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Case Report

Pubic symphysis tethering technique under endoscopic approach for treatment of pelvic open-book injury: A cadaver study

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ABSTRACT

Purpose: Pubic symphysis disruption is common in pelvic trauma. Open reduction and internal fixation with a plate is the gold standard technique. Despite increasing interest in an endoscopic approach, the challenges of specific endoscopic instrumentation, reduction and fixation remains. In this feasibility cadaveric study, we aimed to describe a novel endoscopic technique of fixation of pubic symphysis disruption with a spinal vertebral tethering system.

Methods: Endoscopic pubic symphysis fixation with the tethering method was performed on a female cadaver specimen as well as an artificial pelvic model.

Results: We describe a step-by-step technique where three abdominal portals were utilized in order to insert screws in the pubic body and superior pubic ramus under endoscopic visualization. The synthetic tether ligament was introduced through a lateral portal and fixed and tensioned to reduce and compress the pubic symphysis.

Conclusions: While open plate fixation is the current gold standard of pubic symphysis disruption there is increasing interest in the minimally invasive endoscopic approach. In this feasibility cadaveric study, we present a new minimally invasive endoscopic fixation method to treat pubic symphysis disruption with a synthetic ligament.

Background

Pubic symphysis disruption is common in high energy pelvic trauma with an open book (anterior-posterior compression) mechanism of injury [1]. The disruption corresponds to injury to the anterior pelvic ring and is often associated with incomplete or complete posterior ring injuries. Symphysis diastasis of less than 2 cm is generally considered stable and can be treated non-operatively. In unstable injuries, the current gold standard of treatment is open reduction internal fixation with a metal plate through a modified Stoppa approach [2]. An open approach is invasive and can be associated with infection, hematoma, bladder injury, incisional hernia and can be technically difficult in patients with previous surgical approaches in the same region. The endoscopic extraperitoneal approach was developed as a minimally invasive approach to avoid some of these problems [3–5], however, endoscopy can be technically difficult and there is a lack of specific instrumentation. Further, with traditional plate fixation it is not uncommon for hardware failure and breakage leading to secondary displacement and diastasis of the symphysis [6–9].

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We propose a novel technique that is 1/a minimally invasive endoscopic extraperitoneal technique to reduce approach related complications, 2/uses instrumentation that is adapted to endoscopic use, 3/uses a synthetic ligament instead of a metal plate (a "vertebral tethering" system used in idiopathic scoliosis) and 4/offers the possibility of in-situ reduction. In this study we evaluate the feasibility of endoscopic pubic symphysis fixation and reduction with the tethering system.

Material and method

Pubic symphysis fixation with the tethering method was carried out on a Sawbone® pelvis (Fig. 1) as well as on a female cadaver. The fixation method chosen was the TETHER™ system from Zimmer Biomet Laboratory (Florida, USA). Two anchors and two 5.5 mm diameter alloyed titanium screws were inserted into the pubic body and superior pubic rami on either side of the pubic symphysis. A Sulene®PET (polyethylene-terephthalate) synthetic ligament was inserted into each screw, tensioned and locked using a torque limiting device. The procedure was performed with endoscopy in the extraperitoneal space utilizing three portals with CO2 insufflation and a 0° angled laparoscopy endoscope. The position of the implants was assessed under fluoroscopy.

Results

Surgical technique

Surgical set up

The cadaver is positioned supine on a radiolucent table. The endoscopy column is positioned at the foot of the table and the image intensifier at the side.

Pubic symphysis exposure

We utilize an extraperitoneal endoscopic approach which is a well described modified Stoppa approach used in the treatment of groin hernias and pelvic ring injuries [4,5]. To establish the viewing portal, a 12 mm sub-umbical incision is made with dissection down to the rectus aponeurosis. Once the aponeurosis identified it is incised and the rectus muscles are split in the midline. Using blunt finger dissection we separate the prevesical and preperitoneal spaces. A 12 mm trocar is inserted and CO2 insufflation is commenced at 20 mmHg pressure. After insertion of the endoscope the space is further developed with sweeping motions of the endoscope towards the pubic symphysis. Two further instrument portals are created under endoscopic visualization. They are placed approximately 5 cm away from the midline and located halfway between the umbilicus and the pubic symphysis (Fig. 2). Portal position is confirmed under endoscopic visualization to ensure there is favorable instrument trajectory to the pubic symphysis and superior pubic rami. The exposure is now complete.

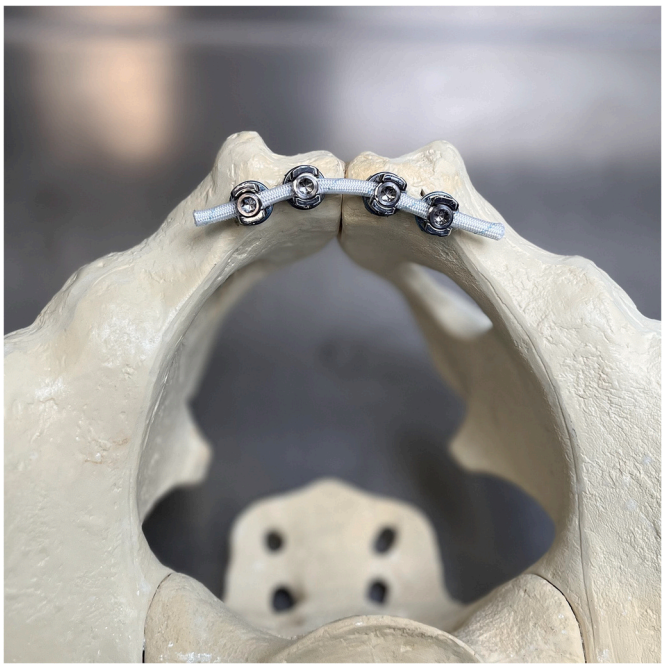

Fig. 1. Sawbone model with the final construct.

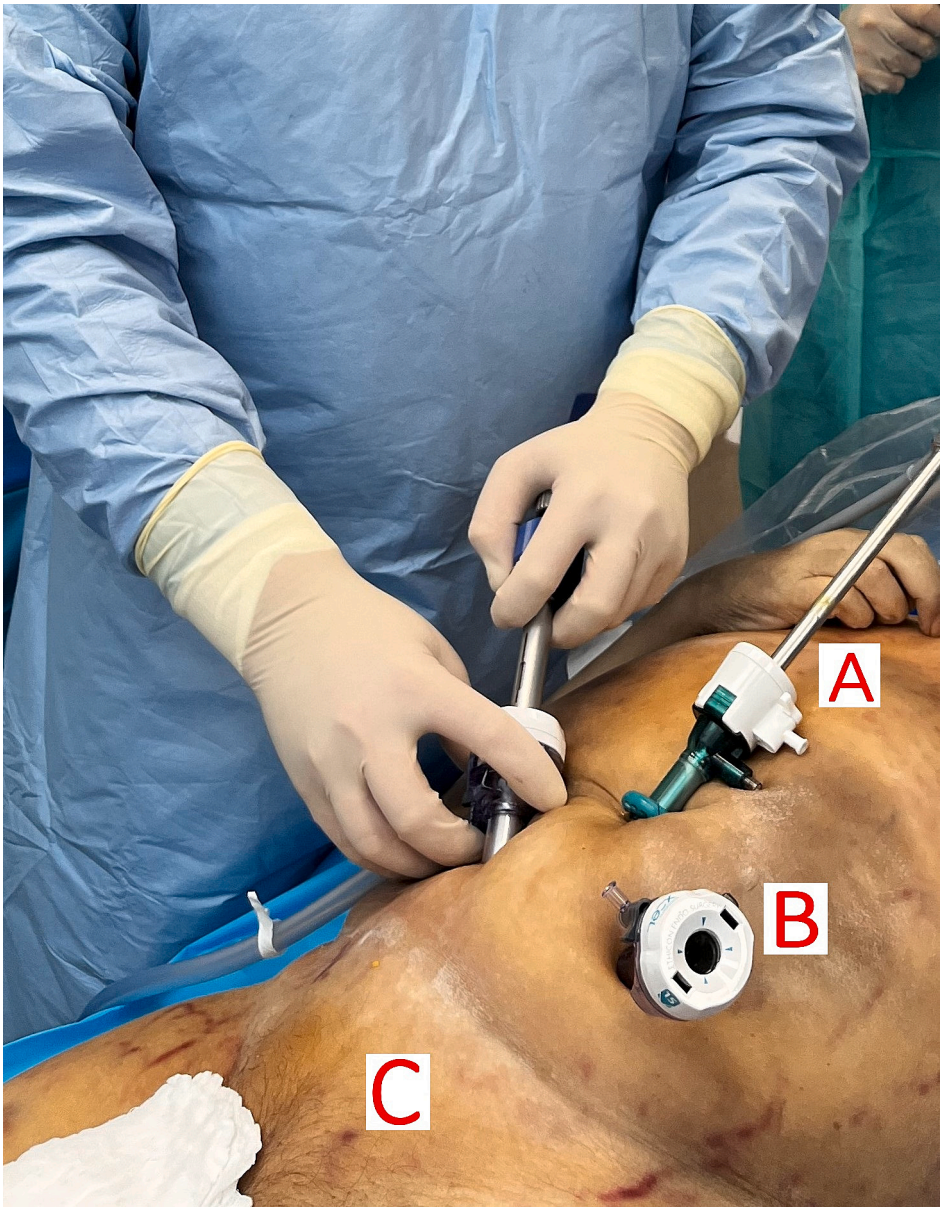

Fig. 2. Surgical set up.
A: Subombilical viewing portal.
B: Lateral instrumental portal.
C: Pubic symphysis.

Screw placement

The TETHER™ system is an all-threw-one instrument that allows insertion of the implants (Fig. 3).

A titanium alloy anchor is fixed on the gripper, a square tip is positioned in the center of the anchor. The gripper with the anchor is then inserted through one of the lateral portals. Under endoscopic visualization, the anchor is positioned on the superior surface of the pubic body as close as possible to the pubic symphysis. It is critical to carefully visualize this process under endoscopy as it allows safe and precise control of the positioning and direction of the instrument. Positioning can be further confirmed with an AP, inlet and outlet fluoroscopy Xrays. The anchor is then impacted into the bone with a hammer. The path of the drill and screw is now set by the direction and placement of the anchor. A long drill can be passed through the cannulated gripper or alternatively a 4.5 mm tap can be used directly as the near cortex has already been penetrated by the square tip mounted on the anchor. With the aid of the endoscope the length of the screw can be assessed on the tap handle. Finally, a 5.5 mm monoaxial screw is inserted. The final position is confirmed under endoscopy and fluoroscopy and the tulips are set perpendicular to the plane to allow passage of the synthetic ligament.

The same steps are repeated for a further 3 screws to create a construct with 2 bicortical screws either side of the pubic symphysis

Fig. 3. Specific endoscopic instrumentation.
A: "All-through-one" instrument: anchor inserter with long awl.
B: 4.5 mm non cannulated tap.
C: Sounder.
D: Screwdriver.

(Figs. 4 and 5).

Placement of the synthetic ligament

Sulene®PET synthetic ligament is cut to the appropriate length. This is inserted by the right or left lateral portal depending on the most suitable side. The synthetic ligament is positioned in the furthest most lateral screw under endoscopic control ensuring it protrudes from the end of the lateral screw by at least one centimeter. The other end of the synthetic ligament comes out through the portal it was inserted and this is left long. The synthetic ligament is fixed in the most lateral screw tulip with a torquing device that is introduced through the contralateral portal. The synthetic ligament is then positioned in the screw immediately medial to the previous screw and the free end outside the body is inserted into a tensioning device. The synthetic ligament is tensioned, which is confirmed endoscopically, and the bolt is then locked. This process is repeated a further 2 times with reduction and compression of the symphysis occurring between the second and third screw. The remaining synthetic ligament from the last screw is cut leaving more than a 1 cm free end.

Final check

The construct tension is confirmed under endoscopy and placement and position are checked under endoscopy and fluoroscopy (Fig. 6). Closure is carried out according to the usual protocol.

Discussion

Multiple methods of pubic symphysis fixation have been described [9–11] and open reduction internal fixation with metal plate remains the gold standard, but this technique is associated with frequent mechanical complications [6–9]. At our institution, in the

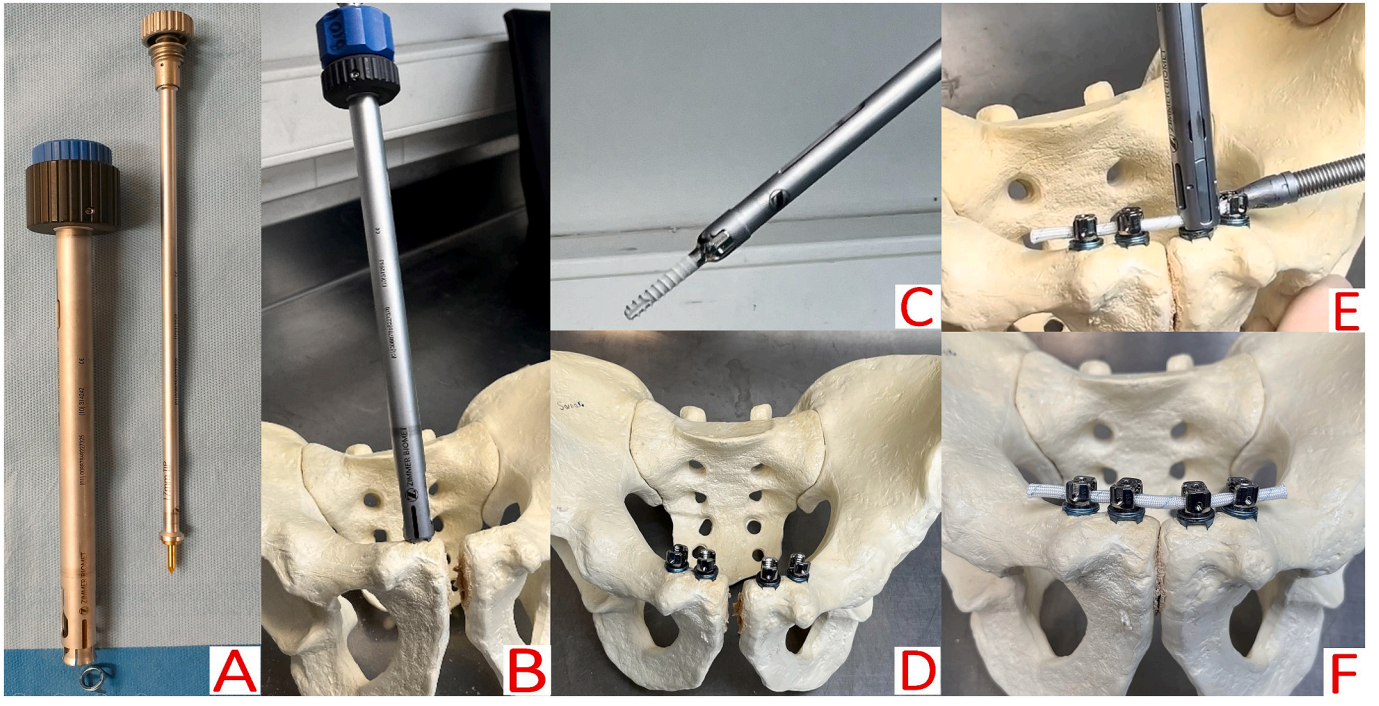

Fig. 4. Surgical steps on sawbone model.
A: Locking the anchor on the anchor inserter.
B: Impaction of the anchor in the pubic bone.
C: Insertion of a 5.5 mm screw.
D: Front view of the pelvis after positioning the four screws.
E: The ligament is inserted and tensioned.
F: Final construct.

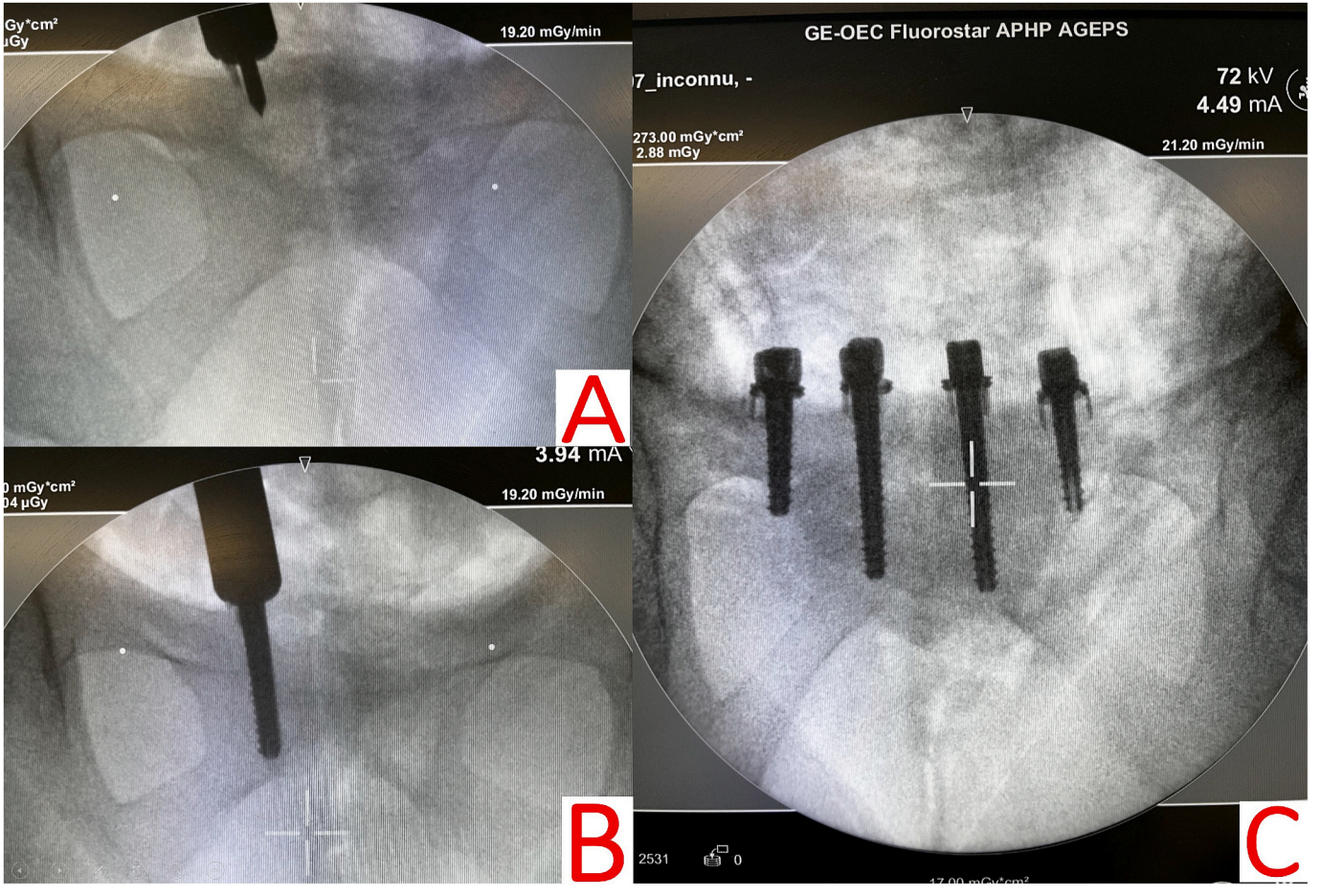

Fig. 5. Surgical steps under fluoroscopic control.
A: Anchor and awl placement on the pubic body.
B: First screw inserted in the pubis.
C: Final construct.

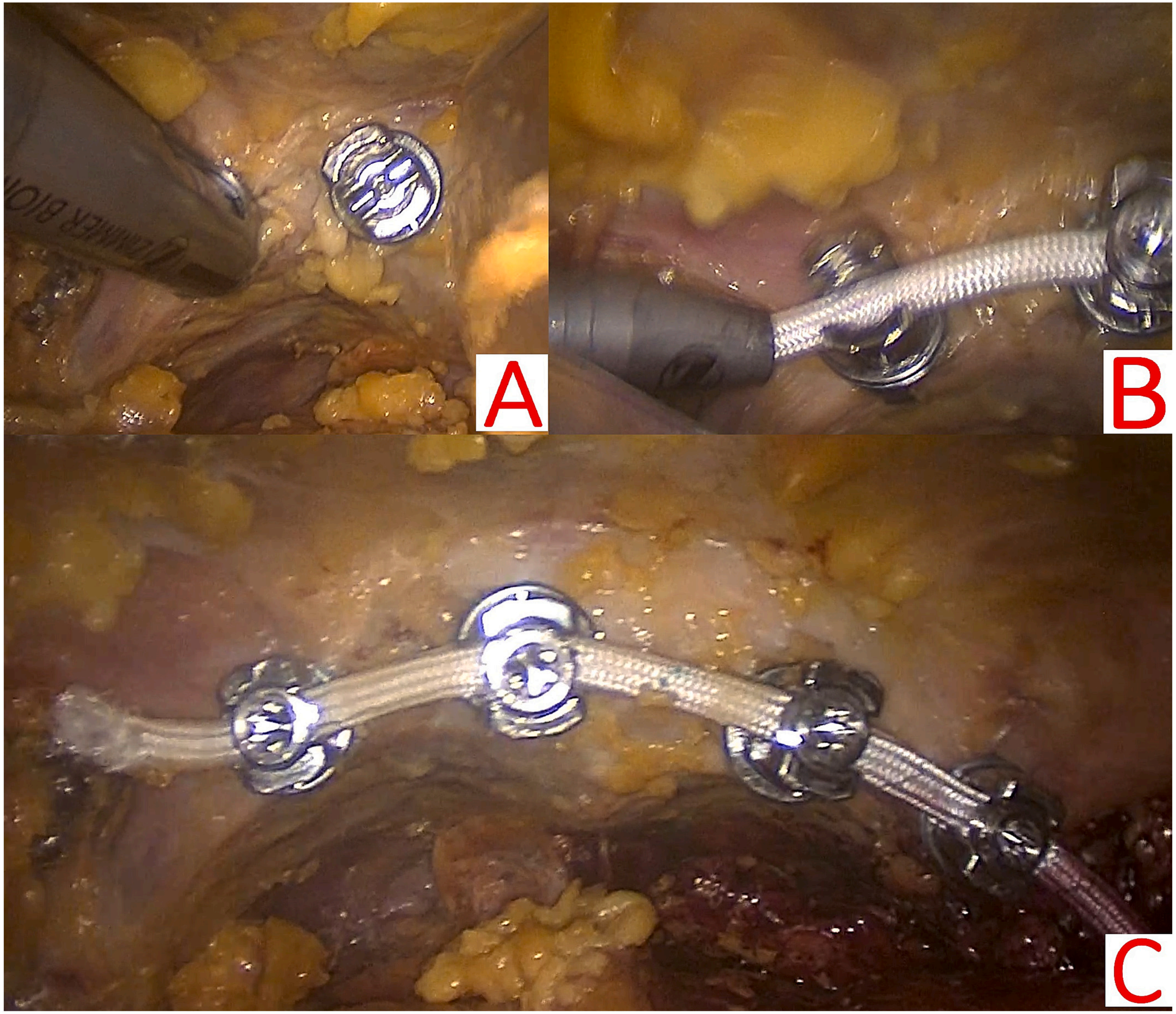

Fig. 6. Intraoperative endoscopic views.
A: Screw insertion on the left pubic superior ramus.
B: Ligament insertion.
C: Final construct view under endoscopy.

mid-term follow up, we have observed hardware failure, breakage, screw pullout and subsequent secondary displacement. Less invasive techniques such as percutaneous screw fixation have been developed with promising results described in the literature [11,12], which unfortunately, we have not been able to replicate and have experienced issues with loss of hardware position and secondary displacement.

It is important to note radiological secondary displacement and hardware failure does not necessarily mean poor clinical outcome [13]. Once ligament healing in the symphysis is complete, unless an arthrodesis was performed, we expect micromotion to persist due to the nature of the joint. Regardless of the material used for fixation we would expect material fatigue failure to occur due to persistent chronic micromotion. This is similar in principle to screw breakage in ankle syndesmosis injuries, which in some centers, are routinely removed to avoid this problem. More recently, the development of synthetic suture button systems has allowed the avoidance of this issue without compromising biomechanical stability [14]. Feng et al. have attempted to use suture button devices in symphysis fixation [15], however, we believe the biomechanical demands placed on the implant are far greater in the symphysis than in the ankle syndesmosis.

We believe that the vertebral tethering system with a synthetic ligament, as demonstrated in this technique, is well-suited for the fixation of the pubic symphysis in cases of open-book pelvic trauma with a symphysis diastasis greater than 2 cm. Through this cadaveric study, we validated the feasibility of this technique under endoscopy. However, further biomechanical and clinical studies are necessary to validate the concept and assess the safety of the technique, especially since mechanical complications such as rope slippage and loss of correction have been reported in scoliosis patients treated with this method [16,17].

In our opinion, posterior percutaneous iliosacral screw fixation could be considered, particularly in cases of complete posterior ring injury. For more unstable pelvic ring injuries, such as vertical shear, caution is advised due to the increased mechanical stresses on the fixation.

Regarding contraindications, a history of abdominal surgery may complicate the endoscopic approach due to adhesions that hinder dissection of the preperitoneal space, increasing the risk of perforation. If necessary, conversion to a conventional open approach using the same fixation technique is possible. Postoperative guidelines following this fixation are the same as those for conventional fixations in our center: sitting is allowed from day one, and walking without weight-bearing on the injured side for 45 days.

Other spinal systems, such as Infix, have also shown good results [18]. The system used here offers the advantage of being designed for endoscopic use, utilizing a synthetic ligament instead of a metal plate, and allowing the application of tension to achieve in-situ compression and reduction. The main limitation of this technique, as described in this study, is the longer operative time (75 min) compared to the open technique; however, this was our first experience, and we expect the learning curve to improve operative times in the future.

Conclusion

While open reduction internal fixation with a metal plate is the gold standard for pubic symphysis disruption, there is a trend towards the use of minimally invasive techniques. In this cadaveric study, we demonstrated the feasibility of a new method of minimally invasive endoscopic fixation of the pubic symphysis with a synthetic ligament. Biomechanical and clinical studies are needed to assess efficiency and security of the technique.

Ethics approval and consent to participate

No (cadaver study).

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No.

CRediT authorship contribution statement

Pierre Emmanuel Moreau: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Conceptualization. **Ali Bokhari:** Writing – original draft. **Sarah El Yahiouni:** Resources, Data curation, Conceptualization. **Quentin Manach:** Methodology. **Peter Upex:** Conceptualization. **Guillaume Riouallon:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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