Fascia Suture Technique and Suture-mediated Closure Devices: Systematic Review

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Abstract

Keywords

- ▶ suture-mediated closure devices
- ▶ Prostar XL
- ▶ Proglide system
- ▶ fascia suture technique
- ▶ percutaneous endovascular aortic aneurysm repair
- ▶ femoral access
- ▶ complications

Background The aim of the present study is to review the available data on suture-mediated closure devices (SMCDs) and fascia suture technique (FST), which are alternatives for minimizing the invasiveness of percutaneous endovascular aortic aneurysm repair (p-EVAR) and reduce the complications related to groin dissections.

Methods The Medline, ClinicalTrials.gov, and Cochrane library – Cochrane Central Register of Controlled Trials (CENTRAL) databases were searched for publications regarding SMCD and FST between January 1999 and December 2016.

Results We review 37 original articles, 30 referring to SMCDs (Prostar XL and Proglide), which included 3,992 patients, and 6 articles referring to FST, which include 426 patients. The two techniques are compared only in one article (100 patients). The two types of SMCDs were Prostar and Proglide. In most studies on SMCDs, the reported technical success rates were between 89 and 100%, but the complication rates varied greatly between 0 and 25%. Concerning FST, the technical success rates were also high, ranging between 87 and 99%. However, intraoperative complication rates ranged between 1.2 and 13%, whereas postoperative complication rates varied from 0.9 to 6.2% for the short-term and from 1.9 to 13.6% for the long-term.

Conclusions SMCDs and FST seem to be effective and simple methods for closing common femoral artery (CFA) punctures after p-EVAR. FST can reduce the access closure time and the procedural costs with a quite short learning curve, whereas it can work as a bailout procedure for failed SMCDs suture. The few failures of the SMCDs and FST that may occur due to bleeding or occlusion can easily be managed.

During the last decade, percutaneous endovascular aortic aneurysm repair (p-EVAR) has been an attractive minimally invasive technique in a selected group of patients with aortic anatomy suitable for endografting. Traditionally, endovascular aortic aneurysm repair using the cut-down surgical approach (s-EVAR) was preferred, mostly owing to the large sheath sizes of the early devices.^{1–5} However, as a result of

the exposure of the common femoral arteries (CFAs), local groin wound complications were common in the postoperative period.^{6–13} To minimize its invasiveness and reduce the complications related to groin dissections, some surgeons developed alternative access techniques.

Fascia suture technique (FST)^{14,15} has gained field the last years as an alternative option for covering the common

femoral artery (CFA) after p-EVAR. In 1997, Diethrich¹⁴ and, several years later, Larzon et al¹⁵ were the pioneers, who described the method as minimal access suture technique of the cribriform fascia “fascia closure”; however, it is still not widely adopted.

An alternative surgical option that has been described after the recent advances in stent graft technology (reduction of stent-graft delivery profile) refers to suture-mediated closure devices (SMCDs).^{16,17} Perclose Prostar XL (Abbott Vascular, Redwood City, CA) is the main device available for percutaneous closure of large bore arterial access sheath. Although, Prostar XL was the only device with formal approval for use in EVAR, several authors have used the Proglide system (Abbott Vascular, Redwood City, CA) off-label in daily clinical practice until April 2013.^{18,19} Thereafter, the Proglide system is approved for 5 F to 21 F closure, with double Proglide use required for larger than 8 F sheaths.

The primary aim of this article was to determine the efficacy and safety of the FST and SMCDs regarding closing CFA punctures after p-EVAR. All the available data from prospective, retrospective, and randomized controlled trials that reported loco-regional complications have also been evaluated in this systematic review.

Methods

Search Strategy, Data Sources, and Eligibility Criteria

A systematic review was conducted in accordance to the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines. A study protocol was agreed upon and was strictly followed by all authors. Identification of eligible studies was performed using three distinct databases through December 2016: Medline, ClinicalTrials.gov, and Cochrane library – Cochrane Central Register of Controlled Trials (CENTRAL). The following MeSH terms were utilized in various combinations: “Suture-mediated closure devices” and “Fascia Suture Technique.” and the keywords “Percutaneous endovascular aneurysm repair (p-EVAR)” and “Femoral Artery Access Sites.” Moreover, the reference lists of all included articles were examined manually for further references. All studies were independently assessed by two investigators (Georgios Karaolanis and Konstantinos G. Moulakakis), and the full texts of the studies were retrieved.

Studies were included in the present review if:

- They provided results referring to SMCDs that involved only the Prostar XL and/or Proglide closure devices.
- They provided results referred to FST.
- A series of at least 10 patients were studied.

Articles were excluded if:

- They were referring also to other SMCDs other than Prostar XL and/ or Proglide closure devices.
- They provided data of the SMCDs use in other surgical fields other than the vascular.
- Narrative reviews described the FST and the SMCDs without elaboration data.

Prospective, retrospective, and randomized trials were included, but letters, reviews, and non-English language articles were excluded. We sought to review all updates on the subject after the introduction of the FST in the treatment armamentarium.

As primary outcomes, technical success rate and loco-regional complications using both closure techniques (FST/SMCDs) were considered. Secondary outcomes assessed were operative time, hospital stay, and time to ambulation in the SMCDs group. In the FST group, short- (≤ 30 days) and long-term (> 30 days and within 12 months) complications were also classified as secondary outcomes.

Definitions

The definition of technical success was not uniform across all studies in the SMCDs group.^{16–18,20–45} We attempted to standardize technical success as the ability to obtain hemostasis at the access site without the need for surgical cut down. On the other hand, in the FST group, technical success was defined as the achievement of hemostasis with adequate distal perfusion within the first 24 hours without femoral occlusion or use of additional fascial sutures.^{15,46–50} Any complication (bleeding and/or thrombosis) that leads to additional procedure within 24 hours was classified as intraoperative complication, whereas complications, such as bleeding, thrombosis, pseudoaneurysm, stenosis, neuralgia, seroma, and local infection, that took place after 24 hours were considered postoperative.

Fascia Suture Technique

Under general, spinal, or local anesthesia, puncture of the femoral artery just below the inguinal ligament and after its identification either palpably, through duplex or through computed tomography angiography (CTA), is performed. The next step after the completion of any endovascular procedure is the fascia closure. This procedure requires the introducer with the dilator and the guide wire to remain in place. First, the skin incision at the introducer insertion site is extended either transversally by 4 to 8 cm¹⁵ or longitudinally by 3 to 4 cm.⁴⁶ Dissection down, but not through, the femoral fascia follows. Fascia closure is performed either with one stitch (No. 2 PDS absorbable suture) in the fascia on each side of the introducer with the arterial wall intentionally not included in the stitch¹⁵ or with a double U-shaped suture line (No. 2 PDS absorbable suture) on both sites of the lumen of the introducer, as it was recently described.⁵⁰ Subsequently, the sutures are tightened with simultaneous withdrawal of the introducer. When hemostasis is achieved, the guidewire is removed, and the sutures are further tightened. In case of inadequate hemostasis, reinsertion of the introducer is indicated to perform supplementary suturing either through primary fascia suturing or with a superficial Z-shape (Prolene 3–0) suture.⁴⁷ During this step, attention should be paid so that suturing achieves bleeding stoppage without causing narrowing of the vessel. In case of further bleeding, open dissection of the femoral artery and arterial closure is indicated, and this was defined as a technical failure.⁴⁷ A handheld Doppler is used to identify the flow through the

femoral segment.^{15,47} The whole procedure is completed with the skin closure without the use of external compression.

Results

The literature search yielded 1,605 publications (►Fig. 1). After an extensive review, 1568 publications (non-English language, review articles, letter, and correspondences, duplicate or no relevant with the topic) were excluded from subsequent evaluation. Thirty-seven original articles with a total of 4,518 patients were eligible for the present systematic review: 30 referring to SMCD, 6 to FST, and 1 article comparing SMCD with FST.

Study Characteristics

Out of the 30 studies referring to SMCD,^{16–18,20–46} only 2^{17,20} were randomized controlled trials (RCTs) (SMCD with open cut down), and the other 28^{16,18,21–46} were non-randomized trials (NRCTs). In addition, 9 out of the 30 studies also included cases with groin dissection as a control group for comparison,^{16,17,20,21,28,30–32,43} whereas the remaining 21

studies included only cases with SMCDs. The effectiveness of the Proglide system was evaluated in four studies,^{18,28,29,42} whereas the outcomes of the two SMCDs were compared and described in two studies.^{27,29} On the other hand, all six studies^{15,47–51} referring to FST were non-randomized trials and did not include a control group with groin dissection for comparison. Recently, one RCT study investigated whether the FST can reduce the access closure time and the procedural costs compared with the Prostar XL technique in patients ($n = 100$) undergoing EVAR.⁵² The 30 original articles reporting results of SMCD included 3,992 patients having undergone closure of the wound of CFA by this method. Concerning the six studies on FST, they included 426 patients and 660 catheterized CFA in total.

Results of SMCD

The two types of SMCD that were used in the reviewed studies were Prostar XL and the Proglide system. Prostar XL was used in 27 studies,^{16,17,20–27,29–41,43–46} and Proglide was used in 6 studies.^{18,20,27–29,42} In three studies,^{20,27,29} both Prostar and Proglide devices were used. The rates of technical success by access site ranged between 63

Fig. 1 Flowchart summarizing literature search results. FST, fascia suture technique; SMCDs, suture-mediated closure devices.

and 100%, but with only two articles^{34,37} reporting rates below 80% and most articles^{16–18,20–33,35,36,38–46} reporting rates between 89 and 100%. The rates of technical success by patient ranged between 53 and 100%, but with only three articles reporting rates below 80%^{22,34,35} and most articles reporting rates between 89 and 100%.^{16,17,21,23,28–30,32,33,36,40–44,46} The complication rates varied greatly, with rates between 0 and 25%.^{16–18,20–33,35,36,38,39,41–46} The mean operating time ranged between 86.7 and 180 minutes.^{16,17,20,21,25,28–32,34,37,41,45} The mean time to ambulation was mentioned in only four articles, and it ranged between 17 and >24 hours,^{17,20,25,29} with the exception of one article in which it was only 4 to 6 hours after the operation.³⁸ The mean duration of hospital stay was between 1.3 and 6.7 days.^{16,20,21,25,26,28–32,36,37,41,42,45}

► **Tables 1 and 2** summarize the above results.

It is worth mentioning that out of the six studies that used the Proglide system,^{18,20,27–29,42} five used the 6 F Proglide system,^{18,27–29,42} and one used the 8 F Proglide system,²⁰ while three used only the Proglide system,^{18,28,42} and the other three used either the Proglide or the Prostar XL system.^{20,27,29} However, only two studies compared the Proglide with the Prostar XL system.^{20,27} Nelson et al²⁰ reported no significant differences between the two systems in terms of blood loss, operative time, technical failure, major access-related complications, groin pain, time to ambulation, or length of hospital stay. In addition, neither Nelson et al²⁰ nor Pratesi et al²⁷ detected significant difference between the two systems in regards to technical failure (Nelson et al: Proglide: 6%, Prostar XL: 11.8%; $p = 0.487$ and Pratesi et al: Proglide: 2.5%, Prostar XL: 3.3%; $p = 0.33$). Similarly, Nelson et al²⁰ found no significant difference between the two systems as far as major access-related complications are concerned (Proglide: 6%, Prostar XL: 11.8%; $p = 0.487$).

Results of FST

The technical success rates were high, ranging between 87 and 99%. The rates of intraoperative complications ranged between 1.2 and 13%, whereas the rates of short-term complications, within 30 days from the operation, were from 0.9 up to 6.2%. Similar were the rates of long-term complications >30 days from the operation, which varied between 1.9 and 13.6%.^{15,47–51} ► **Table 3** illustrates the above results. Only one study, conducted by Larzon et al,⁵² has attempted to compare FST with SMCD. In particular, median access closure time was shorter with the FST than the Prostar XL Device (12.4 min versus 19.9 min, $p < 0.001$), but no significant differences were detected between FST and SMCD in regards to the rates of technical failure, complications, or reintervention. In addition, there was a decrease in cost by €800 when FST was used ($p < 0.001$).⁵²

Discussion

In all fields of surgery, there is a trend toward less invasive procedures, aiming at reducing hospital stay, complications, and mortality. In vascular surgery, for the treatment of aortic diseases, open surgical technique is gradually less applied,

and instead p-EVAR is a widely accepted treatment modality today. As a result of the gradually increased popularity of the latter, the debate regarding the method of arterial closure grows. FST and SMCDs have emerged as alternative techniques for closure of CFA^{14,15,33} after p-EVAR.

Since the first description by Haas et al in 1999,³³ the “preclose” technique has been used increasingly to perform p-EVAR. The technique utilizes SMCDs, such as Prostar XL and/or Proglide in off-label application, to close arterial access larger than 10 F. The technical success rate was 100% based on a sample of 12 patients. One year later, a first attempt was made by Traul et al,³⁴ who used the Prostar XL 10 device on 17 patients with endovascular repair of abdominal aortic aneurysm. In particular, they used two 10 Fr devices on the side of the main body and one contralateral 10 Fr device contralateral. The technical success of this first attempt was low (63% by access site and 53% by patient), but the success rates have risen since then in most studies.^{17,28,29,32,33,43}

In our analysis, the technical success rate ranges between 89 and 100%, whereas the loco-regional complications were calculated between 0 and 25%. Our results are absolutely consistent with two recently published studies.^{53,54} In the first study,⁵³ the use of the Prostar XL device has indicated overall good results for the percutaneous techniques with a weighted average success rate of 91% (87–95%) in the same time that regarding local complications a risk ratio of 0.87 (95% confidence interval [CI]) in favor of p-EVAR over surgical access was found a lower risk which nevertheless did not reach statistical significance. In the second study,⁵⁴ the reported technical success in p-EVAR group was 92%, whereas the local complications were reported lower in the group undergoing percutaneous access (risk ratio, 0.47; 95% CI). In the same time, the aforementioned studies revealed that p-EVAR compared with s-EVAR seemed advantageous in terms of reduced procedural time, hospital stay, and time to ambulation in comparison. These results were confirmed in our study (► **Tables 1 and 2**) with the mean operative time to be 86.7 to 180 min, the hospital stay 1.3 to 6.7 days, and mean time to ambulation 17 to 24 hours. To minimize the groin complication, rates should be considered in the context of patient selection for p-EVAR. As demonstrated in most series, and to be eligible for p-EVAR, patients had to meet certain anatomical criteria.^{17,18,20,24,27,28,30,37,38,44,46} The main reasons why some patients were not considered candidates for p-EVAR were: small iliofemoral artery size (<6 or <7 mm diameter),^{22,46} high CFA bifurcation,^{23–27} anterior or circumferential CFA calcification,^{23–27} scarred groin,^{17,34,43,45} obesity,^{25–27} CFA aneurysm,²² and the presence of vascular graft in the inguinal zone.⁴³ So, particular caution is needed when clinicians perform p-EVAR in this group of patients, whereas their experience and familiarity with the devices remain significant predictors of success.⁴⁴

An alternative closure technique of the femoral artery (FST) has gained territory in the last years after the first description by Diendrich.¹⁴ The first attempt to evaluate it in the daily clinical practice was made by Larzon et al¹⁵ who used this technique in 51% (131/257) of the femoral arteries

Table 1 Summary of all the studies using SMCDs after p-EVAR and their characteristic

Authors	Year of publication	Type of study	Number of patients (n)	Type of device	Number of devices (n)	Catheter sheath size (Fr)
Torsello et al ¹⁷	2003	RCT	30 (15 p-EVAR, 15 s EVAR)	Prostar XL 10	1	≥14 Fr
Nelson et al ²⁰	2014	RCT	151 (101 p-EVAR, 50 s EVAR)	Prostar XL 10 Fr or Proglide 8 F	1 Prostar and 2 Proglide	21 Fr
Ichihashi et al ²⁸	2016	RS	146 (50 p-EVAR, 96 s EVAR)	Proglide 6 F	1	16–24 Fr/12–18(c)
Pratesi et al ²⁷	2015	OS	1322	Prostar XL 10 (78.4% of cases) Proglide 6 F (21.6% of cases)	1 Prostar or 2 Proglide	9–25 Fr
Rijkée et al ²⁶	2015	OS	85	Prostar XL 10	1	9–22 Fr
Petronelli et al ²⁵	2014	OS	200	Prostar XL 10	1	18–24 Fr /12–18 Fr(c)
Skagius et al ²⁴	2013	OS	114	Prostar XL 10	1	20–26 Fr
Thomas et al ²³	2013	OS	50	Prostar XL 10	1	8–25 Fr
Metcalfe et al ⁴⁵	2012	OS	57	Prostar XL 10	1	12–22 Fr
Kracjer et al ²⁹	2011	PS	38	Prostar XL 10/ Proglide 6 F	1 or 2 Prostar or 2 Proglide	>17 F/9 Fr (c)
Grenon et al ⁴²	2009	RS	15	Proglide 6 F	2	15–21 Fr
Eisenack et al ⁴⁴	2009	OS	500	Prostar XL 10	1	14–24 Fr
Heyer et al ⁴¹	2009	OS	14	Prostar XL 10	1	20–22 Fr/16–18 Fr (c)
Arthurs et al ⁴⁰	2008	OS	88	Prostar XL 10	1	12–20 Fr
Lee et al ¹⁸	2008	OS	292	Proglide 6 F	2	12–24 F
Jean-Baptiste et al ¹⁶	2008	OS	40 (19 p-EVAR, 21 s EVAR)	Prostar XL 10	2 Prostar/1 Prostar (c)	18–24 Fr
Najjar et al ³²	2007	OS	37 (15 p-EVAR, 22 s EVAR)	Prostar XL 10	1	12–18 Fr
Watelet et al ²²	2006	OS	29	Prostar XL 8 and 10	2 Prostar XL 8 or 1 Prostar XL 10	16–22 Fr
Starnes et al ³⁹	2006	OS	49	Prostar XL 10	1	12–24 Fr
Petersen et al ⁴³	2005	OS	11 (7 p-EVAR, 4 s EVAR)	Prostar XL 10	1	18 Fr
Borner et al ²¹	2004	OS	121 (95 p-EVAR, 26 s EVAR)	Prostar XL 10	1	14–20 Fr
Morasch et al ³¹	2004	OS	82 (47 p-EVAR, 35 s EVAR)	Prostar XL 10	1	12–18 Fr
Quinn and Kim ³⁸	2004	OS	63	Prostar XL 10	1 Prostar for <12 Fr sheaths, or 2 for >12 Fr	12–16 Fr
Howell et al ³⁰	2002	OS	126 (30 p-EVAR, 96 s EVAR)	Prostar XL 10	1	22 and 16 Fr (c)

(Continued)

Table 1 (Continued)

Authors	Year of publication	Type of study	Number of patients (n)	Type of device	Number of devices (n)	Catheter sheath size (Fr)
Rachel et al ³⁷	2002	OS	100	Prostar XL 10	2	16/22 Fr
Quinn et al ³⁶	2002	OS	15	Prostar XL 10	2	14–20 Fr
Howell et al ⁴⁶	2001	OS	144	Prostar XL 10	1	16 Fr
Teh et al ³⁵	2001	OS	44	Prostar XL 10	1	18–20 Fr/16–18 Fr (c)
Traul et al ³⁴	2000	OS	17	Prostar XL 10	2 Prostar/1 Prostar (c)	22 Fr/16 Fr (c)
Haas et al ³³	1999	OS	12	Prostar XL 10	1 Prostar for 16 Fr sheaths, and 2 for 22 Fr.	16–22 Fr
Total	1999–2015	RCT/OS/RS	3992	Prostar/Proglide	1 Prostar and/or 1 or 2 Proglide	9–26 Fr

Abbreviations: c, contralateral; FST, fascia suture technique; NR, non-reported; OS, observed study; p/s-EVAR, percutaneous/surgical cut down EVAR; RCT, randomized control trial; RS, retrospective study; SMCDs, suture-mediated closure devices.

after endovascular repair of the thoracic or abdominal aorta. In this study, exclusion criteria were not reported, and the detection of the CFA preoperatively was assessed with palpation. A few years later, Harrison et al⁵¹ reviewed their results for 69 cases, where CFA were detected by duplex ultrasound. Exclusion criteria in this study were morbid obesity, high bifurcation of CFA, previous groin surgery, inadvertent high puncture, arteries with diameter <5 mm, and the surgeons' preference. It is worth mentioning that Harrison et al⁵¹ proposed one of the crucial steps of the procedure, which is to leave a guidewire in the artery lumen until satisfactory hemostasis is achieved.

Subsequently, Montán et al⁴⁷ presented their results from 160-sutured fascial cases, where CFA were assessed with preoperative fluoroscopic guidance. In this study, there were no anatomical exclusion criteria such as high bifurcation of the CFA, and the thickness of the fat overlying the CFA did not compromise the success of the technique. In the same period, Mathisen et al.⁴⁹ reviewed their results in a retrospective study, which included 49 patients (81 femoral access sites). The CFA was detected using palpation. It is worth mentioning that in these later studies, plaque/calcification did not appear to influence the success of fascia closure, as it was reported with the SMCD.^{23–27} A new attempt to evaluate the technical success was made by Dziekiewicz et al.⁵⁰ In this study, 58 patients (116 CFA) were included, whose CFA were detected preoperatively using a CTA. Recently, we published our experience with the results to be acceptable.⁴⁸ Primary and secondary technical success rates were high with 96.1 and 100%, respectively, and with low short- and mid-term technical failures.

The other finding of our analysis was that p-EVAR using FST reported a technical success between 87 and 99%. Most short-term complications (0.9–6.2%) associated with the technique, such as dissection, pseudoaneurysm formation, arterial stenosis, and ischemia, could be identified using handheld Doppler in the operation room and a duplex scan postoperatively. Moreover, perioperative bleeding could be tackled immediately by reintroducing the sheath over the retained guidewire and putting additional sutures if needed. Long-term complications (1.9–13.6%), such as arterial stenosis or pseudoaneurysms were faced either surgically or conservatively. Therefore, we judged the technique as safe, effective, and durable with a quite short learning curve. Moreover, FST seems to offer a “no-touch” artery closure, which could be advantageous in case of endovascular treatment of ruptured aortic aneurysms.⁵² The lack of the preclosure preparation of the access site seems to be advantageous under these critical situations. Furthermore, as demonstrated in the Larzon et al's study,⁵² FST can work as a bailout procedure for failed Prostar XL suture. In the same study, there was an attempt to investigate whether FST can reduce the access closure time and the procedural costs compared with the Prostar XL technique.⁵² The FST was raised as faster (median closure time 12.4 min) than Prostar (median closure time 19.9 min), but the main reason why the FST was significantly cheaper was the reduction in material costs. There was a significant cost difference in favor of FST, with a median difference of €800.⁵²

Table 2 Summarizes all the studies using SMCDs after p-EVAR and their characteristics

Authors	Year of publication	Technical success by access site (%)	Technical success rate (%)	Complication rates n (%)	Mean hospital stay (days)	Mean operative time (min)	Time to ambulation (h)
Torsello et al ¹⁷	2003	NR	93% (Prostar XL) 100% (s-EVAR)	13%	NR	86.7 ± 27 min (Prostar XL)/ 107.8 ± 38.5 min s-EVAR	20.1 ± 3 (Prostar XL)/ 33.1 ± 19.4 (s-EVAR)
Nelson et al ²⁰	2014	95%	NR	5%	1.3 ± 0.7 (Proglide) 1.4 ± 0.9 (Prostar)	107 ± 45 min (Proglide) 95 ± 35 min (Prostar)	17 ± 7.2 (Proglide) 16 ± 9.1 (Prostar)
Ichihashi et al ²⁸	2016	100%	100%	4%	6.7 ± 6.8 (Proglide) 9.3 ± 4.5 (s-EVAR)	153 ± 47 (Proglide)/ 211 ± 88 (s-EVAR)	NR
Pratesi et al ²⁷	2015	96.8%	NR	3.2%	NR	NR	NR
Rijkée et al ²⁶	2015	93.5%	NR	6.5%	5.19 ± 4.93	NR	NR
Petronelli et al ²⁵	2014	97.5%	NR	2.5%	≥2	45–300 min (150 ± 30 min)	≥24
Skagius et al ²⁴	2013	91.5%	NR	8.5%	NR	NR	NR
Thomas et al ²³	2013	93.6%	90%	7.7%	NR	NR	NR
Metcalfe et al ⁴⁵	2012	95.2%	NR	4.8%	2	131 (105–151)	NR
Kracjer et al ²⁹	2011	NR	97%	3%	1.4	117 ± 47	17 ± 15
Grenon et al ⁴²	2009	93%	93%	7%	2.2	NR	NR
Eisenack et al ⁴⁴	2009	96.1%	95.4%	3.9%	NR	NR	NR
Heyer et al ⁴¹	2009	96%	93%	4%	1.4	119	NR
Arthurs et al ⁴⁰	2008	95%	95%	NR	NR	NR	NR
Lee et al ¹⁸	2008	94.4%	NR	5.5%	NR	NR	NR
Jean-Baptiste et al ¹⁶	2008	92% (Prostar) 90% (s-EVAR)	92% (Prostar) 90% (s-EVAR)	16% (Prostar) 14% (s-EVAR)	5.8 (Prostar) 7.8 (s-EVAR)	130 min (Prostar)/ 122 minute (cut down)	NR
Najjar et al ³²	2007	NR	100% (Prostar) NR (s-EVAR)	0% (Prostar) NR (s-EVAR)	3.0 ± 6.9 (Prostar) 11.5 ± 6.9 (s-EVAR)	107 ± 30 min (Prostar)/ 205 ± 31 min (s-EVAR)	NR
Watelet et al ²²	2006	83%	72%	17%	NR	NR	NR
Starnes et al ³⁹	2006	94%	NR	6.3%	NR	NR	NR
Petersen et al ⁴³	2005	NR	100% (Prostar) 100% (s-EVAR)	0% (Prostar) 0% (s-EVAR)	NR	NR	NR

(Continued)

Table 2 (Continued)

Authors	Year of publication	Technical success by access site (%)	Technical success rate (%)	Complication rates n (%)	Mean hospital stay (days)	Mean operative time (min)	Time to ambulation (h)
Borner et al ²¹	2004	89% (Prostar) NR	89% (Prostar)	21% (Prostar)	4	180 min (100–425) (Prostar XL)	NR
Morasch et al ³¹	2004	NR	NR	19% (Prostar) 17% (s-EVAR)	1.48 (Prostar) 1.89 (s-EVAR)	139 min (Prostar) 169 (s-EVAR)	NR
Quinn and Kim ³⁸	2004	NR	NR	23%	NR	NR	4–6
Howell et al ³⁰	2002	97% (Prostar) NR	93% (Prostar)	7% (Prostar) NR (s-EVAR)	1.3 ± 0.6	105 ± 21 min (Prostar)	NR
Rachel et al ³⁷	2002	64–85%	NR	NR	1.6	106 min	NR
Quinn et al ³⁶	2002	NR	93%	7%	6.5 (urgent cases) 1.7 (elective)	NR	NR
Howell et al ⁴⁶	2001	NR	94%	6%	NR	NR	NR
Teh et al ³⁵	2001	85%	75%	25%	NR	NR	NR
Traul et al ³⁴	2000	63%	53% (Prostar)	NR	NR	90 min	NR
Haas et al ³³	1999	100%	100% (Prostar)	0%	NR	NR	NR
Total	1999–2015	63–100%	53–100%	0–25%	1.3–6.7	86.7–180 min	>4

Abbreviations: c, contralateral; FST, fascia suture technique; NR, non-reported; p/s-EVAR, percutaneous/ surgical cut down EVAR; SMCDs, suture-mediated closure devices.

Table 3 Short- and long-term results of FST after P-EVAR among various studies

Authors	Number of patients (n)	Number of Femoral sites (n)	Technical success (%)	Complications (n (%))		
				Intraoperative n (%)	<30 days n (%)	>30 days n (%)
Larzon et al ¹⁵	127	131	87.8%	16 (12.2%)	NR	2 (1.5%)
Harrison et al ⁵¹	38	69	87%	9 (13%)	4 (5.8%)	NR
Montán et al ⁴⁷	100	160	91.3%	14 (8.8%)	2 (1.3%)	9 (5.6%)
Mathisen et al ⁴⁹	49	81	99%	1 (1.2%)	5 (6.2%)	11 (13.6%)
Dziekiewicz et al ⁵⁰	58	116	96%	5 (4.3%)	1 (0.9%)	3 (2.6%)
Bountouris et al ⁴⁸	54	103	96.1%	4 (3.9%)	1 (1%)	2 (1.9%)
Total	426	660	87–99%	1.2–13%	0.9–6.2%	1.5–13.6%

Abbreviations: FST, fascia suture technique; N, number of arteries in every study; NR, non-reported; p-EVAR, percutaneous endovascular aortic aneurysm repair.

On the other hand, FST presents two weak points that the vascular surgeon must keep in mind for successful outcomes. First, not all patients have an anatomically distinct femoral fascia, especially on the medial side. Weakness of the femoral fascia may cause leakage and difficulty in suture sealing. Second, optimal puncture site below the inguinal ligament and above the femoral bifurcation represents the cornerstone for a successful FST. A puncture above the inguinal ligament may make the femoral closure less effective, as the femoral fascia is not appropriate for the coverage of the artery wall, and retroperitoneal bleeding may occur. In addition, low puncture close to the deep femoral artery (DFA) might also lead to the same complication and cause hemorrhage in the groin.³⁰

To the best of our knowledge, this is the first study that collect overall data from the FST and SMCDs studies after p-EVAR. However, the study presents some limitations. First, the nature of p-EVAR and FST studies that include only three randomized controlled trial. Furthermore, the reviewed studies presented some differences with regard to the type of endovascular procedure, the indication for the treatment, the type of closure device used, and the duration of follow-up. All studies failed to provide clear guidelines when SMCDs and FST were useful under significant confounders, such as vascular calcification, obesity, groin scarring, etc. Moreover, the outcome was described with relevant terms, such as technical success and failure. Further studies with a large number of patients are necessary to compare the two techniques and to extract essential and safe conclusions.

Conclusions

SMCDs and FST seem to be effective and simple methods for closing CFA punctures after p-EVAR. The techniques seem to be applicable to all patients, even in emergency procedures, whereas the few failures that may occur due to bleeding or occlusion can easily be managed. Particular caution is needed when clinicians perform p-EVAR using SMCDs where their experience and familiarity with the devices remain significant predictors of success. FST can reduce the access closure time and the procedural costs with a quite short learning curve, still the results remain controversial due to the limited number of published studies.

Conflicts of Interest

None.

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