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ORIGINAL ARTICLE

EASY (endoscopic approach to the symphysis): a new minimally invasive approach for the plate osteosynthesis of the symphysis and the anterior pelvic ring—a cadaver study and first clinical results

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Abstract

Background Minimally invasive surgical approaches to reduce approach-associated morbidity are an interdisciplinary goal in surgery. In principle, the endoscopic approach for the extraperitoneal repair of groin hernias is the minimally invasive variant of the modified Stoppa-approach, which is used for the treatment of pelvic ring injuries in traumatology.

Method Anatomical feasibility study regarding the plate osteosynthesis of the anterior pelvic ring via a minimally invasive variant of the modified Stoppa-approach.

Results We present the minimally invasive variant of the modified Stoppa-approach in a human cadaver step by step, both photographically and radiologically. Feasibility of the plate osteosynthesis of the symphysis is presented in a patient with open book injury via the minimally invasive approach using standard laparoscopic instruments.

Conclusion The plate osteosynthesis of the anterior pelvic ring via the minimally invasive variant of the modified Stoppa-approach is feasible with existing standard laparoscopic instruments.

Keywords Symphysis · Pelvic ring · Plate osteosynthesis · Stoppa-approach · Minimally invasive surgery · EASY-approach

Background

Injuries of the pelvic ring occur with two peaks regarding frequency and age. The first peak occurs between the second and third life decade, the second peak occurs between the seventh and eighth life decade.

Typical mechanisms of trauma in young patients are high-energy traumas with rupture of the symphysis and partial instability of the posterior pelvic ring ("open book injury") or complete instability of the pelvic ring with discontinuity of the anterior and posterior pelvic ring. These injuries usually require osteosynthetic stabilization of the pelvic ring. However, in elder patients, pelvic ring injuries usually are the consequence of a low-energy trauma with fractures of the pubic rami and partial instability of the posterior pelvic ring ("lateral compression injury"). These injuries can be treated conservatively in the majority of the cases [1, 2].

To stabilize the posterior pelvic ring, percutaneous screw osteosynthesis of the iliosacral joint has evolved as a minimally invasive procedure [3–5]. Minimally invasive procedures for the stabilization of the anterior pelvic ring are the external fixation or the percutaneous intramedullary screw osteosynthesis [6, 7].

However, there is no minimally invasive approach in the case of an indication for a plate osteosynthesis of the anterior pelvic ring. The most widely used approach to the symphysis or the anterior pelvic ring is a modification of the Stoppa-approach, which is an extension of the Pfannenstiel-approach. By detaching the abdominal wall muscles from the pelvic ring and the inguinal ligament the symphysis and the superior pubic ramus can be explored. If needed, the exploration can be extended to the quadrilateral plate and

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the greater sciatic notch [8, 9]. The original Stoppa-approach was described by Stoppa in 1973 for the preperitoneal mesh placement in the treatment of both-sided inguinal hernias [10]. In the course of the further development of minimally invasive surgery, this approach was minimized and has been used for more than 20 years as a standard approach in the minimally invasive treatment of groin hernias ("total extraperitoneal patch plasty", TEP) [11, 12].

Aim of this study was to minimize the wide extension of the modified Stoppa-approach similar to the TEP-approach. The technique is presented step by step by an example of a plate stabilization of the symphysis in a human cadaver setting and the clinical feasibility is demonstrated in a patient with an open book injury.

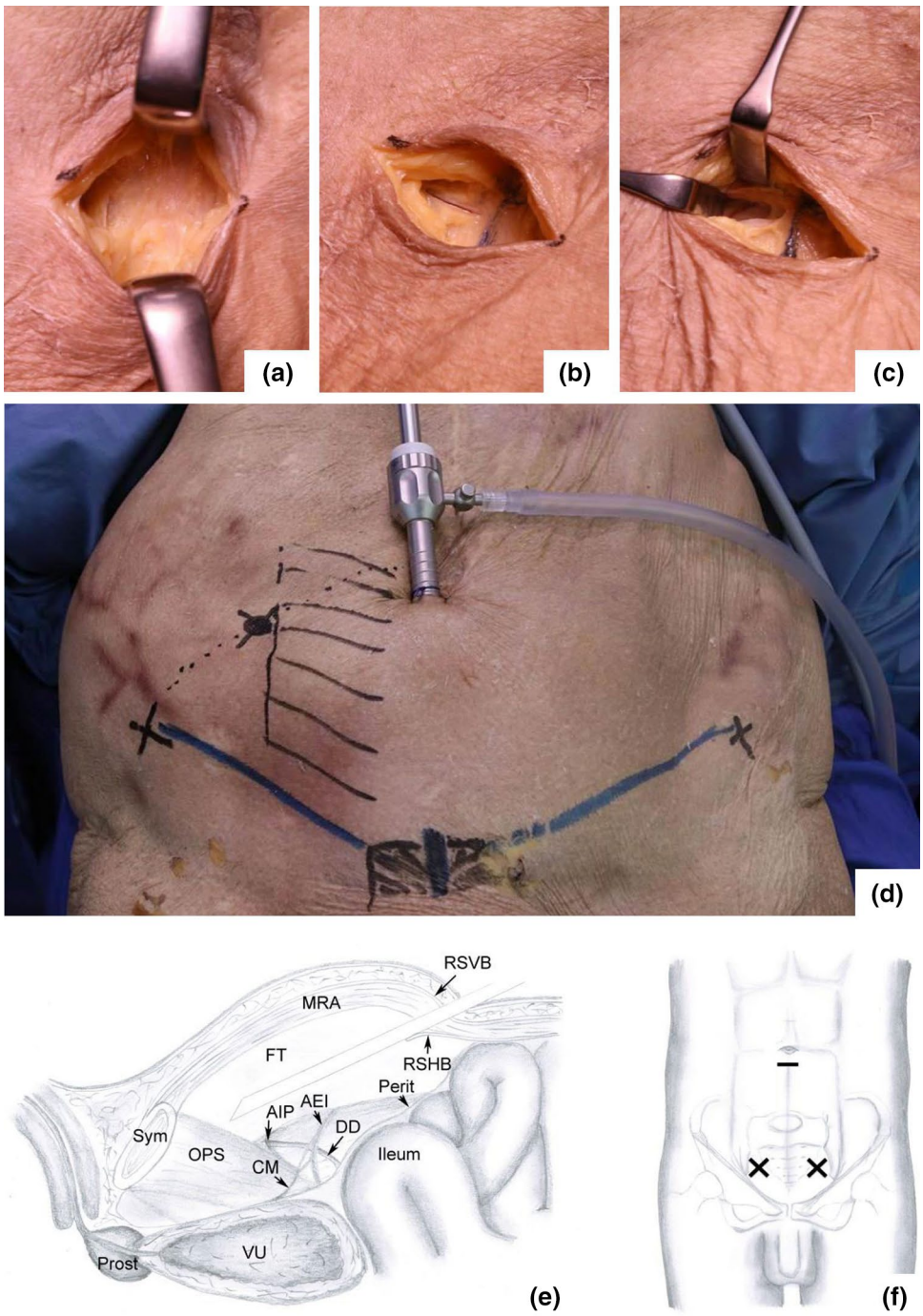

Fig. 1 Infraumbilical transverse skin incision (**a**) and transverse incision of the right anterior rectus sheath (**b**). After preparation onto the posterior rectus sheath (**c**) the Herloon®-trocar is placed strictly on the posterior rectus sheath/transverse fascia in front of the symphysis. After inflating the balloon, the Herloon®-trocar is removed and a standard laparoscopy trocar is inserted (**d**). After dissecting the preperitoneal space with the balloon (**e**) the two working trocars are placed under vision transrectally about 4–5 cm proximal to the symphysis (**f**). *Sym* symphysis, *OPS* ramus superior ossis pubis, *Prost* prostate, *VU* vesica urinaria, *CM* corona mortis, *DD* ductus deferens, *AIP* anulus inguinalis profundus, *AEI* arteria epigastrica inferior, *FT* fascia transversalis, *MRA* musculus rectus abdominis, *Perit* peritoneum, *RSHB* posterior rectus sheath, *RSVB* anterior rectus sheath

Description of the technique

In three human cadavers we established the EASY-approach and carried out a complete minimally invasive plate osteosynthesis of the symphysis with standard laparoscopic instruments. The technique is presented step by step and illustrated with photographic and radiological images as well as schematic drawings.

Positioning of the patient and EASY-approach (Fig. 1)

In supine position with both arms located away from the body, the abdomen is washed and draped from the symphysis to the belly button. The skin is incised transversely 2 cm inferior to the belly button over a length of about 3–4 cm with preparation of the anterior rectus sheath. The anterior rectus sheath is incised on one side without crossing the linea alba. The rectus muscle is held to the lateral side and the posterior rectus sheath is prepared. The balloon trocar (Herloon®, B. Braun Aesculap, Melsungen, Germany) is initially pushed forward along the posterior rectus sheath and caudally of the arcuate line, along the transverse abdominal fascia, until it is finally positioned in front of the symphysis. There, under vision with the laparoscope, the balloon is inflated through the trocar. It is important not to harm the peritoneum in order to avoid a pneumoperitoneum which makes further preparation difficult. In case of an accidental lesion of the peritoneum, a Verres needle can be placed in the upper right quadrant to let off the intraperitoneal CO_2. After dissecting with the balloon, the balloon trocar is removed and a 10-mm standard laparoscopy trocar is inserted. CO_2 is insufflated with a pressure of 16–20 mmHg and a laparoscope with 30° optic is used for the further operation. Two working trocars (5 and 10 mm) are placed about 4–5 cm proximal to the symphysis through both rectus muscles under endoscopic vision to avoid injury of the epigastric vessels.

Preparation of the spatium retzii and the symphysis (Figs. 2, 3)

With electric scissors and a dissector the prepared space is expanded along both superior pubic rami to the lateral side. The retropubic space (spatium Retzii) is dissected bluntly and the urinary bladder is shifted off dorsally. The corona-mortis-vessels are prepared on both pubic rami and can be ligated with clips, if necessary. If needed, the symphysis can be cleared out with the electric scissors or with a laparoscopic suction device.

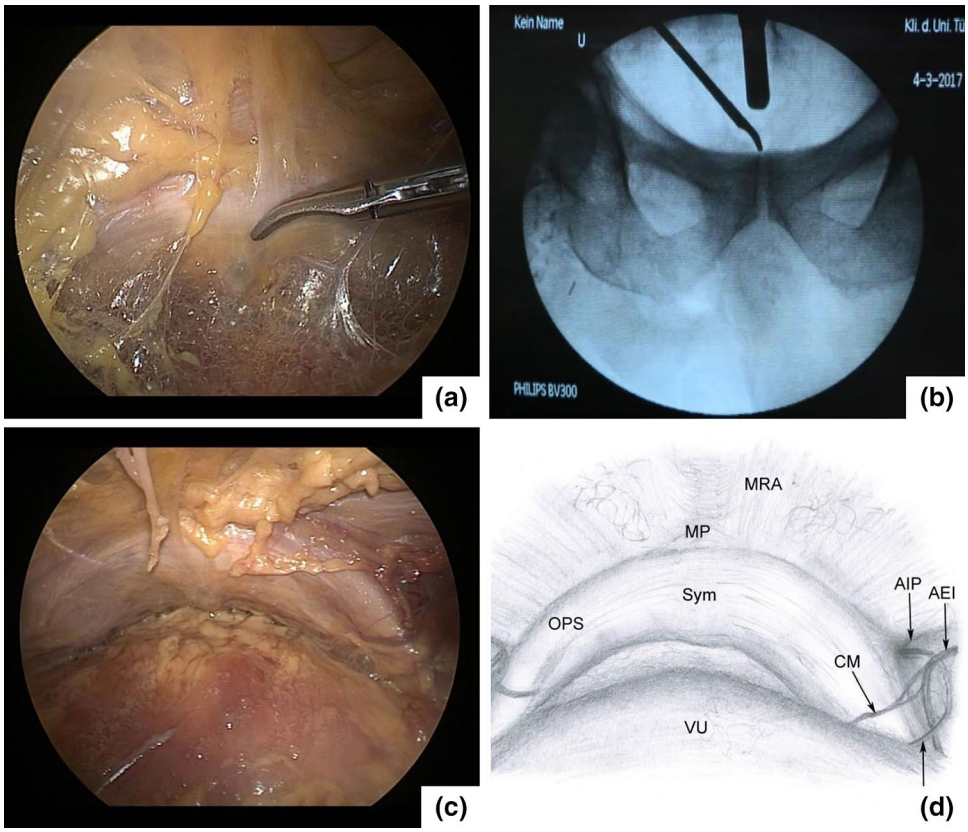

Fig. 2 Preparation of the spatium Retzii with electric scissors (**a**) under fluoroscopic control (**b**). At the end of preparation the symphysis shows up in the total extension with presentation of both superior pubic rami (**c, d**). The urinary bladder lies dorsally and the corona-mortis-vessel can be ligated with clips if necessary. *Sym* symphysis, *MP* mons pubis, *OPS* ramus superior ossis pubis, *VU* vesica urinaria, *CM* corona mortis, *DD* ductus deferens, *AIP* anulus inguinalis profundus, *AEI* arteria epigastrica inferior, *MRA* musculus rectus abdominis

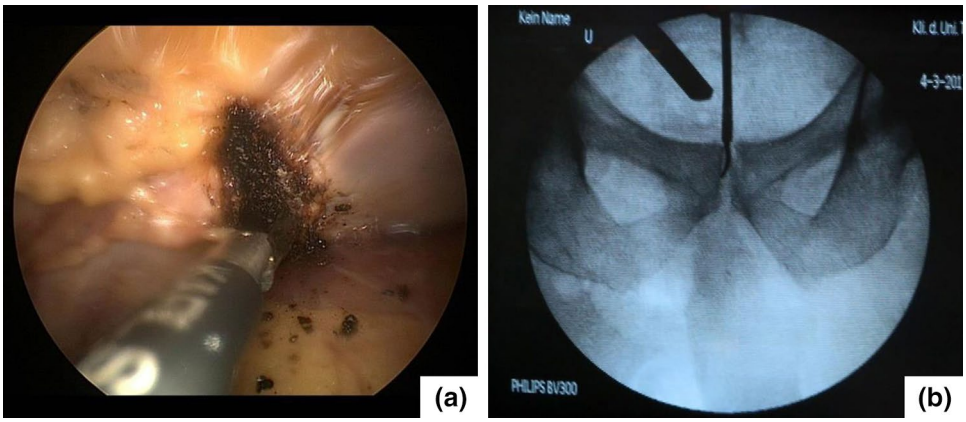

Fig. 3 If needed, the symphysis can be cleared out using electric scissors or an endoscopic suction unit (**a**). Fluoroscopic control of symphysis debridement (**b**)

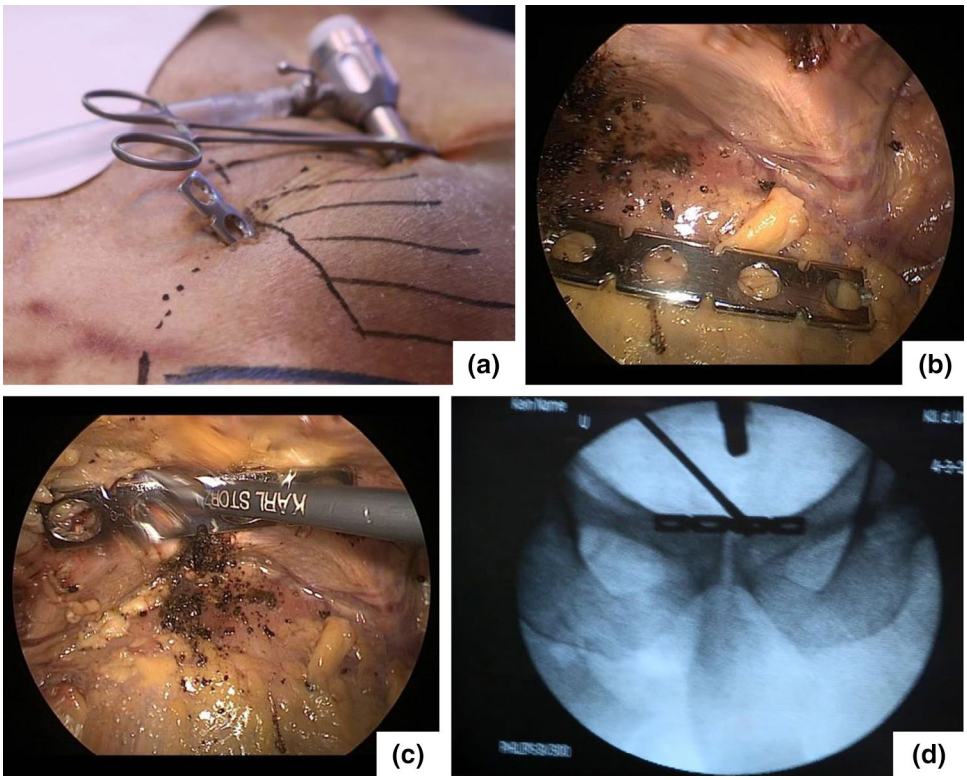

Fig. 4 Incorporation of the plate through a transrectal incision (**a**) under endoscopic visualization (**b**). The plate is positioned with an endoscopic grasper (**c**) under fluoroscopic control (**d**)

Stabilization of the symphysis with a plate (Figs. 4, 5, 6)

The osteosynthesis plate is inserted via the 10-mm transrectal incision and is positioned with an endoscopic forceps under direct vision. The position is controlled by fluoroscopy. The lateral drill holes and screws are placed via the ipsilateral transrectal trocars, while the medial drill holes and screws are placed via the trocar in the midline after switching the camera to a transrectal trocar. All drill holes and screws are placed under direct visualization and simultaneous fluoroscopy. By switching the trocar positions, it is ensured that the screws are inserted in the right angulation of about 30°. A dorsal corticalis perforation with damage to the urinary bladder can be excluded by the direct visualization. After completion of the plate osteosynthesis of the symphysis, fluoroscopy (inlet-/outlet view) is used to check the correct position of the plate as well as the correct reconstruction of the pelvic ring.

The cutting/suture times decreased in the three cadavers from about 45 min to roughly 22 min. In fact, we did see a steep learning curve since the cadaver study allowed us to adopt positioning of endoscopic portals and gather experience about the preparation of the upper pubic rami. However, we have to mention that the first author, who performed the cadaver operations, has an extended experience

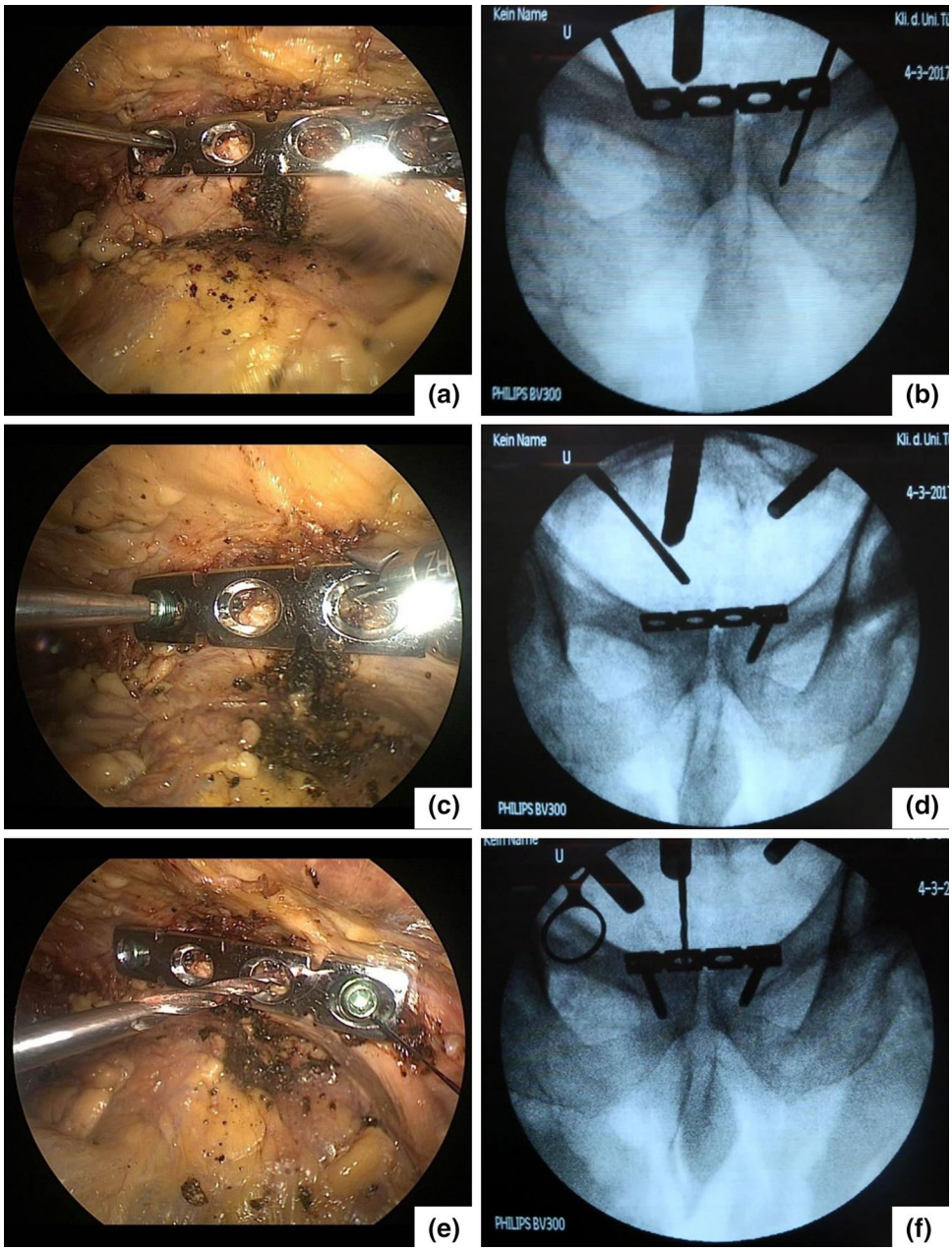

Fig. 5 Fixation of the plate. The lateral screws are drilled and placed via the ipsilateral transrectal trocars under endoscopic visualization and fluoroscopic control (**a**–**d**). The medial screws are drilled and placed via the infraumbilical trocar under endoscopic visualization and fluoroscopic control (**e, f**)

in endoscopic hernia approach (TEP) due to his abdominal surgery specialization.

Case report

A 20-year-old male patient suffered from a polytrauma due to an accident, in which he crashed frontally into a car with his motorbike. Beside a thoracic trauma with bilateral lung contusions and a ruptured posterior cruciate ligament of the right knee, he had a pelvic injury with a bilateral open book injury with traumatic rupture of the symphysis and an anterior ligamentary injury of both sacroiliac joints (Fig. 7, CCF-classification B3.1 a1b1c5). The secondary survey revealed the first diagnosis of an inguinal testis on the left side.

Emergency stabilization of the pelvis was done by a supraacetabular external fixator (Fig. 8). After stabilization of the pulmonary function, we performed the endoscopic assisted plate osteosynthesis of the symphysis 13 days after the accident. Stabilization was done in the previously described technique via the EASY-approach using a 4-hole 4.5 mm-LCDCP-plate (Fig. 9). Following the stabilization of the symphysis, a bilateral percutaneous screw osteosynthesis of the sacroiliac joints was performed using two cannulated 7.5 mm screws. The overall operation time was 197 min,

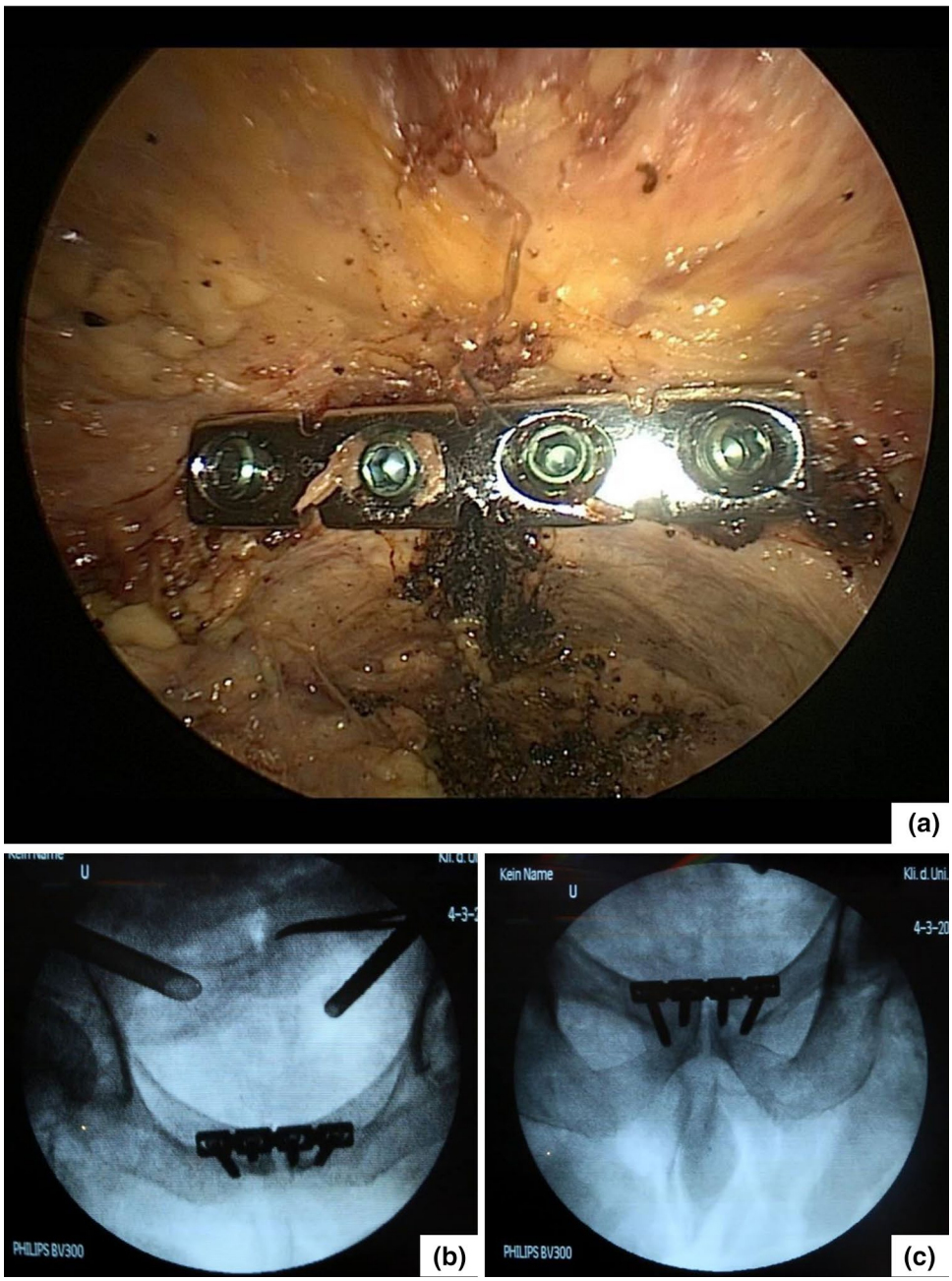

Fig. 6 Final endoscopic (**a**) and fluoroscopic documentation of the correct position of the plate in inlet-/outlet-view (**b, c**)

and intraoperative blood loss was about 50 ml. There was no intra- or postoperative complications. In the further course, the inguinal testis was operated by the urologists.

Postoperative mobilization was done with partial weight bearing of 20 kg for the right leg due to the PCL lesion. Postoperative radiology showed a very good reconstruction of the pelvic ring (Fig. 10). The patient was discharged from the hospital on the 35th day after the accident and the 21st day after the endoscopic stabilization of the symphysis.

Discussion

Minimization of long, wide or multiple surgical incisions is a goal of all surgical disciplines to reduce the incision-related morbidities. This has been demonstrated in the past 35 years, especially in the field of minimally invasive general surgery, where the development of special instruments and techniques reduced the surgical site morbidities significantly. In consequence, nowadays highly complex procedures like pancreatic head resection or esophageal resection can be performed not only minimally invasive but even as single-incision surgery [13–15]. The advantages of minimally

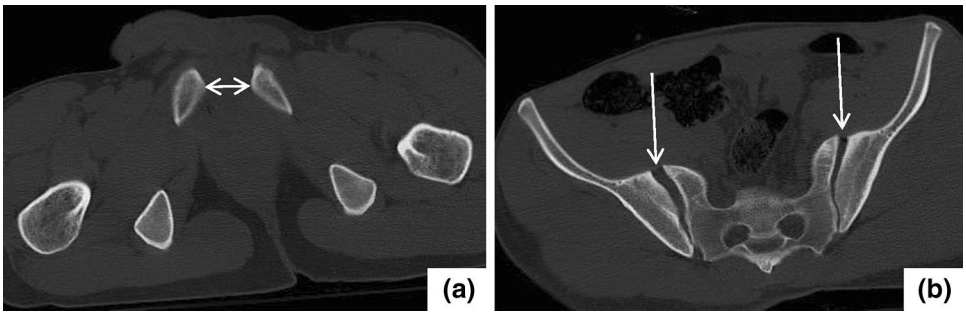

Fig. 7 CT-scan of the bilateral open-book-injury with traumatic rupture of the symphysis (**a** double-arrow) and the bilateral anterior injury of the sacroiliac joints (**b** arrows). CCF-classification: B3.1 a1 b1 c5

invasive surgery have been evaluated in detail and are generally accepted [16]. These advantages especially concern: less postoperative pain, lower rate of surgical site infections, shorter time of hospitalization and in the long-term course lower rates of incisional hernias [17, 18]. Moreover, minimally invasive surgery has been shown to result in a shorter time of unemployability, which can be very long in pelvic ring fractures [19, 20]. Also, in traumatology and especially in pelvic surgery, there is clearly a trend towards reducing the size of incisions. Nowadays, the percutaneous screw stabilization of the sacroiliac joint is the gold standard for the stabilization of the posterior pelvic ring [3–5]. But also fractures of the anterior pelvic ring and the acetabulum can be stabilized by percutaneous screw insertion in some special indications [6, 7]. However, a significant disadvantage of percutaneous techniques is the missing visualization of the structures and the reduced options of reduction techniques in complex fractures. Therefore, open approaches are still the gold standard for fractures, which require a plate osteosynthesis. For the anterior pelvic ring the most widely used open approach is the modified Stoppa-approach. However, typical complications of the modified Stoppa-approach are: bleeding from the inferior epigastric vessels, lesions of nerves of the abdominal wall (e.g. the ilioinguinal nerve), injuries of the spermatic cord in male patients or the development of incisional hernias due to the detachment of the abdominal wall muscles. These complications occur in a frequency of up to 30% [21–25]. Additionally, in cases of a plate osteosynthesis of the anterior pelvic ring and the symphysis, there is a risk of an injury of the urinary bladder, as the dorsal parts of the symphysis and the spatium Retzii usually can be explored digitally only. Therefore, the ventral parts of the urinary bladder are protected by a metal spatula [8]. Another typical complication of an open osteosynthesis of pelvic injuries is the accidental laceration of the corona-mortis-vessel—an anastomosis between the external iliac artery and the obturatory artery running across the pubic rami.

In consequence, beside the general advantages of minimally invasive surgery the presented EASY-approach has four significant advantages compared to the conventional modified Stoppa-approach:

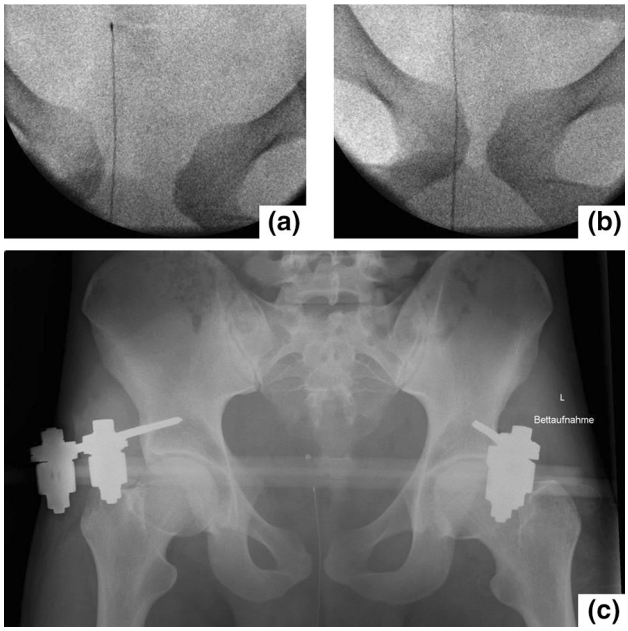

Fig. 8 Emergency stabilization of the pelvis by a supraacetabular external fixator. Fluoroscopic view of the widened symphysis before (**a**) and after stabilization (**b**). Postoperative radiology demonstrates the correct reconstruction of the pelvic ring (**c**)

1. The risk for incisional hernias is reduced, as the abdominal wall muscles are not detached.
2. As the inguinal canal stays untouched, the risk of lesions of the spermatic cord in male patients is significantly reduced.
3. The direct visualization of the dorsal parts of the symphysis and the spatium Retzii reduces the risk of accidental iatrogenic injuries of the urinary bladder.
4. An accidental laceration of the corona-mortis-vessel can be almost completely excluded due to the excellent visualization of the vessels.

However, whether the minimally invasive approach can reduce the complication rates of the implant removal procedures, is uncertain right now.

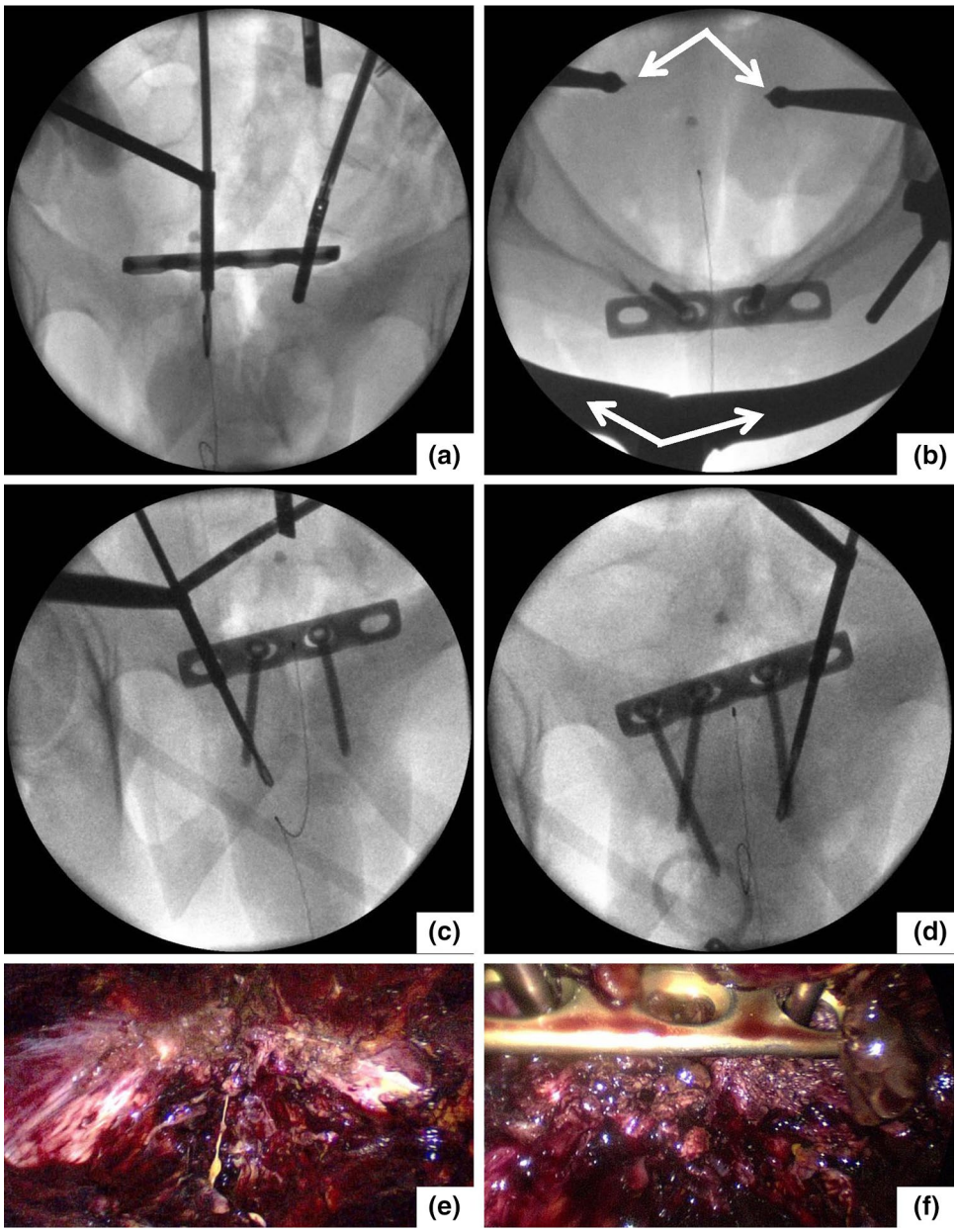

Fig. 9 Endoscopic assisted stabilization of the symphysis with a plate. Primarily, the medial screws are drilled and placed (**a, f**). For drilling, the external fixator has to be dismantled, the reposition is held by a large clamp around the fixator pins (**b** arrows). Finally, the lateral screws are drilled and placed (**c, d**). Endoscopic view on the symphysis (**e** see also Fig. 2c)

Regarding the case report, the following difficulties were registered during the operation:

1. The exact positioning of the plate on the ventral part of the symphysis required a partial detachment of the dorsal parts of the pyramid muscles from the pubic rami. The ventral parts of the rectus muscles could be left in place. Furthermore, an additional incision of 15 mm was done directly overneath the symphysis (Fig. 11, red arrow). However, the position of the plate was still not ideal, but we decided to accept this position as the screws had a tight hold in the bone, and the patient was set to partial weight bearing on the affected side for 6 weeks postoperatively due to the PCL lesion anyhow. The patient was free of complaints 3 months postoperatively with no radiographic signs of implant loosening.
2. To drill the holes the external fixator was dismantled. Reposition of the symphysis was held by placing a big clamp around the fixator pins (Fig. 9b).
3. The illumination with the used 5 mm optic was suboptimal (Fig. 9e + f). Maybe also the used light source which is meant for arthroscopic surgery was inadequate for proper illumination.
4. The long operation time of 197 min exceeded our usual operation time of about 75 min by far. Introducing new surgical techniques into the clinical setting—and especially endoscopic ones—usually results in significant longer operation times. This is well known from other

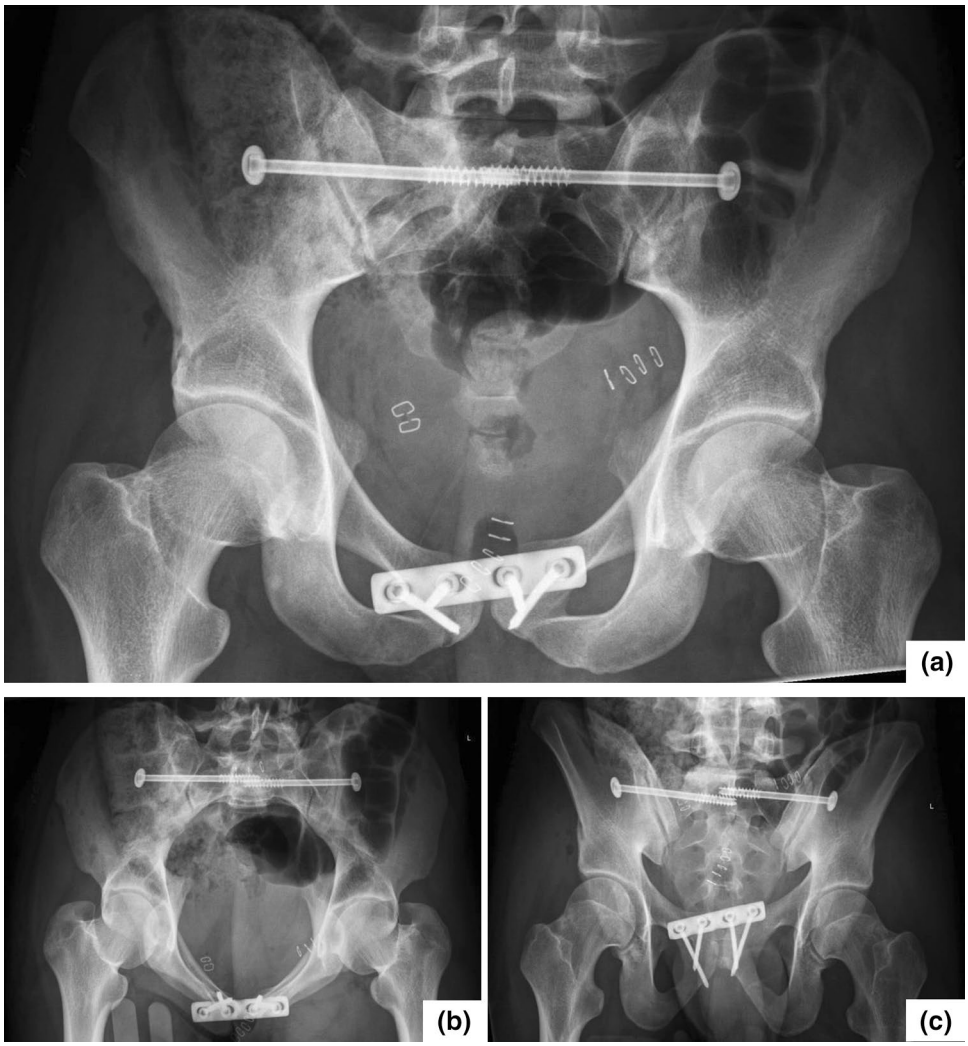

Fig. 10 Postoperatively, the pelvic ring is reconstructed correctly with bilateral screws in the sacroiliac joints and the plate on the symphysis (**a**). Inlet-view (**b**), Outlet-view (**c**)

surgical disciplines, when in the beginning the operation time of any new endoscopic procedure is significantly longer compared to the respective open procedure. However, with increasing experience surgery times shorten and approximate to surgery times with established techniques or even fall below them.

Perspective

The question about the best way to reduce a dislocated fracture or the symphysis in case of an open-book-injury remains open. It could be conceivable that either bilateral compression to the trochanteric region is effective or that reduction works fine with an external fixator—like in the presented case. Another possibility would be the reduction via a clamp, which is placed through an additional small incision. However, whether the EASY-approach can be used in cases of displaced fractures of the anterior pelvic ring or even the acetabulum depends on the options to reduce displaced fractures and is under investigation right now.

Another question regards the position of the plate. It would be helpful to place the plate more dorsal to the symphysis or pubic ramus compared to the open procedure. However, biomechanical testings of different plate positions are necessary [26]. Until the results from the biomechanical testings are not available, dorsal detachment of the pyramid muscles should be performed to achieve a standard plate position on the ventrocranial parts of the anterior pelvic ring.

Right now, the extension of the EASY-approach to the complete pelvic brim, including the iliopectineal line, the quadrilateral plate, the greater sciatic notch and the sacrolilac joints is investigated in a cadaver study. This extended EASY-approach may be used in the future as a minimally invasive alternative to the ilioinguinal approach of Letournel, which is the gold standard for the osteosynthetic treatment of acetabular fractures with main dislocation in the region of the anterior column.

Fig. 11 View of the incisions 3 days postoperatively. Arrows: Incisions according to Fig. 1f. Dotted arrow: Additional incision over the symphysis. The other two incisions are from the external fixator

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Compliance with ethical standards

Conflict of interest Drs. Markus Alexander Küper, Alexander Trulson, Inga Maria Trulson, Christian Minarksi, Leonard Grünwald, Christoph Gonser, Christian Bahrs, Bernhard Hirt, Ulrich Stöckle and Fabian Maria Stuby have no conflicts of interest or financial ties to disclose.

Ethical approval The cadaver studies were performed at the Institute of Clinical Anatomy and Cell. Analysis of the Eberhard Karls University in Tübingen, Germany. The rules of the Declaration of Helsinki were strictly followed throughout the cadaver study. The body donors approved the scientific usage of their bodies for teaching and research purposes in their lifetime and the local Ethics committee of the University of Tübingen approved the scientific usage. The patient approved the publication of his case including history of the accident, course of his in-patient treatment and surgical course with images of the operation situs and the postoperative scars as well as the fluoroscopic and radiological images.

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