatment of fractures of the anterior column is either the ilioinguinal approach or the modified Stoppa approach.^{4,5} Both provide an excellent overall view of the acetabulum but can also result in complications such as hernia, hematoma, thrombosis, lesions of vessels or nerves, and impaired wound healing.⁶

Minimally invasive arthroscopic techniques have been increasingly used in trauma and orthopaedic surgery over the last decades with excellent results and reduced morbidity. The goal is to reduce the iatrogenic damage and to minimize the invasiveness of every operation.⁷⁻⁹ We present an alternative surgical approach for minimally invasive endoscopic-assisted internal fixation of the acetabular fracture and share our experience, tips, and tricks. The anterior plating of the acetabulum in hemi-endoscopic (APACHE) technique combines the gold standard of the lateral window of the ilioinguinal approach with a minimally invasive endoscopic procedure. This made it possible to perform the surgery without the Pfannenstiel incision and keep the rectus abdominal muscle completely intact. The assumed advantages include reducing postoperative pain and achieving better remobilization because detaching the muscle was not necessary. In addition, smaller incisions are associated with a lower infection rate and the prevention of nerve and vessel lesions.

Method

Before surgery X-ray series and computed tomography (CT) scans are obtained. In the showed example the fracture is classified as an A 3.2 injury according to the Arbeitsgemeinschaft für Osteosynthesefragen guidelines and as an anterior column plus posterior hemitransverse according to Letournel (Fig 1).

From the Department of Orthopedics and Trauma Surgery, University Hospital of Bonn (K.K., K.W., M.J., J.R., M.G.), Bonn, and the Department of Surgery, University Hospital of Bonn (P.L.), Bonn, Germany.

K.K. and K.W. contributed equally to this work.

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Address correspondence to Martin Gathen, M.D., University Hospital of Bonn, Dept. of Orthopedics and Trauma Surgery, Venusberg-Campus 1, 53127 Bonn, Germany. E-mail: martin.gathen@ukbonn.de

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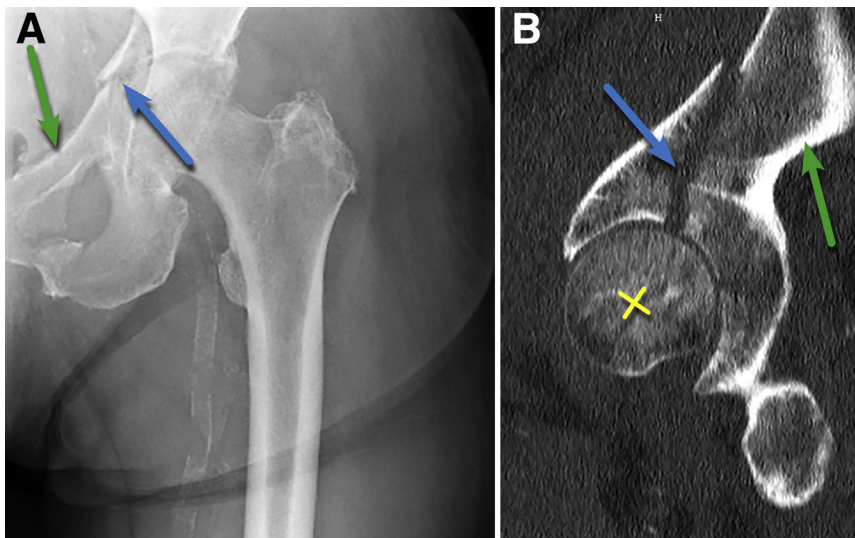


Fig 1. (a) An 81-year-old female patient with an anterior column plus posterior hemitransverse fracture of the acetabulum. Technique: X-ray ap of the left hip. The iliopectineal line (green arrow) is interrupted, which is a sign of an anterior fracture of the acetabulum. The blue arrow marks the fracture line. (b) Digitally reconstructed computed tomography scan of the pelvis in sagittal view, showing a visible split and dislocation of the anterior column (blue arrow). The green arrow marks the posterior column, the x marks the femur head.

The surgical procedure is performed in an interdisciplinary setting by an experienced general surgeon and an orthopaedic surgeon. The study was approved by the Medical Ethics Committee (University Ethics Committee No. 248/18).

Operative Technique

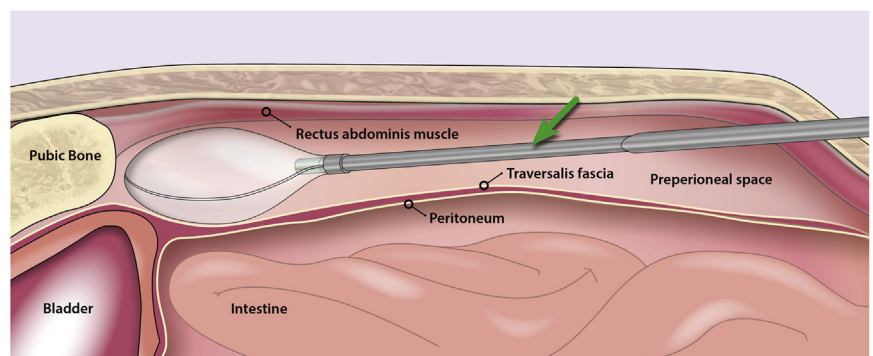
Approach

The patient is placed in a supine position on a carbon table that allows imaging by image intensifier fluoroscopy. A Foley catheter is inserted to minimize the risk of a bladder injury.

To visualize the superior pubic ramus, the standard procedure for endoscopic inguinal hernia repair with a total extraperitoneal approach is chosen.¹⁰ The endoscopy terminal (Visera 4K UHD; Olympus, Tokyo, Japan) is placed at the patient's feet. Through an infraumbilical midline incision of about 15 mm, the subcutaneous tissue and Scarpa's fascia is dissected next to the right anterior layer and the rectus sheath is incised longitudinally. Retracting the rectus muscle laterally, a balloon trocar (Herloon; B. Braun Aesculap,

Tuttlingen, Germany) is introduced and guided down to the symphysis strictly on the posterior layer of the rectus sheath. The correct placement is verified with a 30° endoscope (CH-S400; Olympus). Subsequently, the balloon is inflated to bluntly dissect the preperitoneal space, as shown in Figure 2, according to the guidelines for endoscopic treatment of inguinal hernias.^{10,11} The balloon trocar is then replaced by a 12-mm port (MIT-System; B. Braun Aesculap), which was sutured in place, and a "pneumoperitoneum" (15 mm Hg, UHI-4 Insufflation Unit; Olympus) is established. While the infraumbilical port is used primarily for the endoscope, 1 additional port (Kii; Applied Medical, Rancho Santa Margarita, CA) is placed in the midline under direct visualization, according to the patient's anatomy (Fig 3). The port is established roughly midway between the symphysis and the umbilicus. The tissue is then dissected from medial to lateral starting from the pubic tubercle, using a raspator and a laparoscopic scissor. The arcus mortis needs to be identified and clipped. The iliopectineal fascia is released and divided from the pelvic brim and os pubis by careful retraction

Fig 2. Schematic drawing of the abdomen, sagittal view. The picture illustrates the total extraperitoneal approach to visualize the pubic bone and the acetabulum. The balloon trocar (green arrow) is placed in the preperitoneal space to bluntly dissect it for surgery. The correct placement was checked via endoscope.



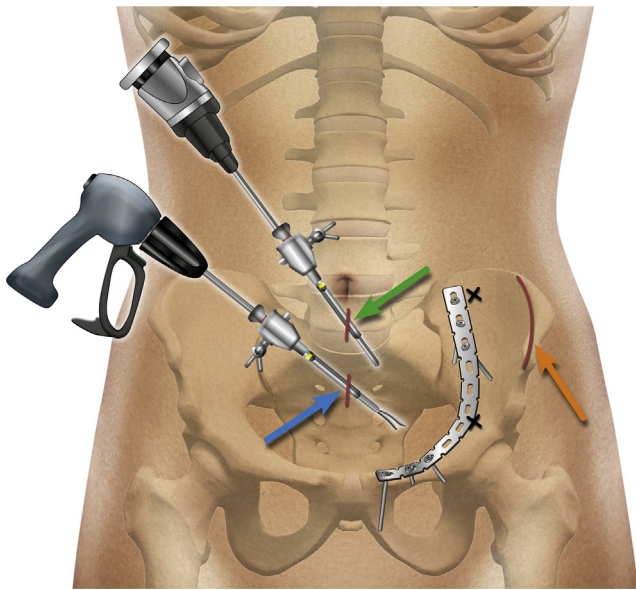


Fig 3. Anterior view of the operational area (schematic drawing). The first incision is an infraumbilical midline incision of about 15 mm (green arrow). One additional incision was made more caudal also in the midline (blue arrow). The infraumbilical port is used primarily for the endoscope whereas further ports can be used for numerous instruments. On the left iliac crest, the lateral window of the ilioinguinal approach is shown (orange arrow). This approach can be used to guide in the reconstruction plate (x).

of the femoral vessels cranially and laterally. This step is essential to place the plate safely beneath the vessels (Video 1). The lateral window of the ilioinguinal approach is used to access the pelvic bone from the sacroiliac joint to the lateral border of the iliopsoas muscle.³

Reduction

The reduction can be achieved through the lateral window. First, the split of the os ilium is reduced and held with the help of pointed reduction forceps. The anterior column is reduced with a straight balls spike, and preliminary fixation is provided by intramedullary K-wires. The posterior hemitransverse can be reduced with a long lag screw in the posterior column of the acetabulum.

Fixation

A large-fragment titanium reconstruction plate is used (DePuy Synthes, Raynham, MA). The plate is inserted through the lateral approach and channeled under the neurovascular pathway using a FiberStick (Arthrex, Naples, FL) that is connected to the plate.

The distal trocar is used to drill the threaded hole using a 3.2 mm twist drill bicortically into the superior pubic ramus. The screw length is measured with the help of marks on the drill. Depending on the grip and the bone quality, 4.0 mm cancellous screws or 4.5 cortex screws can be implanted. Figure 4 shows the

intraoperative view of the plate during fixation. The reduction and implant position is checked by fluoroscopy in standardized planes (AP, inlet, and outlet views). Figure 5 shows the final result after plate fixation. Table 1 summarizes pearls and pitfalls of the technique, and Table 2 shows advantages and disadvantages.

Aftercare

After surgery, the patient is not allowed to bear weight on the affected extremity for 6 weeks. There is no restriction on the mobility of the hip joint, and the patient is allowed to sit up straight. Consistent physiotherapy is performed from day 1 after surgery, and thrombosis prophylaxis needs to be provided with a low molecular heparin until remobilization and full weightbearing resumed. Follow-up examinations and X-ray controls after 6 and 12 weeks are recommended.

Discussion

The APACHE technique offers a promising alternative approach for anterior plate fixation of the acetabulum that does not compromise the rectus abdominis and pyramidalis muscles. In our experience, the area in which the muscles are reattached can cause pain, and this may be a relevant factor in the delayed mobilization of the patient. Other authors have also described residual suprapubic pain after ORIF of the anterior pelvis that does not correlate with implant failure or inadequate reduction.¹² The APACHE approach also reduces the required Pfannenstiel incision from approximately 6 to 8 cm to two incisions of 1.5 cm each. This may reduce the rate of surgical site infection, which is reported to be 3–11% after the Pfannenstiel approach, and also leads to a better aesthetic result.^{13,14} The extraperitoneal approach is associated with a minimal risk of lesions of the spermatic cord in male

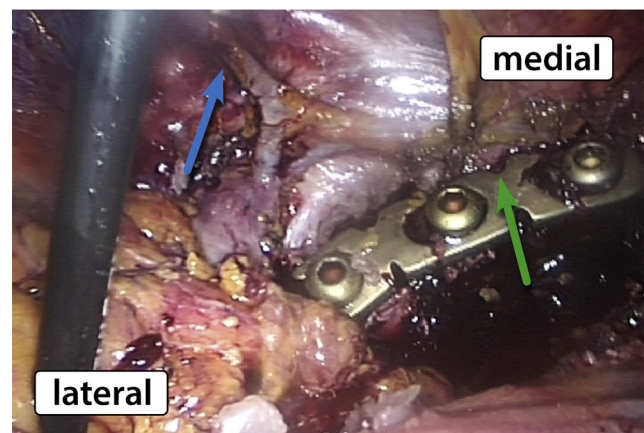


Fig 4. Intraoperative view of the plate after final fixation (green arrow). The medial parts of the reconstruction plate and the 3 medial screws are visible. The epigastric vessels can also be seen (blue arrow).

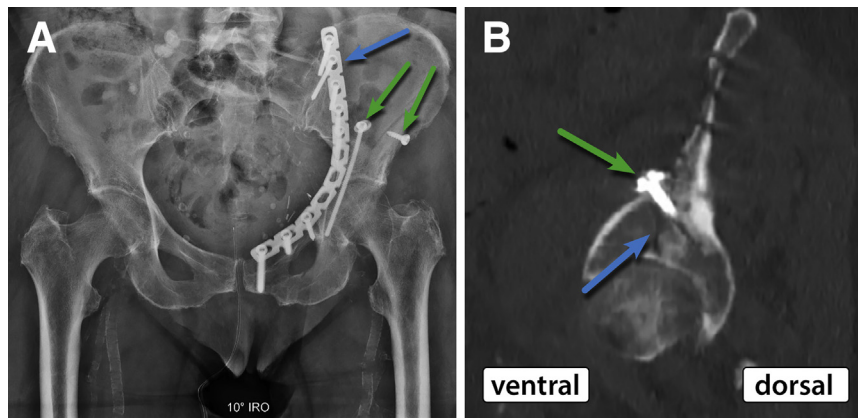


Fig 5. (a) Postoperative X-ray of the pelvis showing the final result after endoscopic-assisted plate fixation of the left acetabulum. On the left side the large-fragment titanium reconstruction plate is (blue arrow). Two further compression screws are visible (green arrows). (b) Postoperative computed tomography scan of the pelvis in sagittal view after plate fixation. One screw and parts of the plate are visible (green arrow). The fracture line is marked with a blue arrow. Anatomical reduction is achieved (Compare Fig. 1b).

patients and allows excellent visualization of the corona mortis vessels. The blood loss in the presented case was 640 mL. Other authors describe higher blood losses of between 450 and 2150 mL for the modified Stoppa or the ilioinguinal approach.^{15,16} Another complication of the standard approach is lesions of the urinary bladder. The observed rate of bladder lesions using the total extraperitoneal approach procedure for hernia repair is extremely low at 0.15%.¹⁷

Other authors also see the advantages of a less-invasive approach and have presented alternative strategies to treat acetabulum fractures. A minimally invasive technique was introduced by Ruchholtz et al.¹⁵ in 2012. They describe a 2-incision minimally invasive approach to treat fractures of the anterior column.¹⁵ The authors describe a good visualization of the fracture side combined with a low complication rate. Nevertheless, in their procedure, a notching of the rectus abdominis muscle and a bikini line incision is still necessary. Wolf et al.¹⁸ describe a similar approach with a longitudinal incision in the median lower abdomen and an extraperitoneal exposure of the pubic symphysis in 23 clinical cases. The authors found a reduction of complications associated with the classic ilioinguinal approach and good access to the fracture site.¹⁸

Table 1. Pearls and Pitfalls

Pearls	
Pearls	Precise preoperative planning including CT scans, digital planning of the plate position and fracture reduction
	Correct positioning of the port system to avoid leakage of the carbon dioxide gas
	Using suitable instruments such as a long screw driver that allows a stable attachment of a screw
Pitfalls	
Pitfalls	A lack of hemostasis quickly leads to limited visualization.
	Two experienced surgeons are required to perform the surgery.
	Large amounts of carbon dioxide gas that leak into the soft tissue lead to limited visualization because of a high counter pressure.
	Sometimes a Trendelenburg position is not possible. Patients with a compromised respiratory system may show respiratory failure under mechanical ventilation.

Further studies describe modifications of established approaches or less invasive techniques with the goal of reducing complications and providing good exposure to the area of interest.¹⁹⁻²¹ Trulsson et al.²² performed a cadaver study to investigate the possibility of endoscopic preparation of the pelvic ring. The study demonstrated the feasibility of visualizing the acetabulum and para-acetabular anatomic structures from the symphysis to the iliosacral joint, including the quadrilateral region. The study notes a considerable potential for clinical use but also underlines the difficulties in fracture reduction using an endoscopic approach.²² The APACHE approach requires excellent knowledge of the anatomy of the pelvis and experience in laparoscopic techniques. To carry out this approach, an interdisciplinary team and considerable resources are necessary. There is a potential learning curve that will take some time in the beginning, and the approach is not applicable in all fracture types. We consider fractures of the anterior wall, anterior column, and associated anterior column plus posterior hemitransverse, as well as injuries to both columns as suitable indications for the APACHE approach.

We see an enormous potential to reduce the rate of common complications such as hernia or surgical site infection. An endoscopic approach to plate the pubic symphysis has already become the standard procedure

Table 2. Advantages/Disadvantages

Advantages	
Advantages	Smaller incisions, Pfannenstiel incision can be avoided
	Rectus abdominis and pyramidalis muscles are not compromised
	Safe preparation with good visualization of the corona mortis vessels
	Fast remobilization and fast recovery
	Better visualization of the medial fracture zone that usually can only be palpated
Disadvantages	
Disadvantages	Greater surgical time and learning curve in the beginning
	Fewer opportunities for reduction
	A severe fracture-dislocation cannot yet be treated by the technique

in our and other institutions.²³ In cases of massive soft tissue damage to the pelvis, the technique can be helpful because the approach lies cranial to the fracture site. In addition, we believe that the approach has some advantages in massively obese patients compared to an open approach.

The APACHE technique is an alternative approach for fractures of the anterior acetabulum column. It is a logical development to push the limits of minimally invasive acetabulum surgery and will become a standard procedure in future trauma management.

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