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REVIEW

A meta-analysis comparing open anterior component separation with posterior component separation and transversus abdominis release in the repair of midline ventral hernias

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Abstract

Purpose This study aims to compare the outcomes of posterior component separation and transversus abdominis release (PCSTAR) with the open anterior component separation (OACS) technique. OACS, first described by Ramirez et al. (Plast Reconstr Surg 86(3):519–526, 1990), has become an established technique for local myofascial advancement in abdominal hernia surgery. PCSTAR, described by Novitsky et al. (Am J Surg 204(5):709–716, 2012), is being used more frequently and is rapidly becoming the technique of choice in complex ventral hernia repair.

Methods Analysis was conducted according to PRISMA guidelines. A systematic search of the MEDLINE, EMBASE and Pubmed databases was performed. Studies reporting exclusively on midline ventral hernia repair were reviewed. Studies describing PCSTAR were selected and compared to matched studies describing OACS. Meta-analysis was used to compare outcomes between the two-pooled groups.

Results Seven studies describing 281 cases of PCSTAR for midline incisional hernia using a retromuscular mesh placement were identified. Six comparable studies describing 285 cases of OACS and retromuscular mesh placement were identified from the same search. Pooled analysis demonstrated a hernia recurrence rate of 5.7% (3.0–8.5) for PCSTAR and 9.5% (4.0–14.9) for OACS. Comparative analysis demonstrated no significant difference between hernia recurrence rate ($p=0.23$). The use of bridging mesh was not significantly reduced by the use of PCSTAR (3.1%) when compared to ACS (7.5%) ($p=0.22$). No significant difference was found in wound complication rates between PCSTAR and OACS, respectively, 'superficial' 10.9 vs 21.6% ($p=0.15$); and 'deep' 9.5 vs 12.7% ($p=0.53$).

Conclusions These data suggest PCSTAR have comparable outcomes to OACS. This analysis is limited by the lack of comparative studies and heterogenicity in the OACS group.

Keywords Abdominal wall reconstruction · Anterior component separation · Posterior component separation · Transversus abdominis release

Introduction

The field of ventral hernia surgery and complex abdominal wall reconstruction has developed rapidly over the last 20 years. The principle of anatomical restoration to achieve a sound, tension-free, mesh-reinforced hernia repair has been shown to improve short-term complication rates and long-term hernia recurrence compared to a bridging mesh [1–4]. It is often difficult to restore the rectus sheath in the midline in large abdominal wall defects particularly if there is significant loss of domain.

To help achieve anatomical restoration Ramirez et al. first described the technique of open anterior component separation (OACS) in 1990 [5]. The team performed dissection of the abdominal wall in 10 cadavers where the anterior subcutaneous fat was dissected from the rectus sheath to expose the linear semi-lunaris. The external oblique was then separated from the internal oblique to allow lateral mobilization of the rectus sheath, and restoration in the midline. This

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technique allowed for an additional 5 cm of lateral muscle mobilization in the upper abdomen and 10 cm in the lower abdomen. A case series of 11 patients was described where the technique was used to good effect [5]. The use of local myofascial advancement has minimized the need for distant fascia lata or anterolateral thigh flap, which are associated with greater morbidity [6].

Over the years, it was observed that there were a number of problems arising as a result of the OACS technique. Subcutaneous dissection was associated with seromas, wound infections and abscess formation. These complications were reduced by the use of minimally invasive anterior component separation, such as perforator sparing or endoscopic techniques, but these techniques are not possible in all cases. The lateral area, where the external oblique has been divided, can develop a bulge or lateral abdominal wall hernias, and once performed there is no possibility of further anterior component separation should the hernia recur. The use of mesh reinforcement has also been described along with OACS and their use in combination is thought to be safe and recommended in current guidelines in certain situations, such as significant loss of domain [7]. Recurrences rates of this technique range from 9 to 18% [8, 9].

Novitsky et al. first described the posterior component separation and transversus abdominis muscle release (PCSTAR) in 2012 [10]. This technique utilized the retromuscular space, accessed by incising the posterior rectus sheath and dissecting the posterior sheath back to the transversus abdominal muscle. The muscle was then divided along the length of the medial border to access the space between the muscle and transversalis fascia. The dissection was then continued laterally round to the psoas muscle to allow maximum mobilization. Similar levels of fascial advancement were achieved whilst avoiding subcutaneous tissue dissection and allowing preservation of a retromuscular space for mesh placement.

PCSTAR is rapidly becoming the technique of choice for local myofascial advancement in complex ventral hernia repair. This study aims to compare the outcomes of PCSTAR with OACS and establish if one technique is better across a range of reported outcomes including short-term complications and hernia recurrence.

Methods

Search strategy and terms

The study was conducted according to the PRISMA guidelines. MEDLINE, EMBASE and Pubmed database searches were carried out to identify all papers reporting on outcomes of midline ventral hernia repair using "component separation" techniques. The search term "component separation" was used. The reference lists of all related studies were reviewed and relevant papers were included.

Inclusion criteria

Studies reporting exclusively on outcomes from midline ventral hernia repairs utilizing component separation techniques from 1990 onwards were included. Outcomes of studies describing PCSTAR in conjunction with retromuscular mesh placement were identified. Studies describing OACS using only retromuscular mesh placement were identified and matched to the included PCSTAR studies post hoc by comparing demographics. Only studies published in English and investigating human subjects were included.

Exclusion criteria

Studies that included outcomes from non-midline hernia repairs (for example, lateral abdominal wall and parastomal) were excluded. Studies were excluded if they described cohorts that included some patients who did not have component separation techniques used as part of their hernia repair. Studies describing minimally invasive anterior component separation and/or non-retromuscular mesh placement (e.g. onlay mesh placement) were excluded. Outcomes of paediatric cohorts and case series reporting less than or equal to 5 cases were excluded. Review articles, conference abstracts, discussion articles and commentaries were excluded. Non-human, cadaveric and basic science studies were also excluded.

Data collection

The search results were assessed and titles screened by the first reviewer (JDH). Papers were assessed by two independent reviewers (JDH and CAL) according to the inclusion and exclusion criteria. Included papers were assessed using the Methodological Index for non-randomized studies (MINORs) tool and the Downs and Blacks checklist for non-randomized study assessment [11, 12]. Data were extracted by the first reviewer and cross-checked independently by the second reviewer. Agreement on included papers and extracted data was reached following discussion between reviewers. It was noted that the majority of the papers describing PCSTAR were published from the same institution. To ensure there was no significant overlap in patients included in the cohorts, we contacted the corresponding author who informed us there was minimal overlap (< 10 patients) between two of the studies [14, 15] and studies [15] and [16]. There was no overlap between studies [14] and [16]. Based on this additional information the decision was made to include all the identified papers in the analysis.

Data extraction

Data were extracted for study demographics (population, study year, study design, sample size), patient demographics (sex, age, BMI, diabetes, smoking status), hernia details (defect size, number of previous hernia repairs, presence of contamination), operative details (type of repair, use of mesh, use of bridging mesh, use of component separation), post-operative complications (length of stay, recurrence of hernia, wound-related morbidity, mortality), and average follow-up. Data from the included studies were stored in

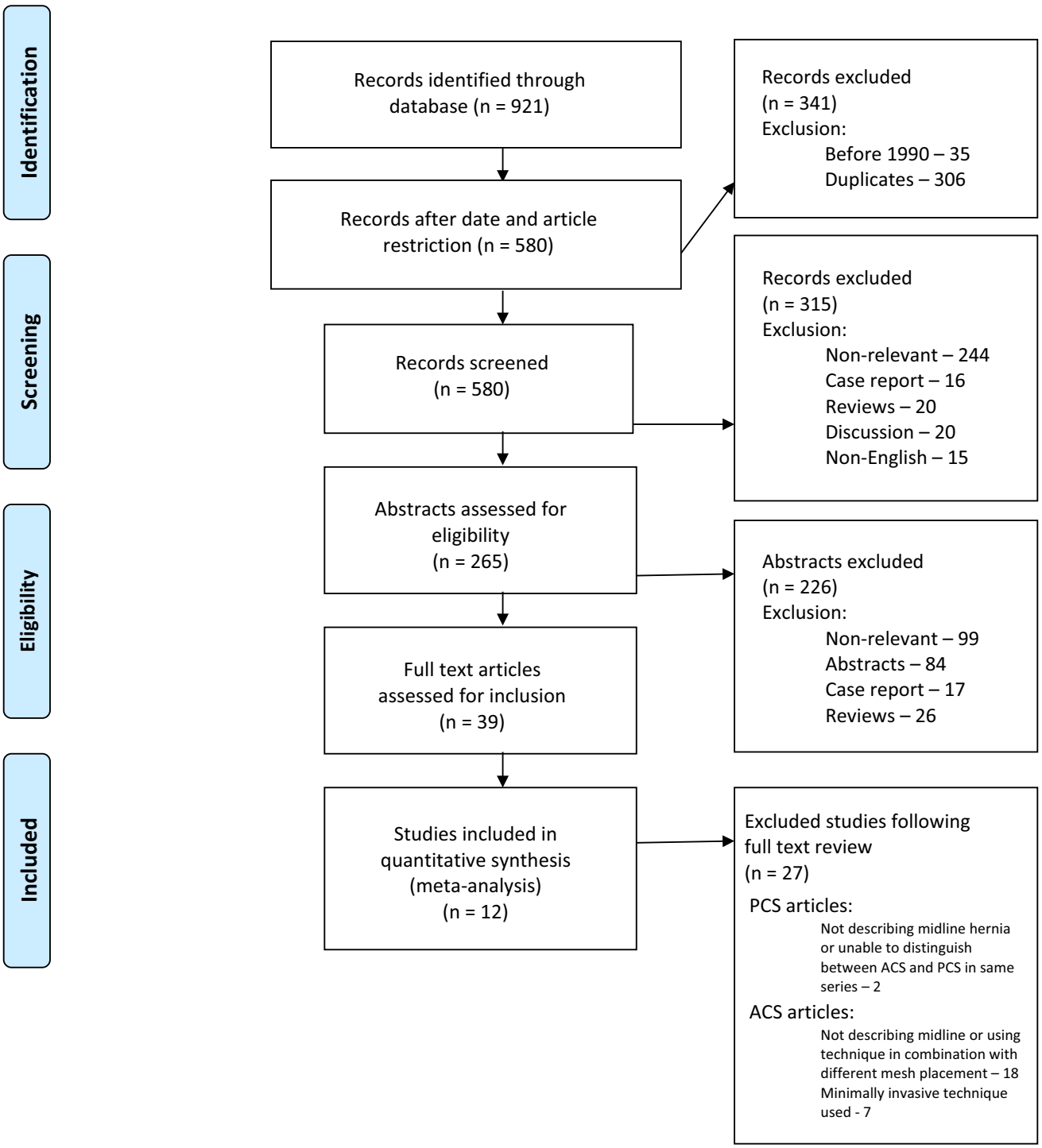

Fig. 1 A PRISMA flowchart demonstrating study selection

Table 1 Demonstration of included papers and study quality divided by study type (top—comparative study; middle—PCSTAR only; bottom—OACS only)

Title	Author	Publication year	Study type	Patient number	Mesh used		Year	MINORs	D&B's
					Biologic	Synthetic			
Posterior and open anterior components separations: a comparative analysis [13]	Krpata et al.	2012	Prospective database comparative cohort, single centre	111	61	50	2006–2011	9	12
Initial UK experience with transversus abdominis muscle release for posterior components separation in abdominal wall reconstruction of large or complex ventral hernias: a combined approach by general and plastic surgeons [18]	Appleton et al.	2016	Retrospective, cohort, single centre	12	9	3	2013–2014	11	14
Outcomes of retromuscular porcine biologic mesh repairs using transversus abdominis release reconstruction [17]	Fayezizadeh et al.	2016	Prospective database, cohort, single centre	77	77	0	2007–2014	11	16
Repair of massive ventral hernias with "quilted mesh" [16]	Posielski et al.	2015	Prospective database, cohort, single centre	32	0	32	NR	9	15
Posterior component separation and transversus abdominis muscle release for complex incisional hernia repair in patients with a history of an open abdomen [15]	Petro et al.	2015	Prospective database, cohort, single centre	29	15	19	2011–2013	9	16
Posterior component separation with transversus abdominis release successfully addresses recurrent ventral hernias following anterior component separation [14]	Pauli et al.	2015	Prospective database, cohort, single centre	55	5	24	2006–2011	9	15
Transversus abdominis muscle release: a novel approach to posterior component separation during complex abdominal wall reconstruction [10]	Novitsky et al.	2012	Retrospective, cohort, single centre	42	0	42	2006–2009	10	13
Total abdominal wall reconstruction with component separation, reinforcement, and ventral abdominoplasty in patients with complex ventral hernias [19]	Espinosa et al.	2016	Retrospective, cohort, single centre	58	NR	NR	2010–2014	8	13
Outcome in porcine acellular dermal matrix reinforcement of infected abdominal wall defects: a prospective study [20]	Zerbib et al.	2015	Prospective database, cohort, single centre	18	18	0	2010–2012	10	15
Comparison of synthetic and biologic mesh in ventral hernia repair using components separation technique [21]	Sandvall et al.	2014	Retrospective, cohort, single centre	72	45	27	2006–2010	9	14

Table 1 (continued)

Title	Author	Publication year	Study type	Patient number	Mesh used		Year	MINORs	D&B's
					Biologic	Synthetic			
Component separation with porcine acellular dermal reinforcement is superior to traditional bridged mesh repairs in the open repair of significant midline ventral hernia defects [22]	Richmond et al.	2014	Retrospective, cohort, single centre	40	40	0	2006–2012	10	15
Indications and outcomes following complex abdominal reconstruction with component separation combined with porcine acellular dermal mesh reinforcement [23]	Patel et al.	2011	Retrospective, cohort, single centre	41	41	0	2007–2011	9	15

NR not reported

an Excel spreadsheet (Microsoft, Redmond, Washington, USA).

Statistical analysis

Statistical analysis was performed using SPSS (IBM Analytics, New York, USA). Pooled data were analysed for anterior and posterior component separation for outcome including hernia recurrence, use of bridging mesh, wound complications (superficial, deep), re-operation and length of stay. I^2 values were calculated to determine heterogeneity. Student *t* test, Chi-squared and Mann–Whitney *U* tests were used to test for statistically significant differences between groups.

Results

A database search identified 921 studies. Papers published before 1990 (the year "component separation" was first described) were excluded and duplicates were removed leaving 580 studies. Three hundred and fifteen studies were excluded following title review, and a further 226 were removed following assessment of abstracts. The resulting 39 articles were reviewed in full and a further 27 were excluded according to the criteria. This resulted in the inclusion of 12 studies: one study comparing outcomes of posterior and anterior component separation [13], six discussing posterior component separation only [10, 14–18], and five discussing anterior component separation only [19–23]. In total, 12 studies were assessed for quality and included in the meta-analysis (Fig. 1 and Table 1). Assessment of the quality of included studies revealed there were no ideal studies. Scores ranging from 8 to 11 on MINORs and 12–16 on Downs and Black were seen. Studies lost marks on both scores, primarily as a result of the lack of comparative data, lack of prospective data collection or sample size calculation and comparative statistics.

There were no randomized trials or prospective controlled studies of the two techniques. Only one paper, utilizing a prospectively maintained database, compared the two techniques directly [13]. Of the papers describing PCSTAR, four also utilized prospectively maintained databases to identify the cohort [14–17] and the remaining two describe retrospective cohorts [10, 18]. Of the papers describing OACS, one uses a cohort from a prospectively maintained database [20] and four describe retrospective cohorts [19, 21–23].

Pooled data for 281 patients who received PCSTAR are demonstrated in Table 2. Heterogeneity across these papers for all outcomes, except for length of stay was not significant. The heterogeneity seen for length of stay is likely due to the fact only three papers reported on this finding. Pooled hernia recurrence rate was found to be 5.7% (CI 3.0–8.5).

Table 2 Demonstration of pooled data for PCSTAR for all outcomes

Outcome	Number of studies	Heterogeneity		Pooled % (95% CI) $N=281$
		p value	I^2 (%)	
Hernia recurrence	7	0.49	0	5.7% (3.0%, 8.5%)
Wound complications (superficial)	7	0.63	0	10.9% (7.3%, 14.5%)
Wound complications (deep)	7	0.39	5	9.5% (6.0%, 13.0%)
Re-operation	5	0.81	0	3.8% (0.4%, 7.3%)
Bridging mesh	6	0.28	20	3.1% (0.0%, 7.2%)
Length of stay (days)	4	< 0.001	92	7.7 (5.2, 10.2)

Table 3 Demonstration of pooled data for OACS for all outcomes

Outcome	Number of studies	Heterogeneity		Pooled % (95% CI) $N=285$
		p value	I^2 (%)	
Hernia recurrence	6	0.05	56	9.5% (4.0%, 14.9%)
Wound complications (superficial)	5	< 0.001	89	21.6% (7.4%, 35.8%)
Wound complications (deep)	3	0.17	43	12.7% (3.4%, 22.1%)
Re-operation	4	0.56	0	5.9% (2.0%, 9.8%)
Bridging mesh	6	0.02	63	7.5% (1.7%, 13.4%)
Length of stay (days)	3	0.10	56	9.0 (5.3, 12.8)

Table 4 Pooled data comparing patient demographics of studies of PCSTAR with OACS

Patient demographics	PCSTAR $N=281$	OACS $N=285$	p value
Sex male (%)	49.8	39.3	0.03
Age (years) (mean, SD)	56.14 (3.2)	57.23 (2.95)	0.54
BMI (mean, SD)	34.8 (3.05)	35.75 (1.61)	0.58
Defect size (cm^2) (mean, SD)	457.42 (158.74)	355.17 (185.11)	0.61
Number previous hernia repair (%)	90.1	63.4	< 0.001
Diabetes (%)	30.1	38.0	0.06
Smoker (%)	16.7	20.7	0.26
Pre-operative contamination (VHWG grade 3/4) (%)	34.1	47.4	0.01
Mortality (%)	0.0	0.01	0.87
Median follow-up (mths, IQR)	18 (9–26)	14 (12–20)	1.00

It can be seen that there are significantly more contaminated wounds in the OACS group and more patients who have had a previous hernia repair in the PCSTAR group. No other difference in the two groups was statistically significant

Pooled data for 285 patients who received OACS are demonstrated in Table 3. Heterogeneity across these papers was significant for all outcomes. This is likely the result of the widespread use of this technique for abdominal wall reconstruction resulting in varying hernia grades and patient comorbidity. The pooled hernia recurrence rate was found to be 9.5% (CI 4.0–14.9).

Pooled data for patient demographics were analysed and compared between the PCSTAR and OACS groups (Table 4). There was no statistically significant difference between the patient mean age, mean BMI, mean defect size, diabetes, the presence of pre-operative contamination, mortality and average follow-up. The PCSTAR group had significantly more male patients and more who had previous hernia repairs. The OACS group had significantly more patients with wound contamination at the time of surgery. Results from the meta-analysis of the outcome data can be found in Table 5 and forest plots comparing the outcomes in Fig. 2. No statistically significant difference between the two techniques was seen across any of the observed outcomes.

Table 5 Demonstration of the meta-analysis of outcomes comparing PCSTAR with OACS

Outcome	Difference % (95% CI)	*p* value
Hernia recurrence	− 3.7% (− 9.8%, 2.4%)	0.23
Wound complications (superficial)	− 10.7% (− 25.3%, 3.9%)	0.15
Wound complications (deep infection)	− 3.2% (− 13.2%, 6.8%)	0.53
Re-operation	− 2.1% (− 7.3%, 3.2%)	0.44
Bridging mesh	− 4.4% (− 11.5%, 2.7%)	0.22
Length of stay	− 1.3 (− 5.8, 3.2)	0.57

Difference was calculated by subtracting OACS from PCSTAR. A negative value implies favouring PCSTAR; however, no significant difference was seen for any outcome

Discussion

These data demonstrate that PCSTAR has comparable outcomes with OACS across a number of key outcomes relevant to hernia surgery. No statistical difference in outcomes between the two groups was observed, to favour one technique over the other. The use of bridging mesh was also comparable implying a similar amount of fascial medialisation can be achieved with the two techniques.

Comparing the difference between the two groups demonstrates that there is no statistically significant difference between the two, in most of the measured patients' demographic markers. The only differences observed were in number of previous hernia repairs (more in the PCSTAR group) and pre-existing wound contamination (more in the OACS group). Although this method of comparing the two groups is not ideal, the fact they are comparable across a number of pre-operative factors that are known risk factors for hernia recurrence aids the meta-analysis.

The lack of comparative studies and randomized trials makes direct comparison between the two groups difficult. In addition to this, the inherent heterogeneity in the OACS group makes it hard to draw a robust conclusion from these data. Given PCSTAR is a relatively new technique this is the first attempt in the literature that has been made to compare this procedure with the more established OACS. The heterogeneity observed in the PCSTAR group is minimal. It could be argued that this is a result of some overlap of patients between studies. Given that this overlap was confirmed as only of a few patients in two studies, it is felt this would unlikely lead to a statistically significant result. This, therefore, aids the comparison and is reassuring that the outcomes in this group are likely to be consistent. Every effort to minimize heterogeneity in the OACS group has been made by trying to standardize the remaining elements of the procedure including midline incision and site of mesh placement. Nevertheless, given this technique is widely used it is likely a comparison of outcomes across 285 patients will give a good estimate of the potential outcomes of this technique as a whole. We believe this is because it is used across a patient group with significant inherent heterogeneity, and the observed rates in our study for all measured outcomes were comparable with other published studies for OACS outcomes [24].

At the very least, these data suggest PCSTAR is as safe as OACS with comparable levels of hernia recurrence. Superficial wound complications trended towards favouring PCSTAR. OACS is acknowledged to have issues relating to wound complications and various minimally invasive and "perforator sparing" methods have been described and have been found to reduce the incidence of wound morbidity in direct comparison of the two techniques [25–27]. Given PCSTAR was only performed via midline laparotomy in the included studies, studies investigating outcomes from minimally invasive OACS were excluded from the analysis. Despite this, a significant amount of heterogeneity in wound outcomes from OACS was seen.

The only paper included in the analysis that directly compares the two techniques comes from the group who developed PCSTAR [13]. They retrospectively compared the outcomes from these two procedures, with 56 OACS and 55 PCSTAR patients. They attempt to make the groups comparable by measuring the difference between a range of pre-operative factors. Defect size, smoking, contamination, number of previous hernia repairs and abdominal surgeries were comparable. Other factors such as age, sex, BMI and diabetes were significantly different between the two groups. It was found that recurrence rates were comparable, possibly trending to favour PCSTAR. It reported significantly better rates of wound complications in the PCSTAR group; however, they also noted that the OACS group had significantly more patients with pre-existing wound infection and diabetes, two key risk factors for this complication [28]. This method of retrospectively comparison is not ideal and a prospective controlled cohort comparison would be the best way of ensuring the comparison was valid.

A randomized controlled trial or a comparative controlled trial to create comparable groups to assess these techniques would be recommended. The inherent difficulty in finding comparable patients in the field of abdominal wall reconstruction includes the range of ventral hernia working group grades, range of other operative factors, such as mesh type, and the range of potential comorbidities in this patient group. A simple sample size calculation to compare just these two factors would require 438 patients, in each group, to establish statistical significance for hernia recurrence (assuming a 95% CI; 80% power; rates of 10% for OACS and 5% for PCSTAR) and 197 patient for superficial wound complications (assuming a

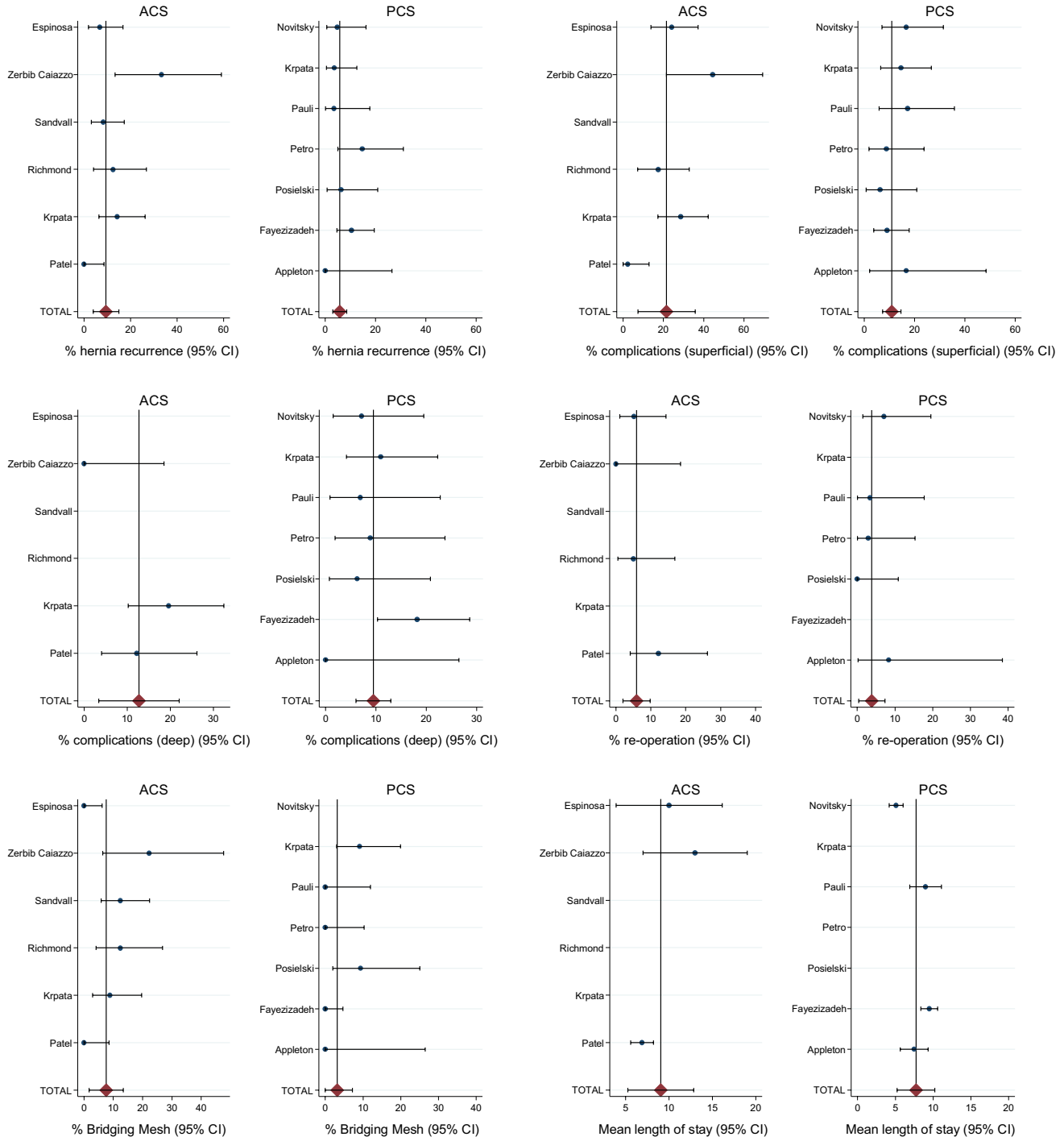

Fig. 2 Forest plots demonstrating a comparison of the observed outcomes and pooled results

95% CI; 80% power; rates of 20% for OACS and 10% for PCSTAR). These numbers would only be achievable by an international multi-centre collaboration. Alternatively, analysis of a large hernia-specific outcome registry, such as the Americas Hernia Society Quality Collaborative or the European Registry of Abdominal Wall Hernias, may give some insight into 'real life' outcomes. The main drawbacks in the use of large-scale registry data include selective reporting and the reliability of long-term follow-up.

Conclusion

Posterior component separation with transversus abdominis release and open anterior component separation have comparable outcomes for complex abdominal wall reconstruction of midline ventral/incisional hernias. The lack of directly comparable data limits scope of any significant conclusions but no previous attempt has been made to establish the relative outcomes of these two procedures. Future controlled comparative trials are recommended to explore the conclusions more accurately as well as standardization of outcome measures, particularly in reporting wound morbidity. PCSTAR is a useful addition to the surgeon's armamentarium.

Author contributions Jonathan Hodgkinson helped design the study, acquired and interpreted the data, drafted and approved the final manuscript; Cosimo Leo helped acquire and interpret the data, drafted and approved the final manuscript; Yasuko Maeda interpreted the data, drafted and approved the final manuscript; Paul Bassett and Siddhartha Oke helped interpret the data, drafted and approved the final manuscript; Carolynne Vaizey contributed to the study design and concept, revised the critically important intellectual content and approved the final manuscript; Janinadra Warusavitarne contributed to the study design and concept, revised the critically important intellectual content and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest JDH declares no conflict of interest; CAL declares no conflict of interest; YM declares no conflict of interest related to the submitted work and declares personal fees from Medtronic and Astellas; PB declares no conflict of interest; SO declares no conflict of interest; CV declares no conflict of interest directly related to the current work and declares consultancy advisor to Acelity and paid lecture for Allergan; JW declares no conflict of interest.

Ethical approval This study did not need approval from an ethic committee.

Human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was not required for this type of study.

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