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Hernia

Medialization after combined anterior and posterior component separation in giant incisional hernia surgery, an anatomical study

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ABSTRACT

Background: To obtain tension-free closure for giant incisional hernia repair, anterior or posterior component separation is often performed. In patients with an extreme diameter hernia, anterior component separation and posterior component separation may be combined. The aim of this study was to assess the additional medialization after simultaneous anterior component separation and posterior component separation.

Methods: Fresh-frozen post mortem human specimens were used. Both sides of the abdominal wall were subjected to retro-rectus dissection (Rives-Stoppa), anterior component separation and posterior component separation, the order in which the component separation techniques were performed was reversed for the contralateral side. Medialization was measured at 3 reference points.

Results: Anterior component separation provided most medialization for the anterior rectus sheath, posterior component separation provided most medialization for the posterior rectus sheath. After combined component separation techniques total median medialization ranged between 5.8 and 9.2 cm for the anterior rectus sheath, and between 10.1 and 14.2 cm for the posterior rectus sheath (depending on the level on the abdomen). For the anterior rectus sheath, additional posterior component separation after anterior component separation provided 15% to 16%, and additional anterior component separation after posterior component separation provided 32% to 38% of the total medialization after combined component separation techniques. For the posterior rectus sheath, additional posterior component separation after anterior component separation provided 50% to 59%, and additional anterior component separation after posterior component separation provided 11% to 17% of the total medialization after combined component separation techniques. Retro-rectus dissection alone contributed up to 41% of maximum obtainable medialization.

Conclusion: Anterior component separation provided most medialization of the anterior rectus sheath and posterior component separation provided most medialization of the posterior rectus sheath. Combined component separation techniques provide marginal additional medialization, clinical use of this technique should be carefully balanced against additional risks.

Introduction

Incisional hernia (IH) repair for giant hernias remains surgically challenging and often requires component separation. Reported recurrence rates after anterior component separation (ACS) and posterior component separation (PCS) are heterogeneous, ranging from approximately 3% to 21% for PCS and 5% to 32% for ACS.[1–3] Differences in follow-up and diagnostic protocols may contribute to this heterogeneity. However, the largest published series of patients undergoing PCS showed a low recurrence rate of 4% after a minimum follow-up of 12 months.[4]

The gold standard of successful IH repair is thought to be tension-free fascial closure with mesh reinforcement. To obtain

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tension-free closure in giant IHs, medialization of the anterior and posterior rectus sheath is required. The most common technique to obtain this is the Rives-Stoppa procedure (ie, dissection of the retro-rectus space).[5,6] However, for large defects, this technique often does not provide sufficient medialization, and additional medialization is required. This can be obtained through release of 1 or more of the lateral abdominal muscles and subsequent dissection of intermuscular planes (ie, component separation techniques, [CSTs]).

Two well-known CSTs are ACS, described by Ramirez et al,[7] and PCS, first described by Novitsky et al.[8] Based on previous anatomical studies, PCS provides the most medialization of the posterior rectus sheath, whereas it is unclear if either technique provides better medialization of the anterior rectus sheath.[9,10]

No prior study evaluated the medialization of combined ACS and PCS, leaving only the internal oblique muscle intact. Nevertheless, in a clinical setting, a recent case series in 12 patients describes simultaneous ACS and PCS for repair of giant IHs.[11] Previously, ACS after PCS has been described by Pauli et al[12] as salvage procedure after hernia recurrence. It remains unclear whether additional medialization obtained through this major procedure would outweigh the additional surgical risks and destruction of anatomical planes, resulting in limited future reconstructive options in case of recurrence.

The primary objective of the current study was to evaluate the obtained medialization of the anterior and posterior rectus sheath after simultaneous ACS and PCS. Secondly, contribution to the total medialization of each surgical step will be assessed, and medialization obtained after ACS and PCS will be compared.

Methods

Fresh-frozen post mortem human specimens obtained from the university whole body donations program were included. All donors had consented to tissue donation for scientific purposes at the Erasmus University Medical Center, Department of Anatomy and Neuroscience. Owing to European regulations, the medical records of included specimens could not be accessed. Institutional review board approval was not required, since this study does not involve live human or animal test subjects. Specimens with visible abdominal wall morbidities, previous abdominal surgery, or specimens with intra-abdominal masses, extensive adhesions, or poor tissue preservation that might interfere with measurements were excluded.

Retro-rectus dissection (Rives-Stoppa procedure)

A midline incision was performed, starting from the xiphoid process, leading down to the pubic bone. Dissection of the subcutaneous tissue was performed in order to expose the linea alba. Afterward, the linea alba was opened carefully, as central as possible, so the rectus sheath was not opened prematurely. Upon entry into the abdominal cavity, the contents were inspected for masses, adhesions, or other visible irregularities. Adhesiolysis was performed if necessary. Afterward, the posterior rectus sheath at the medial edge of the rectus sheath was incised longitudinally, across the entire midline incision. Consequently, the rectus muscle was separated from the posterior rectus sheath, toward the junction of the anterior and posterior rectus sheath. This concluded the retro-rectus dissection.

ACS technique

After the retro-rectus dissection, open ACS, as described by Ramirez et al,[7] was performed. First, subcutaneous tissue was dissected from the fascia of the anterior rectus sheath until the fibers of the external oblique muscle were identified. The external oblique muscle was released by incision of the aponeurosis between the rectus sheath and the external oblique muscle up to the external fascia of the internal oblique muscle. The aponeurosis was opened as far as possible cranially and caudally. Subsequently, the external and internal oblique muscles were separated as much as possible laterally by blunt dissection (Fig 1).

PCS technique

After the retro-rectus dissection, open PCS, as described first by Novitsky et al,[8] with transversus abdominis muscle release was performed. The lamina posterior of the internal oblique of the rectus sheath was incised longitudinally up to the fascia transversalis or peritoneum. Subsequently, the transected transversus abdominis muscle and fascia transversalis or peritoneum were separated laterally as much as possible, up to the psoas muscles, by blunt dissection. Both the pre-transversal and preperitoneal planes may be used, alternating between the two during one procedure can often not be prevented and is considered acceptable. The peritoneum/fascia transversalis was separated less extensively in the area of the pelvis and diaphragm; maximum blunt dissection was aimed for. Any incidental defects created in the transversal fascia or peritoneum were closed with running 4-0 sutures (Fig 2).

Study procedures

Before each experiment, the length and weight of each specimen were recorded. Additional measurements were taken of the abdominal circumference at umbilical level, the distance between the anterior superior iliac spines, and the distance from the xiphoid process to the pubic bone. After exposing the linea alba, before opening it, the width of the linea alba was measured at 3 different locations: (1) halfway between the xiphoid process and the umbilicus (upper abdomen), (2) at the umbilicus (middle abdomen), and (3) halfway between the umbilicus and the pubic bone (lower abdomen). After opening of the linea alba, these positions were marked with sutures on both the anterior and posterior rectus sheath. A Kocher hemostat was clamped on each of these marked points, ensuring consistent measurement locations. Measurements of tissue advancement were performed separately for the anterior and posterior rectus sheath with a custom-made, standardized set-up used in a prior anatomical study.[9] Each of the 3 clamps had a 1-kg weight attached through a string. After opening of the linea alba, reference points were placed on the string. Measurements of tissue advancement were taken relative to the advancement obtained after opening of the linea alba by measuring the advancement of the string in regard to the reference mark (Fig 3). Advancement after opening of the linea alba was estimated relative to the abdominal midline to calculate the total medialization. All measurements were taken with a dial caliper, 4 minutes after initiating the 3 1-kg weights to compensate for eventual creep of collagen tissue. In each specimen, all procedures were performed on both sides (ie, retro-rectus dissection, ACS, and PCS). The abdominal side and CST procedure to start with were randomly assigned. The study-set up is depicted in Figure 3. The study procedures and sequence of measurements are schematically summarized in Figure 4 and Table I.

Data synthesis and statistical analysis

Statistical analysis was performed using IBM SPSS Statistics 25.0 (IBM Corp., Armonk, NY). On each side of the abdomen, similar

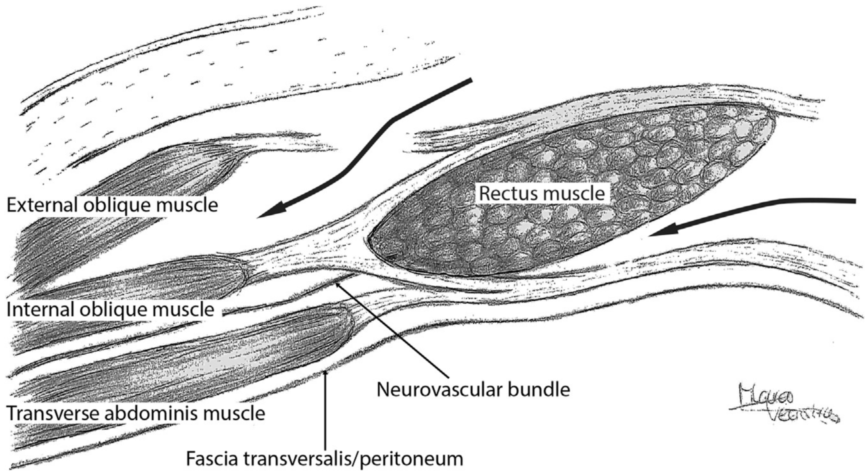

Fig 1. Schematic overview: anterior component separation.

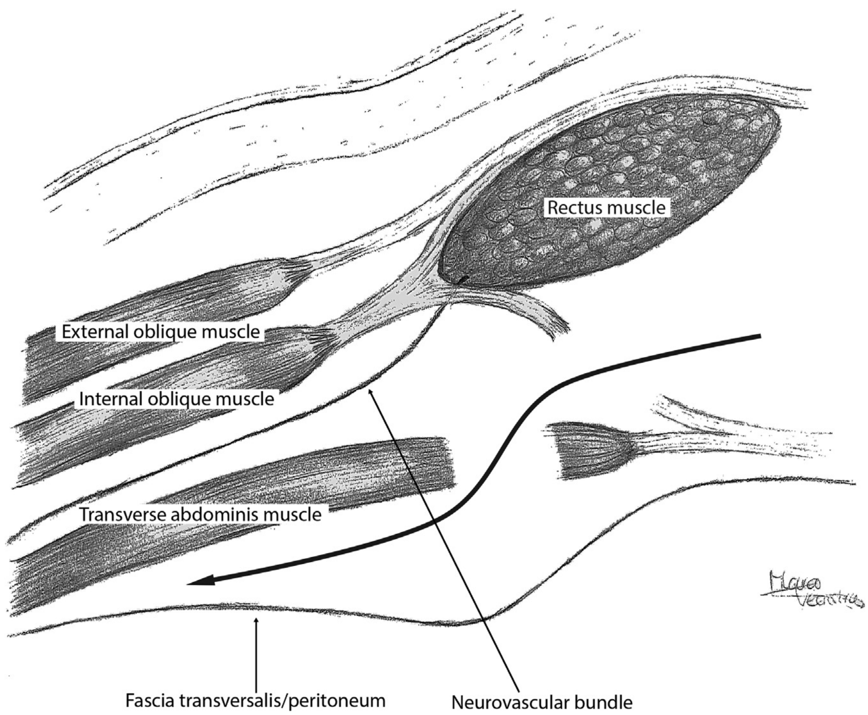

Fig 2. Schematic overview: posterior component separation.

procedures were performed; only the sequence in which these procedures were performed differed. Therefore, these measurements could be adjusted to compensate for left/right differences within 1 specimen. First the proportional unilateral advancement, relative to the total advancement of each surgical step (Table I), was calculated. Hereafter measurements were adjusted with the following formula:

$$\begin{matrix}\textit{proportional}\\ \textit{advancement per step}\end{matrix} \times \frac{\textit{left} + \textit{right max. medialization}}{2}$$

All further data analyses were performed on these adjusted measurements. For the medialization obtained after opening of the linea alba and retro-rectus dissection, measurements of the left and right side were combined. Data were presented as median and interquartile range in millimeters and as percentage of the total medialization obtained after combined CST. Medialization after ACS and PCS was compared with the Wilcoxon signed-rank test. Medialization attributed to the release, dissection, and total ACS and PCS were compared.

Results

Of 13 postmortem human specimens, 10 (6 male, 4 female) were included for final analyses. Three postmortem human specimens were excluded. One specimen had a large intra-abdominal mass interfering with the abdominal wall, another had poor tissue

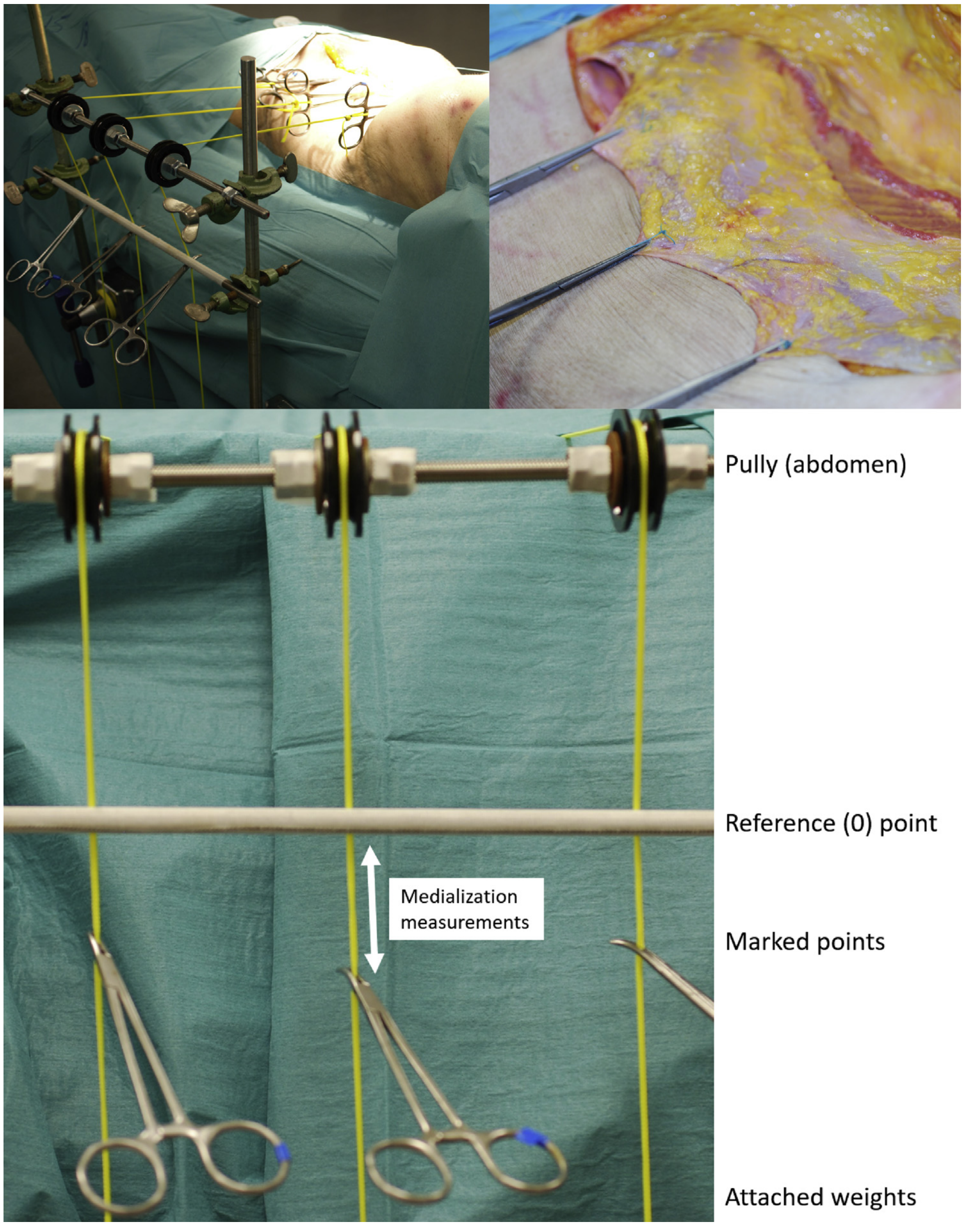

Fig 3. Study set-up, measurements of advancement.

preservation, and an other specimen was excluded owing to destruction of required anatomical planes in previous surgical procedures. Baseline specimen characteristics are presented in Table II.

Medialization after retro-rectus dissection

Medialization after only retro-rectus dissection is summarized in Tables III and IV and visually presented in Figures 5 and 6. For the anterior rectus sheath, retro-rectus dissection provided a maximum of 40%, 34%, and 41% (lower abdomen to upper abdomen) of total medialization obtained after combined CST. For the posterior rectus sheath, retro-rectus dissection provided a maximum of 36%, 27%, and 24% (lower abdomen to upper abdomen) of total medialization obtained after combined CST. In absolute terms (including medialization obtained after opening of the linea alba), total one-sided median medialization after retro-rectus dissection was 4.1, 4.5, and 3.8 cm (lower abdomen to upper abdomen) of the anterior rectus sheath. For the posterior rectus sheath, total one-sided median medialization after retro-rectus dissection was 5.3, 5.5, and 4.2 cm (lower abdomen to upper abdomen) ($n = 20$ hemi-abdomen).

Medialization of the anterior rectus sheath after CSTs

Medialization after CST for the anterior rectus sheath is summarized in Tables III and IV and visually presented in Figures 5 and 6. For the anterior rectus sheath, ACS provided 51%, 59%, and 43% (lower abdomen to upper abdomen) of total medialization obtained after combined CST. PCS provided 27%, 29%, and 27% (lower abdomen to upper abdomen) of total medialization obtained after

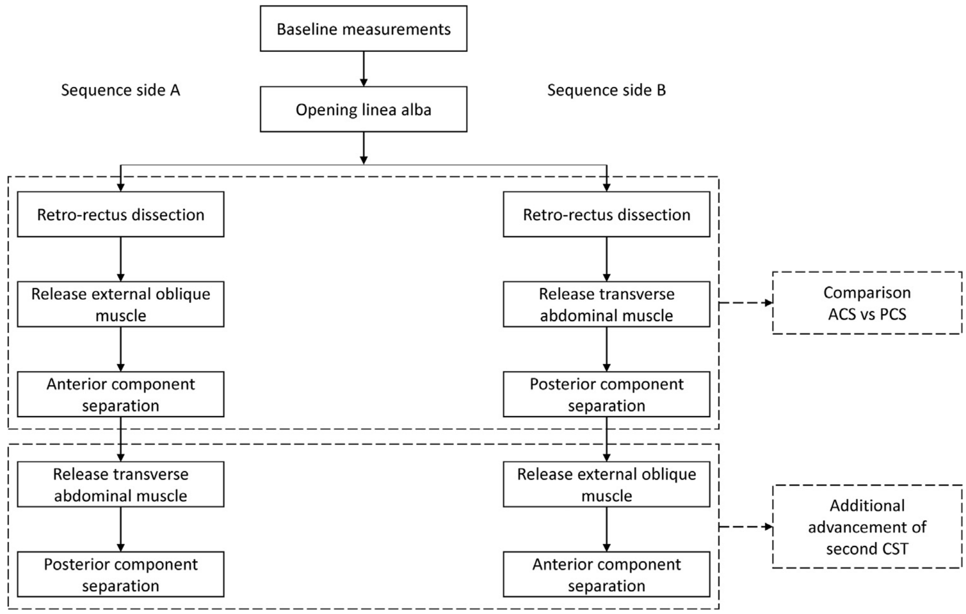

Fig 4. Flow diagram of study procedures and sequence of measurements.

Table I
Assessed surgical steps

Assessed surgical steps	Description
Opening linea alba	Opening of linea alba without opening of the rectus sheath.
Retro-rectus dissection	Complete separation of the posterior rectus sheath from the rectus muscle, towards the junction of the anterior and posterior rectus sheath.
External oblique muscle release	The external oblique muscle was released by incision of the aponeurosis between the rectus sheath and the external oblique muscle up to the external fascia of the internal oblique muscle. The aponeurosis was opened as far as possible cranially and caudally.
ACS dissection	Blunt dissection of the space between the internal and external oblique muscles.
Transverse abdominal muscle release	The lamina posterior of the internal oblique of the rectus sheath was incised longitudinally up to the fascia transversalis or peritoneum.
PCS dissection	The transected transversus abdominis muscle and fascia transversalis or peritoneum were separated laterally as much as possible, up to the psoas muscles, by blunt dissection. Both the pre-transversal and pre-peritoneal planes may be used, alternating between the two during one procedure can often not be prevented and is considered acceptable.

ACS, anterior component separation; *PCS*, posterior component separation.

Table II
Baseline specimen characteristics

Baseline characteristics	Median (IQR)
Circumference at umbilical level, cm	85.3 (81.6–91.3)
Distance xyphoid-pubic bone, cm	32 (29–34)
Distance ASIS-ASIS, cm	25.5 (24.3–27.5)
Width linea alba lower abdomen, mm	17.4 (13.5–20.5)
Width linea alba middle abdomen, mm	21.7 (18.2–28)
Width linea alba upper abdomen, mm	15.1 (9.5–22.5)
Height, cm	172.5 (165.8–174)
Weight, kg	61 (52.7–66.6)
BMI, kg/m^2	21.3 (19.7–22.5)
Male:female	6:4

ASIS, anterior superior iliac spine; *BMI*, body mass index; *IQR*, interquartile range.

combined CST. When comparing ACS to PCS, ACS provided superior one-sided medialization of the anterior rectus sheath (Table V). In absolute terms (including medialization obtained after opening of the linea alba), total one-sided median medialization after ACS was 6.4, 8.2, and 5.3 cm (lower abdomen to upper abdomen). For PCS, total median one-sided medialization was 5.2, 6.0, and 4.7 cm (lower abdomen to upper abdomen) (n = 10 hemi-abdomen).

Medialization of the posterior rectus sheath after CSTs

Medialization after CST for the posterior rectus sheath is summarized in Tables III and IV and visually presented in Figures 5 and 6. For the posterior rectus sheath, ACS provided 14%, 14%, and 18% (lower abdomen to upper abdomen) of total medialization obtained after combined CST. PCS provided 49%, 65%, and 68% (lower abdomen to upper abdomen) of total medialization obtained after combined CST. When comparing ACS to PCS, PCS provided superior one-sided medialization of the posterior rectus sheath (Table V). In absolute terms (including medialization obtained after opening of the linea alba), total one-sided median medialization after ACS was 6.3, 6.9, and 5.5 cm (lower abdomen to upper abdomen). For PCS, total median one-sided medialization was 9.3, 12.9, and 10.0 cm (lower abdomen to upper abdomen) (n = 10 hemi-abdomen).

Medialization by additional PCS after ACS

Obtained medialization is summarized in Tables III and IV, and proportional medialization is visually presented in Figure 6. For the anterior rectus sheath, additional PCS after ACS provided 15%,

Table III
Medialization of the rectus sheath

ACS first				PCS first			
Anterior rectus sheath							
Each surgical step separate, mm	LA	MA	UA		LA	MA	UA
Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)	Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)
Retro-rectus dissection	15 (8–17)	17 (12–25)	14 (11–17)	Retro-rectus dissection	15 (8–17)	17 (12–25)	14 (11–17)
External oblique release	14 (11–18)	17 (14–21)	8 (7–11)	Transverse muscle release	7 (4–13)	8 (7–15)	6 (3–14)
ACS dissection	10 (5–12)	20 (12–21)	7 (4–9)	PCS dissection	4 (3–5)	6 (4–8)	3 (3–5)
+ Transverse muscle release	3 (1–6)	5 (3–9)	4 (2–9)	+ External oblique release	9 (6–11)	13 (9–20)	6 (3–9)
+ PCS dissection	4 (3–8)	4 (3–7)	2 (1–4)	+ ACS dissection	4 (3–8)	6 (5–7)	5 (3–7)
ACS complete	23 (16–30)	37 (26–42)	15 (11–20)	PCS complete	11 (6–17)	14 (11–23)	9 (6–19)
+ PCS complete	7 (4–13)	9 (5–16)	5 (2–13)	+ ACS complete	13 (10–18)	19 (14–27)	11 (6–16)
Cumulative medialization, mm							
Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)	Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)
Retro-rectus dissection	41 (30–48)	45 (40–58)	38 (28–45)	Retro-rectus dissection	41 (30–48)	45 (40–58)	38 (28–45)
External oblique release	55 (41–66)	63 (54–79)	46 (35–56)	Transverse muscle release	48 (34–60)	53 (47–73)	44 (31–59)
ACS dissection	64 (46–78)	82 (66–100)	53 (39–65)	PCS dissection	52 (37–65)	60 (51–81)	47 (34–64)
+ Transverse muscle release	67 (47–83)	87 (69–110)	56 (41–74)	+ External oblique release	61 (43–76)	73 (60–101)	53 (37–73)
+ PCS dissection	71 (50–91)	92 (72–117)	58 (41–78)	+ ACS dissection	65 (46–83)	78 (64–108)	58 (40–80)
Posterior rectus sheath							
Each surgical step separate, mm							
Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)	Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)
Retro-rectus dissection	27 (23–31)	27 (23–31)	18 (12–21)	Retro-rectus dissection	27 (23–31)	27 (23–31)	18 (12–21)
External oblique release	6 (3–6)	6 (3–12)	7 (2–10)	Transverse muscle release	14 (9–25)	32 (19–41)	20 (14–24)
ACS dissection	5 (3–8)	7 (6–12)	6 (5–10)	PCS dissection	25 (20–31)	42 (31–51)	38 (28–46)
+ Transverse muscle release	14 (8–18)	26 (20–33)	17 (12–24)	+ External oblique release	10 (3–11)	5 (1–9)	6 (1–8)
+ PCS dissection	24 (6–31)	32 (29–37)	27 (20–39)	+ ACS dissection	4 (2–5)	8 (5–9)	3 (1–4)
ACS complete	10 (6–14)	14 (9–24)	14 (7–20)	PCS complete	40 (30–56)	74 (49–92)	58 (42–70)
+ PCS complete	38 (14–48)	58 (49–70)	44 (32–62)	+ ACS complete	14 (5–17)	13 (6–18)	9 (2–12)
Cumulative medialization, mm							
Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)	Opening of linea alba	26 (23–30)	29 (28–33)	24 (16–28)
Retro-rectus dissection	53 (46–62)	55 (51–64)	42 (28–49)	Retro-rectus dissection	53 (46–62)	55 (51–64)	42 (28–49)
External oblique release	59 (49–68)	62 (54–76)	49 (31–59)	Transverse muscle release	67 (55–86)	87 (70–105)	62 (43–73)
ACS dissection	63 (52–76)	69 (60–88)	55 (35–69)	PCS dissection	93 (75–117)	129 (100–156)	100 (71–119)
+ Transverse muscle release	77 (60–94)	95 (80–121)	72 (47–93)	+ External oblique release	102 (79–129)	134 (102–165)	105 (72–127)
+ PCS dissection	101 (66–125)	127 (109–158)	100 (67–131)	+ ACS dissection	106 (81–134)	142 (106–174)	109 (73–131)

Median and interquartile ranges are given.
ACS, anterior component separation; *LA*, lower abdomen; *MA*, middle abdomen; *PCS*, posterior component separation; *UA*, upper abdomen.

Table IV
Percentage of total medialization (%)

	Anterior rectus sheath			Posterior rectus sheath		
	LA	MA	UA	LA	MA	UA
ACS first						
Retro-rectus dissection	34%	26%	41%	36%	27%	24%
External oblique release	30%	27%	24%	8%	6%	9%
ACS dissection	21%	31%	20%	6%	8%	8%
+ Transverse muscle release	6%	8%	11%	18%	26%	22%
+ PCS dissection	9%	7%	5%	32%	33%	36%
ACS complete	51%	59%	43%	14%	14%	18%
+ PCS complete	15%	15%	16%	50%	59%	58%
PCS first						
Retro-rectus dissection	40%	34%	41%	34%	24%	21%
Transverse muscle release	18%	16%	17%	18%	28%	24%
PCS dissection	10%	12%	10%	31%	37%	44%
+ External oblique release	23%	26%	18%	12%	5%	7%
+ ACS dissection	10%	11%	14%	5%	7%	4%
PCS complete	27%	29%	27%	49%	65%	68%
+ ACS complete	33%	38%	32%	17%	12%	11%

ACS, anterior component separation; *LA*, lower abdomen; *MA*, middle abdomen; *PCS*, posterior component separation; *UA*, upper abdomen.

15%, and 16% (lower abdomen to upper abdomen) of total medialization obtained after combined CST. For the posterior rectus sheath, additional PCS after ACS provided 50%, 59%, and 58% (lower abdomen to upper abdomen) of total medialization obtained after combined CST.

Medialization by additional ACS after PCS

Obtained medialization is summarized in Tables III and IV, and proportional medialization is visually presented in Figure 6. For the anterior rectus sheath, additional ACS after PCS provided

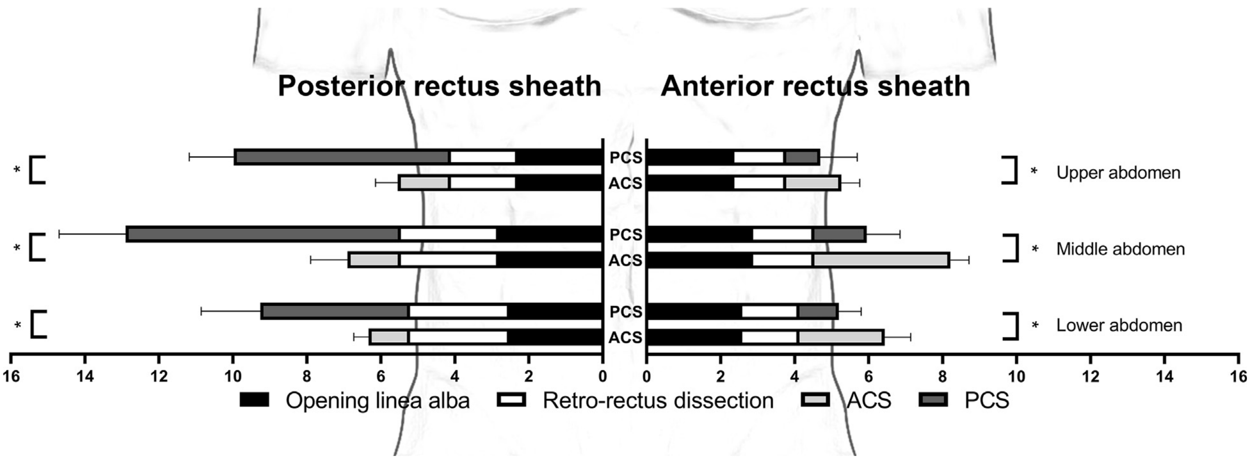

Fig 5. Medialization of the anterior and posterior rectus sheath, ACS versus PCS. *statistically significant (*P* value < 0.05). *ACS*, anterior component separation; *PCS*, posterior component separation. X-axis in cm.

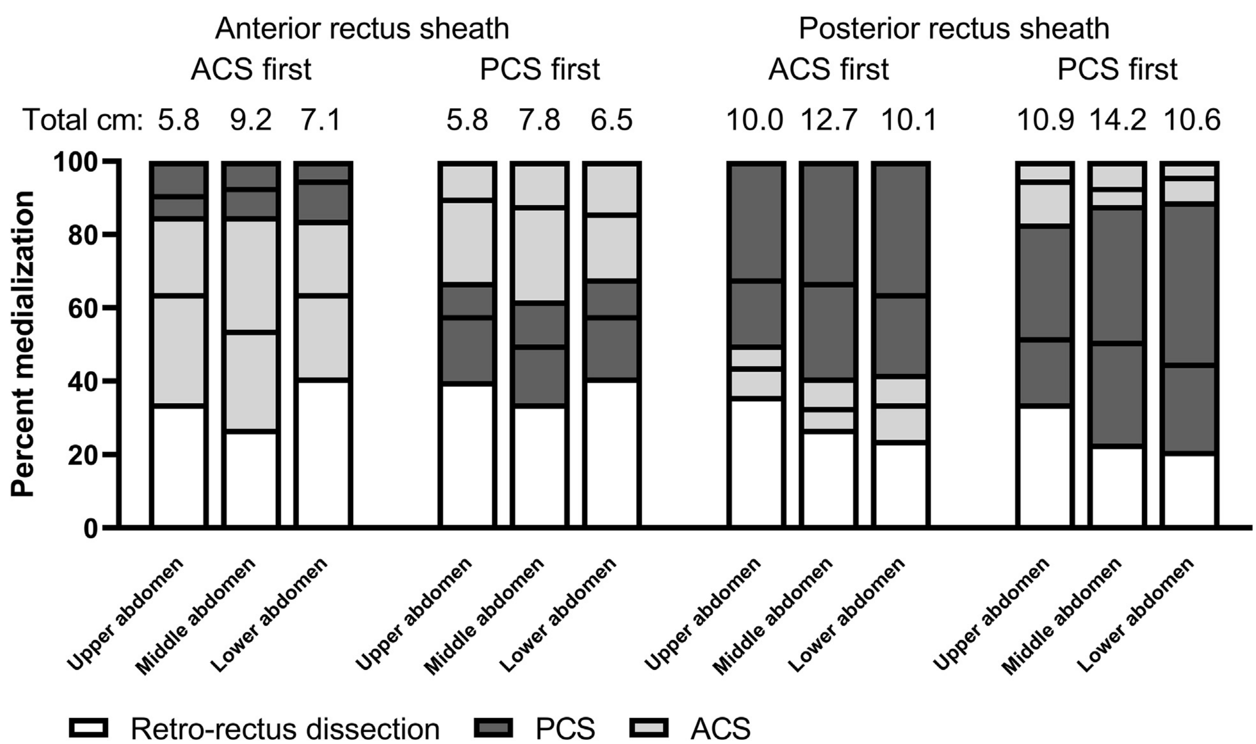

Fig 6. Proportional medialization for each surgical phase. The first section of the columns corresponding to ACS/PCS represents muscle release, and the second part represents intermuscular dissection. Proportions are relative to total medialization after combined ACS and PCS. *ACS*, anterior component separation; *PCS*, posterior component separation.

33%, 38%, and 32% (lower abdomen to upper abdomen) of total medialization obtained after combined CST. For the posterior rectus sheath, additional ACS after PCS provided 17%, 12%, and 11% (lower abdomen to upper abdomen) of total medialization obtained after combined CST.

Discussion

This anatomical-biomechanical study was the first to evaluate medialization of the anterior and posterior rectus sheath after simultaneous ACS and PCS. Additionally, medialization of each surgical step (ie, release of the external oblique and/or transversus abdominis muscle and dissection of intermuscular planes) was assessed. Moreover, the methodology of assessing medialization after component separation was improved because the same procedure was performed in a different sequence, allowing for correction of small differences between the 2 abdominal sides.

Combined ACS and PCS resulted in further medialization when compared with ACS or PCS alone. However, ACS after PCS mainly improved medialization of the anterior rectus sheath (32%–38%) and provided little further medialization for the posterior rectus sheath (11%–17%). The opposite effect was found for PCS after ACS, which resulted in substantial further medialization of the posterior rectus sheath and only marginal further medialization of the anterior rectus sheath. When comparing different procedural steps, retro-rectus dissection in itself is

Table V
PCS versus ACS

	M. transversus abd. release	M. obliquus ext. release	*P*
Anterior rectus sheath			
Lower abdomen	7 (4–13)	14 (11–18)	.285
Middle abdomen	8 (7–15)	17 (14–21)	.009
Upper abdomen	6 (3–14)	8 (7–11)	.445
Posterior rectus sheath			
Lower abdomen	14 (9–25)	6 (3–6)	.037
Middle abdomen	32 (19–41)	6 (3–12)	.007
Upper abdomen	20 (14–24)	7 (2–10)	.005
	PCS dissection	ACS dissection	*P*
Anterior rectus sheath			
Lower abdomen	4 (3–5)	10 (5–12)	.045
Middle abdomen	6 (4–8)	20 (12–21)	.027
Upper abdomen	3 (3–5)	7 (4–9)	.017
Posterior rectus sheath			
Lower abdomen	25 (20–31)	5 (3–8)	.007
Middle abdomen	42 (31–51)	7 (6–12)	.005
Upper abdomen	38 (28–46)	6 (5–10)	.005
	PCS complete	ACS complete	*P*
Anterior rectus sheath			
Lower abdomen	11 (6–17)	23 (16–30)	.005
Middle abdomen	14 (11–23)	37 (26–42)	.005
Upper abdomen	9 (6–19)	15 (11–20)	.005
Posterior rectus sheath			
Lower abdomen	40 (30–56)	10 (6–14)	.005
Middle abdomen	74 (49–92)	14 (9–24)	.005
Upper abdomen	58 (42–70)	14 (7–20)	.005

Median and interquartile range is given.
ACS, anterior component separation; *PCS*, posterior component separation.
Measurements in mm.

essential in terms of proportional medialization, contributing up to 41% of maximum obtainable medialization. Within a CST procedure, both the muscle release and intramuscular dissection provided approximately half of the total contribution of CST. When comparing ACS to PCS, ACS provided superior medialization of the anterior rectus sheath and PCS of the posterior rectus sheath. However, failure to obtain sufficient medialization of the posterior rectus sheath is rare. After PCS the posterior rectus sheath does not add much strength to the reconstruction but primarily serves as barrier between the large retro-muscular mesh and the viscera.

Current results appear comparable to a previous study by our research group.[9] The recent study of Majumder et al[10] reported slightly different results. Overall, medialization reported in this study was higher compared with current analysis; however, in this study, medialization after opening of the linea alba was higher as well. Potentially, differences in measurement methodology or the research sample at hand were present. In the current study, nearly all available specimens were of small size, which could contribute to the observed lower medialization. In the current study, median body mass index (BMI) was 19.7 kg/m^2 versus a BMI ranging between 25 until 35 kg/m^2 in the study by Majumder et al.[10] Additionally, in this previous study, mean values instead of median values were used; high outliers may have a large effect on mean values in small samples. The difference may therefore be explained by differences in methodology, data analysis, and potential inclusion of larger specimens. With reference to the comparison between ACS and PCS, PCS showed superior medialization (nonsignificant) on the anterior and posterior rectus sheath in the study by Majumder et al.[10] We were not able to reproduce the latter results.

The effect of component separation in anatomical studies appears to be relatively minor compared with the subjective experience in clinical practice. Medialization might be higher during surgery under general anesthesia as a result of muscle relaxation. However, relative proportional effects and comparison of techniques may be less influenced by this limitation of an anatomical study.

In a case series of 12 patients, Lopez-Monclus et al[11] first performed PCS followed by ACS owing to inability to obtain tension-free closure after PCS alone. In this study, favorable outcomes were reported with low rates of major complications and occurrence of bulging in only 1 patient. In this series, 2 meshes were implanted, a polypropylene (50 × 50 cm) mesh in combination with an absorbable (20 × 30 cm) mesh, both placed in the preperitoneal plane. This series proved that a combined CST approach is possible for patients with an extreme diameter hernia. However, it is questionable whether sacrificing both the external oblique muscle and the transverse abdominis muscle, leaving only the internal oblique muscle intact, provides sufficient medialization to justify this procedure routinely or in physically active patients. Combined CST could be helpful when after PCS additional medialization of the anterior rectus sheath is required as described by Lopez-Monclus et al.[11] Instead of combined CST, another option, which is currently routinely used, is the usage of the in situ halves of the hernia sac or placement of a bridging mesh. In the rare occasion that one would fail to close the posterior rectus sheath after ACS, a resorbable bridging mesh would be another clinical option. One disadvantage of ACS, if performed ‘open’, is the large subcutaneous dissection required for this procedure, which could result in an increased risk of surgical site occurrences. Potentially, a sequential procedure is justified, intra-operatively retro-rectus dissection can be performed first, and, depending on the remaining gap between the left and right anterior rectus sheath, either ACS or PCS may be performed.

Limitations

This study has several limitations. Although performing this study and measuring the yielded medialization is only possible using postmortem human specimens, tissue characteristics differ after death from in vivo tissue. This may primarily limit the external validity of the study. Given conditions for all specimens were equal, relative, proportional differences and comparisons between techniques remain valid. Additionally, the study design allowed for comparison of the 2 hemi-abdomens in each specimen and correction for small differences between the 2 sides during data-analysis. Therefore, the internal study validity is high. Due to the inclusion of mainly small specimens, total medialization reported in this study may represent an underestimation of actual medialization in the average hernia patient. This is accentuated by the larger medialization found by the previous study of Majumder et al,[10] including, on average, larger specimens. It may be noted that the measurement points for the upper and lower abdomen were placed halfway between the umbilicus and, respectively, the xyphoid process and pubic bone. This may be too close to the umbilicus to show the profound reduction in medialization that would clinically be expected in the proximity of the xyphoid process or pubic bone.

In conclusion, ACS provided the most medialization of the anterior rectus sheath and PCS provided the most medialization of the posterior rectus sheath. Combined CST only provides marginal additional medialization. Clinical use of this technique should be carefully balanced against potential additional risks.

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Conflict of interest/Disclosure

There are no conflicts of interest to declare related to this submitted work.

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