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Single port component separation: endoscopic external oblique release for complex ventral hernia repair

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Abstract

Background Component separation (CS) is a technique which mobilizes flaps of innervated, vascularized tissue, enabling closure of large ventral hernia defects using autologous tissue. Disadvantages include extensive tissue dissection when creating these myofascial advancement flaps, with potential consequences of significant post-operative skin and wound complications. This study examines the benefit of a novel, ultra-minimally invasive single port anterior CS technique.

Methods This was a prospective study of 16 external oblique (EO) releases performed in 9 patients and 4 releases performed in 3 fresh frozen cadavers. All patients presented with recurrent complex ventral hernias, and were administered preoperative *Botulinum Toxin A* to their lateral oblique muscles to facilitate defect closure. At the time of elective laparoscopic repair, patients underwent single port endoscopic EO release using a single 20-mm incision on each side of the abdomen. Measurements were taken using real-time ultrasound. Postoperatively, patients underwent serial examination and abdominal CT assessment.

Results Single port endoscopic EO release achieved a maximum of 50-mm myofascial advancement per side (measured at the umbilicus). No complications involving wound infection, hematoma, or laxity/bulge have been noted. All patients proceeded to laparoscopic or laparoscopic-open-laparoscopic intraperitoneal mesh repair of their hernia, with no hernia recurrences to date.

Conclusions Single port endoscopic EO release holds potential as an adjunct in the repair of large ventral hernia defects. It is easy to perform, is safe and efficient, and entails minimal disruption of tissue planes and preserves abdominal wall perforating vessels. It requires only one port-sized incision on each side of the abdomen, thus minimizing potential for complications. Further detailed quantification of advancement gains and morbidity from this technique is warranted, both with and without prior administration of *Botulinum Toxin A* to facilitate closure.

Keywords Component separation · Ventral hernia · Endoscopic · External oblique release · Minimally invasive

Over the past 20 years, major abdominal wall reconstructive innovations such as component separation (CS), improved synthetic meshes, and the advent of bioprosthetic meshes have advanced the field of complex hernia repair with ensuing improved outcomes. CS is a technique which mobilizes flaps of innervated, vascularized autologous tissue to enable tension-free midline fascial closure of large ventral hernia

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defects. The extensive subcutaneous tissue dissection and division of perforating vessels from traditional open CS as introduced by Ramirez et al. in 1990 [1] predispose to skin flap necrosis, wound dehiscence, infection, and hematoma and seroma formation [2, 3]. Several variants of minimally invasive and endoscopic CS exist, which allow release of the external oblique (EO) fascia from the rectus complex, but require less subcutaneous tissue dissection and preserves the rectus abdominis perforating vessels, thereby reducing complication rates [4–8]. We report on a novel CS technique: a single port, ultra-minimally invasive endoscopic EO release using the MicroAire® Agee system.

Materials and methods

This was a prospective study of a total of 16 EO releases performed in 9 patients and 4 releases performed in 3 fresh frozen cadavers between November 2012 and January 2017 (registration number 2291 in public trials registry http://www.researchregistry.com). All patients underwent either unilateral or bilateral single port EO release during elective laparoscopic or laparoscopic-open-laparoscopic (LOL) repair of complex ventral hernia. Patients were administered preoperative *Botulinum Toxin A* injections to all three layers of their lateral abdominal musculature (EO, internal oblique, and transversus abdominis muscles) prior to elective hernia repair to facilitate closure, as a routine component of the authors' Complex Hernia Programme [9, 10].

EO release was performed using the MicroAire® Smart Release™ endoscopic carpal tunnel release system (MicroAire Surgical Instruments, Charlottesville, VA). It features a disposable, retractable slimline blade, which, when triggered, incises the tissues immediately overlying the blade. The device accommodates a 3-mm endoscope, allowing the release to be performed under direct vision, displayed on a video screen.

Surgical technique

After a general anesthetic had been administered, patients' abdominal walls were mapped using ultrasound, to identify fascial edges, rectus muscle complex, and the linea semilunaris. A 20-mm transverse incision was then made midway between a line drawn from the tip of the tenth rib to a point just inferomedial to the anterior superior iliac spine (ASIS) (Fig. 1). The position of this line was adjusted laterally in selected patients with very large midline defects, depending on the extent of lateral retraction of the rectus muscle surrounding the fascial defect. After the initial incision, the subcutaneous tissues were divided with diathermy to expose the fascia overlying the EO. The fascia and EO were sharply incised; the fibres split

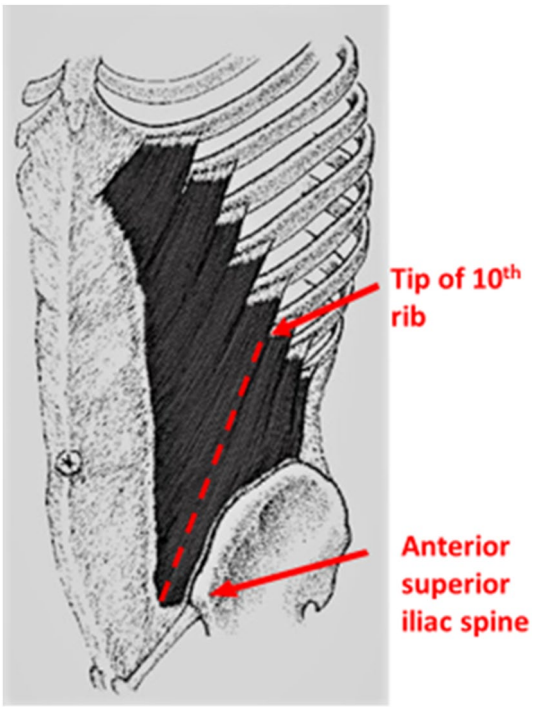

Fig. 1 Single port EO release is performed along a line drawn from the tip of the tenth rib to a point inferomedial to the ASIS. A transverse 20-mm incision is made halfway along this line. The position of this line is adjusted laterally for patients presenting with large hernia defects and substantial lateral retraction of their obliques

in their natural orientation, and the internal oblique (IO) fascia exposed. Stay sutures were applied to allow retraction. Through this incision, a space was bluntly developed in the avascular plane between the internal and external oblique muscles, extending superiorly towards the tip of the 10th rib and then inferiorly towards the inguinal ligament, in the direction of the line previously drawn on the patient's skin (Fig. 2). Under direct vision using a 3-mm endoscope, the MicroAire system was introduced into the space between the EO and IO, the retractable blade triggered, and the overlying EO muscle and fascia incised as the blade is withdrawn (Fig. 3). During withdrawal of the device, the surgeon's free hand was placing gentle pressure on the overlying skin, to allow the blade to incise further into the tissues. This process was performed twice in each direction, superiorly and inferiorly, dividing the EO muscle and overlying fascia in its entirety. The EO release was monitored in real-time using ultrasound as the blade is triggered and withdrawn (Fig. 4). At completion of the EO release, gauze squares were packed into the wounds and left in situ until completion of the hernia repair. This provided pressure hemostasis while the laparoscopic adhesiolysis, transcutaneous midline fascial closure, and intra-peritoneal placement of mesh occurred. The entire procedure was repeated on the contralateral side

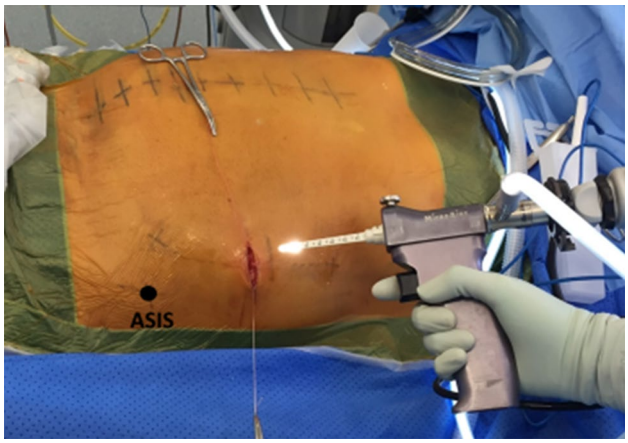

Fig. 2 After delivering a general anaesthetic, the abdominal wall is mapped with ultrasound, and the intended incision marked on the patient. The dissection is continued deep to EO. The MicroAire blade uses a retractable blade and is attached to a 3-mm endoscope and light source

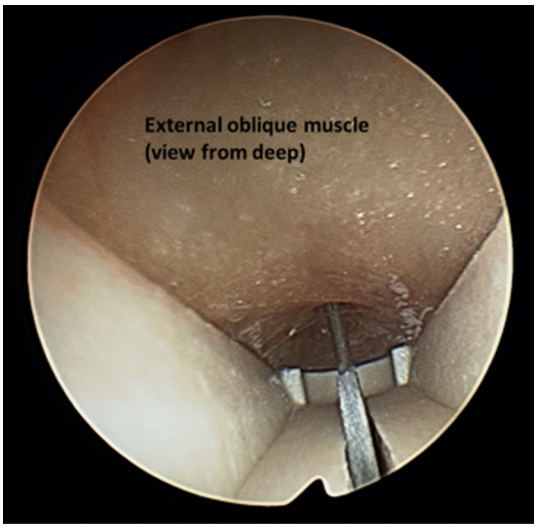

Fig. 3 Endoscopic view of the MicroAire® blade within the avascular plane between EO and IO, as it incises the EO muscle and fascia directly above the retractable blade

if bilateral release was required. A layered closure with absorbable sutures was performed at completion of the entire procedure.

EO release using cadaveric models utilized a similar process. Performed under vision using real-time ultrasound and endoscopy, EO measurements were recorded immediately after release, during pneumoperitoneum, and after pneumoperitoneum. One cadaver underwent complete dissection of the left subcutaneous tissue flap after EO release, to visually demonstrate the potential advancement gains from this procedure (Fig. 5A, B).

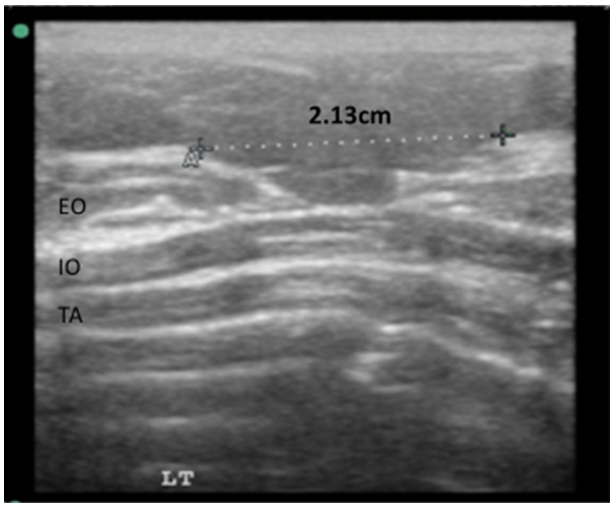

Fig. 4 Ultrasound view of the EO muscle immediately after incision, demonstrating spontaneous separation of the EO. Further myofascial gain is achieved by placing the muscle under gentle tension (for example, during pneumoperitoneum or fascial defect closure)

All releases were performed (or supervised) by the same surgeon (NI). All patients underwent serial physical examination post-operatively, as well as serial CT assessment.

Results

A total of nine patients (four males, five females) underwent single port EO release as a component of their elective complex ventral hernia repair. The average age of patients was 63 years (range 47–81), with a BMI ranging from 25 to 46. Four patients were diabetic. Two patients underwent unilateral EO release for laterally located ventral hernias, with seven patients undergoing bilateral EO release for midline hernias. The mean fascial hernia defect size was 16.5 cm for midline hernias, and 11.5 cm for laterally placed ventral hernias.

Single port endoscopic EO release achieved a maximum 50 mm gain of myofascial advancement per side measured at the level of the umbilicus. Measurements were performed during pneumoperitoneum using the equivalent of 12 mmHg (Fig. 5B) as a standardized means of appreciating the maximum potential myofascial advancement that can be achieved when subjecting the tissues to gentle tension.

To date, there have been no occurrences of hematoma, wound infection, or wound breakdown related to the EO release. In the author's experience, bleeding from the incised muscle was minimal and settled easily—at most, required several minutes of direct pressure over the wound. No patient required further exploration to locate a bleeding vessel, or evacuation of a hematoma. Patients were routinely examined post-operatively, and CT scanning was

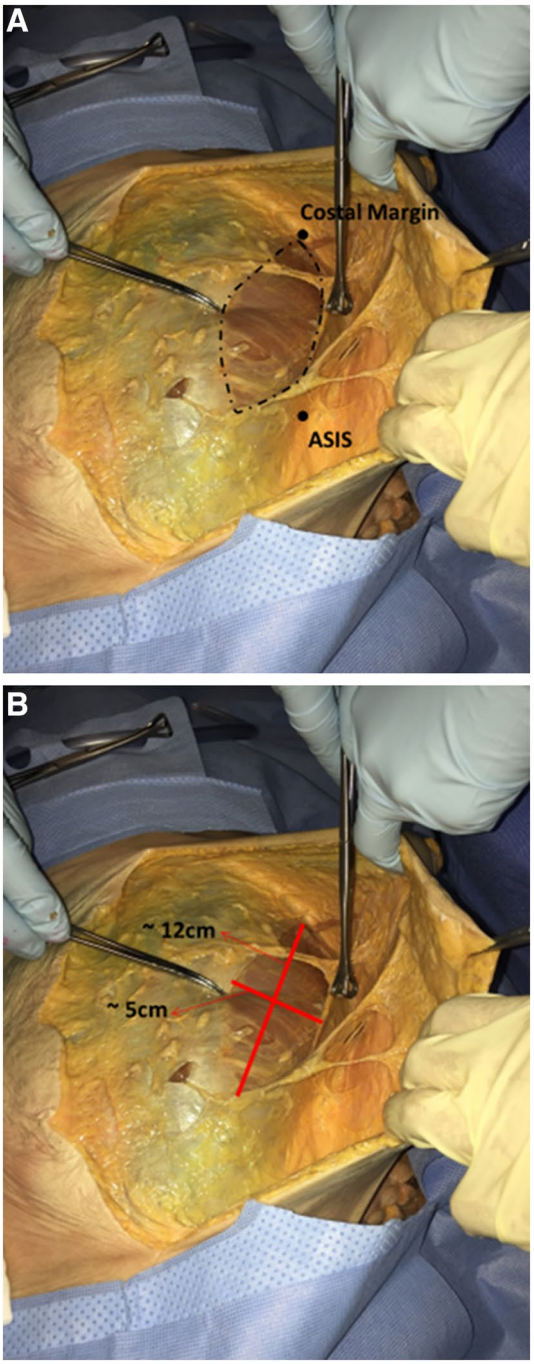

Fig. 5 **A, B** Single port EO release was performed in this cadaver model, with subsequent raising of subcutaneous skin flaps to demonstrate the extent of myofascial advancement. The 50 mm advancement seen in this image was obtained during pneumoperitoneum (12 mmHg)

performed at day 5–7 and at 4 weeks, again demonstrating no evidence of any significant hematoma.

After EO release, all patients proceeded to a laparoscopic or LOL ventral hernia repair using an intra-peritoneal onlay mesh. Mean follow-up is 30 months. There have been no hernia recurrences in this time.

Importantly, no patient has displayed any evidence of laxity or bulge after EO release. This is best demonstrated on CT abdomen which is performed while the patient is activating their abdominal musculature during a 'crunching' manoeuvre (Fig. 6A, B). After hernia repair, patients were routinely monitored with physical examination as well as CT imaging at specific intervals and when clinically indicated.

Discussion

Nine patients in this study underwent endoscopic EO release as an adjunct to their elective hernia repair (seven bilateral and two unilateral releases). Performed at the outset of each patient's procedure, the release was performed in selected patients with exceptionally large defects, to mitigate an *anticipated* difficulty with achieving closure, despite preoperative BTA treatment imparting flaccid paralysis to the lateral abdominal wall muscles. The two unilateral releases were performed on patients with complex *lateral* ventral incisional hernias, measuring 10 cm × 9 cm and 13 cm × 16 cm, in order to medialize the laterally retracted rectus edge and allow reconstitution of the linea alba. The seven bilateral releases were performed on midline ventral hernias with a mean defect width 16.5 cm. These patients were identified preoperatively as likely requiring an adjunct to BTA in order to provide fascial closure. The width of defect (> 15 cm) was a substantial component in this decision-making process. Further factors were the number of previous abdominal procedures, number of prior hernia repairs, and presence and amount of mesh in situ. Each of these factors relates directly to the extent of abdominal wall scarring, fibrosis, and (lack of) tissue compliance, which may make fascial closure more difficult.

The procedure described here is a modified version of the minimally invasive and endoscopic CS techniques currently described in the literature [2–8]. Traditional open CS, as described by Ramirez et al. [1], predisposes to significant wound complications due to extensive tissue dissection, which creates large areas of subcutaneous dead space and disrupts the blood supply to the overlying skin flap. A review of the literature by Rosen et al. [8] found serious wound morbidity in up to 40% of patients undergoing open CS. A 2015 systematic review of the surgical management of incisional hernias found that open CS resulted in skin flap infection or necrosis in 20% of procedures, hematoma in 8%, and seroma in 9% [2]. Both minimally invasive and endoscopic CS techniques were designed to help circumvent these problems by preserving the vascularity of overlying skin flaps and reducing subcutaneous dead space. The authors' single port endoscopic EO release incises the EO muscle belly

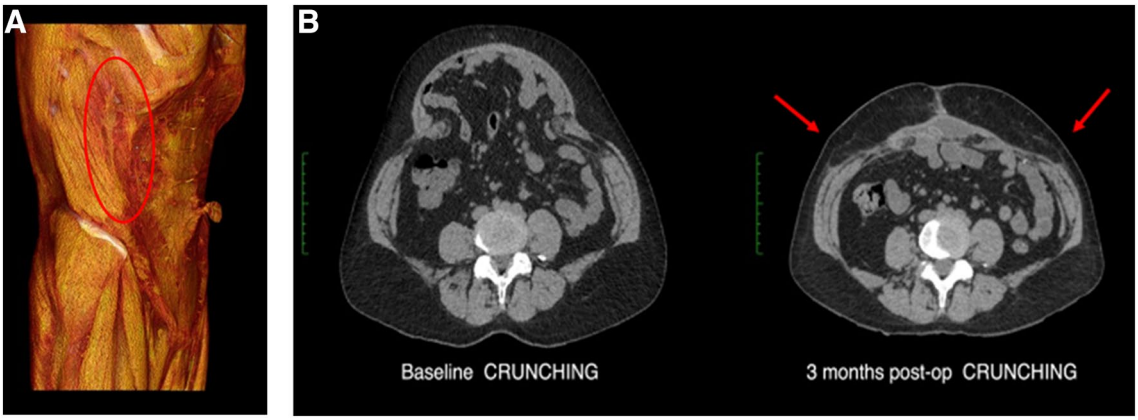

Fig. 6 **A** Volume rendered CT image at 10 months postoperative, demonstrating site of EO incision. Fibrosis of the incised portion of the EO muscle is evident, with minimal loss of functional muscle surrounding the incised area. **B** Comparison axial CT images of the same patient, at the same vertebral level, comparing baseline and postoperative views. During scanning, the patient is performing an active crunching manoeuvre, and demonstrates no post-operative laxity or bulging after single port EO release

along the line of its fibres and its covering fascia in a line between the tip of the tenth rib and the inguinal ligament, but does not require any further disruption or dissection of tissue planes. This technique does not require a dissecting balloon.

Advantages of this technique include its ultra-minimally invasive nature, requiring only a single 20-mm incision, preservation of rectus perforator vessels and creation of virtually no dead space. It does not require a midline laparotomy to perform and is entirely compatible with laparoscopic surgery. The entire procedure takes approximately 6 min per side to perform. As it is the EO muscle and fascia alone which is incised, the sub-adjacent IO and transversus abdominis muscles remain entirely intact to protect against any subsequent postoperative laxity or bulge (Fig. 6A). This procedure also leaves Scarpa's fascia intact, which may provide additional protection from any bulging. Post-operatively, the EO muscle fibroses and heals without causing any clinically evident muscular or fascial defects (Fig. 6B). Due to the lateral nature of the incision, this procedure is safe and effective even when the rectus complex has been previously violated, for example, due to the presence of a stoma or previous incisions.

Traditional open CS involves incising and releasing the EO and, if required, the posterior rectus sheath. This achieves gains of 2, 4, and 2 cm advancements in the upper, middle, and lower thirds of the abdomen, respectively, after releasing the EO. A further 3, 5, and 3 cm can be gained from releasing the posterior rectus sheath [1]. Endoscopic component separation (ECS), as described by Rosen et al., recorded that laparoscopic CS achieved an average of 86% of the myofascial advancement obtained by the open CS technique—in this case, 'complete release' was defined as release of the entire EO fascia from 5 cm cephalad to the costal margin and extending to the inguinal ligament [8]. Alternative ECS techniques achieve similar outcomes by using varying methods to incise and release the EO aponeurosis, and develop the avascular plane between EO and IO. These techniques require a 10–12 mm port and one to two additional 5-mm ports, and utilize a balloon dissector [6, 7, 11].

A potential drawback to this technique is that the overall length of the release is limited to the length of the MicroAire® blade, and will allow a maximal incision length of 9 cm above and below the single incision. The authors' EO fascial release as described above does not extend beyond the costal margin (at the tenth rib) and therefore limits the advancement gains obtainable in the epigastric region. Similarly, advancement gains in the suprapubic region are limited. Although some published CS papers discuss extending their incision up to the costal margin only [6], other endoscopic and minimally invasive CS techniques describe continuing the EO release up to 12-cm cephalad to the costal margin [3, 5, 8, 12], allowing additional myofascial advancement in the epigastric region.

As noted previously, a common element of both open and endoscopic CS techniques is the extensive development of the avascular plane between EO and IO to allow further myofascial advancement gains beyond that achieved from releasing EO alone. This is not a component of the technique being described here. When used in combination with preoperative BTA administration, further dissection beyond the described endoscopic EO release has not been required to achieve fascial closure. This is in keeping with its ultra-minimally invasive nature—a single, small incision plus minimal tissue plane disruption.

Conclusions

Endoscopic single port EO release is simple and effective, and holds significant potential as an adjunct in the closure of large ventral hernia defects. Endoscopic CS is advantageous over open CST in that it avoids extensive skin undermining, ensuring preservation of perforating vessels and minimizes potential dead space and its consequences. Single port EO release, as described above, entails minimal disruption of tissue planes and perforating vessels, and therefore maintains the integrity and functionality of the abdominal wall. This technique should be considered when CS is required as an adjunct in ventral hernia repair. Further studies are warranted to fully evaluate myofascial advancement gains, with and without prior administration of *Botulinum Toxin A* to facilitate closure.

Compliance with ethical standards

Disclosures John Read declares conflict of interest related to the submitted work as he receives financial remuneration from Medicare as a radiologist. Kristen Elstner, Omar Rodriguez-Acevedo, Peter Cosman, Anita Jacombs, Alex Karatassas, Rodrigo Martins, Fernando Arduini, Nabeel Ibrahim, and Anthony Dardano have no conflicts of interest or financial ties to disclose.

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