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Distal Endovascular Extension After FET: Short and Mid-Term Outcome in a High-Volume Single-Center Experience

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Background: This study aims to investigate results and outcomes of distal endovascular extensions after frozen elephant trunk (FET) procedure.

Methods: Between September 2018 and December 2022, all consecutive patients who underwent thoracic endovascular aortic repair (TEVAR) or complex thoraco-abdominal repair (TAA-EVAR) after FET were included in the study. Patients were assigned to "Aneurysm" group or to "Dissection" group according to underlying patology before FET repair. The primary end points were overall technical success and early reintervention rate. Secondary end points included 30-day and mid-term overall survival.

Results: A total of 29 patients were included in the study and divided as follows: $n = 12$ in the aneurysm group and $n = 17$ in the dissection group. The mean age of the population was 64.6 ± 10.2 years, and 69% were male. All patients received TEVAR as primary extension while 9 of them underwent further extension to a subsequent TAA-EVAR in a second stage. Among the dissection group, 7 patients experienced a distal stent-graft-induced new entries caused by the stent-graft portion of the FET. Technical success of the first stage (TEVAR) was fully achieved as well as for the second stage (TAA-EVAR). Within the first 30 days, no patient expired or required early reinterventions. Freedom-from-reintervention at 36 months was 72% and 64% in the aneurysm and dissection group, respectively. Overall, 1 major adverse event (3.4%) and 3 access-related complication (10.3%) occurred among the entire cohort. The Kaplan−Meier survival estimation showed a nonsignificant log-rank value ($P = 0.248$) with a survival rate of 91.7% and 100% at 12, 24, and 36 months each for aneurysm and dissection group, respectively.

Conclusions: Distal endovascular extensions after FET repair are feasible with low perioperative morbidity and mortality regardless of the underlying pathology. Technical success rate of endovascular extension is high, but aortic-related reintervention rate remains quite consistent over time. Thus, a close surveillance is advocated for such patients.

Conflict of interest: N. T. is proctor for Bentley and Cook Medical.

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INTRODUCTION

The introduction of the frozen elephant trunk (FET) technology into clinical routine represents a milestone in the treatment of complex aortic arch pathologies extending into the descending portion of the aorta.[1] Since its early results, several modifications of the prostheses and implantation technique simplified its feasibility and increased its safety.[2–4] Some clinical circumstances require an extension of the stented portion of the FET, typically endoleaks, false lumen perfusion favoring aortic enlargement, or distal stent-graft-induced new entries (dSINEs). Largest series available in the literature report distal extension of the stented FET portion in around 20% of cases, including all cause of treatment. However, contrary to the well-documented results of the FET procedure itself, the technical success and clinical outcome of distal endovascular extensions remains uncertain, especially in the case of complex thoraco-abdominal repair (TAA-EVAR). This study aims to investigate the results and outcomes of a subsequent distal endovascular repair following aortic arch replacement using the FET according to the underlying pathology.

METHODS

Study Design and Data Collection

This study is a retrospective single-center study. All of the patients gave their consent to be inserted in the aortic registry of our department at the time of the study; therefore, no ethical committee approval was needed.

Between September 2018 and December 2022, all consecutive patients undergoing thoracic endovascular aortic repair (TEVAR) or TAA-EVAR following FET—either as an urgent or elective procedure—were included into the study. Patients treated with open surgery after FET, inability to deliver the stent-graft and no availability of good quality computed tomography (CT) scan were considered as exclusion criteria. The included patients were stratified into 2 groups according to the underlying pathology (aneurysm or dissection). Demographic characteristics, clinical morbidities, cardiovascular risk factors, anatomical features, and operative and postoperative parameter were recorded in a dedicated database and retrospectively analyzed. Preoperative and postoperative measurements and case-planning were conducted with the Aquarius iNtuition software (TeraRecon, Foster City, CA). Preoperative measurements of anatomical characteristics included tortuosity index of descending thoracic aorta (DTA) calculated as a ratio between the length along the centerline and the linear distance between the orifice of left subclavian artery and 2 cm proximal to celiac trunk. Oversize of FET stent-graft was calculated as ratio between DTA mean diameter at the landing zone site or true lumen mean diameter and stent-graft diameter, respectively, for aneurysms and dissections. dSINE tears were recorded using follow-up CT scans, and the repair was accomplished electively or urgently according to patient symptoms. Features of target vessels were included in the analysis of postdissection cases (number of stents, device, size, etc.) and their patency assessed at each follow-up CT scan.

Procedures

Isolated TEVAR, performed deploying the endoprosthesis within DTA, was planned to achieve proper sealing of the false lumen entry or the aneurysm. TAA-EVAR was considered if the disease extended into the abdominal aorta. Abdominal extend was also pursued, if the TEVAR alone did not ensure effective sealing or in case of distal progression of the disease following initial treatment. In case of elective TAA-EVAR, a staged approach was planned approximately 1−2 months after the initial TEVAR placement, while one-stage repair was adopted for urgent and emergency cases. Elective patients routinely underwent repair with Cook (Cook Medical Inc, Bloomington, IN) stent-graft for both TEVAR and TAA-EVAR. In elective cases for complex thoraco-abdominal repair, custom-made devices were preferred over off-the-shelf solutions, and in emergency settings, custom-made grafts from different patients were utilized if anatomically suitable.

TEVAR were performed under general or local anesthesia according to patient comorbidity in a hybrid suite. General anesthesia was used for TAA-EVAR when a staged repair was planned without routine use of spinal drainage. Procedural time, radiation dose, volume of contrast, and radiation time were recorded. Additionally, the number of target vessels, type of surgical access, and perioperative complications were documented.

Follow-Up and Postoperative Regimen

Follow-up data were mostly collected from reports of the aortic outpatient clinic and from hospital records, if needed. CT scan was performed before discharge or during the first 30 days after the procedure. In cases of reduced kidney function (glomerular filtration rate of <45 mL/min/1.73 m^2), follow-up examination was changed to

contrast-enhanced ultrasound and additionally thoraco-abdominal CT scan without iodinated contrast. In case of TAA-EVAR, postoperative regimen consisted of double antiplatelet therapy for 6 months, which was later changed to lifelong monotherapy after an uncomplicated course. In cases of additional necessary anticoagulation, only mono-antiplatelet therapy was administered. Double antiplatelet therapy was not provided for patients who received only TEVAR. Patients were invited for routine clinical and radiological follow-up examination in our aortic outpatient clinic at 4–6 weeks, 6 months, 12 months, and yearly thereafter. During follow-up, data of major adverse events, target vessel instability, reinterventions, and mortality were collected.

Definitions

The anatomical extent of aortic aneurysm and dissection was classified according to the current reporting standards based on the preoperative computed tomography angiography.[5] Early postoperative period was defined as occurring within hospital stay or the first 30 days.

Major adverse events were defined as any cause of mortality, acute kidney injury, new-onset dialysis, myocardial infarction, paraplegia, stroke, and bowel ischemia requiring surgical resection. Technical success was defined as successful endovascular access and stent-graft deployment of all aortic devices without any persistent type I or III endoleak or target vessel instability at 30 days and confirmed at first postoperative computed tomography angiography.[5]

End Points

The primary study end points were overall technical success and early reintervention rate. Secondary end points included 30-day and mid-term outcomes embracing reinterventions, dSINE rate, and overall survival estimation.

Statistical Analysis

Statistical data analysis was performed with SPSS Statistics (version 25; IBM, Chicago, IL). Continuous variables were reported as mean ± standard deviation or median with interquartile ranges, depending on the normality of distribution. Categorical variables are presented as number and percentages. Univariate analysis was performed using the *t*-test for continuous variables and Fisher exact test for categorical variables. Mann–Whitney test was used in case of nonparametric variables. Time-to-event analysis was carried out by Kaplan–Meier estimation. A P value < 0.05 was considered statistically significant for all analyses.

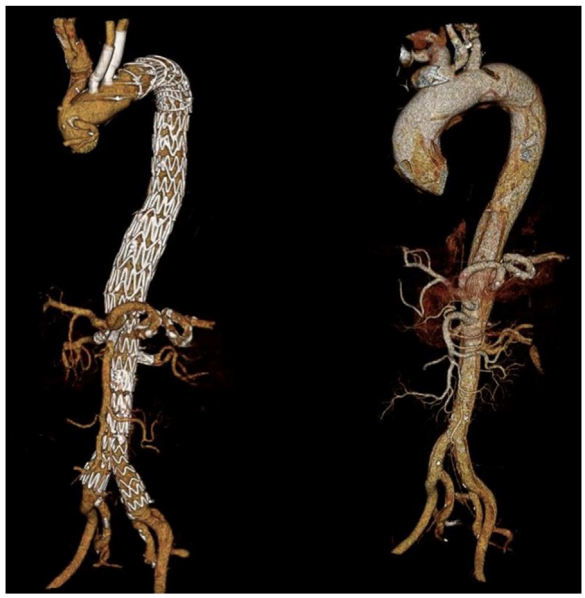


Fig. 1. Complete aortic endovascular repair with 4 fenestration-FEVAR after Stanford type A dissection.

RESULTS

Demographic Characteristics and Preoperative Parameter

During the reference period, a total of 81 patients underwent FET procedure. Among those, only 29 (20 males, 69%) received distal endovascular extension: 12 (41%) were included in the ''Aneurysm'' group and 17 in the ''Dissection'' group according to the underlying patology.

All of the patients received TEVAR (29, 100%) and only 9 of them (31%) had a subsequent TAA-EVAR as a second-stage procedure to complete the repair distally (Fig. 1). The mean age of the entire population was 64.6 ± 10.2 years.

In the aneurysm group, the indications for TEVAR were thoraco-abdominal aortic aneurysm Crawford-Type 1 in 5 patients (42%)—one with rapid progression—and endoleak type Ib of the FET stented portion in 3 (25%). One patient showed twisted and proximally migrated FET stent portion, resulting in endoleak type Ib and thrombus formation within the graft. In the dissection group, dSINE

Table I. Demographic characteristics

Variables	Total ($n = 29$)	Aneurysm ($n = 12$)	Dissection ($n = 17$)	P value
Age	64.6 ± 10.2	68.8 ± 9.1	61.7 ± 10.1	0.063
Males	20 (69.0)	6 (50.0)	14 (82.4)	0.106
Comorbidities				
History of smoking	7 (24.1)	5 (41.7)	2 (11.8)	0.092
Current smoker	6 (20.7)	4 (33.3)	2 (1.8)	0.198
DM	3 (9.3)	3 (25)	0 (0)	0.702
CKD III–V	8 (27.6)	2 (16.7)	6 (35.3)	0.408
eGFR (mL/min/1.73)	68.5 ± 26.2	65.8 ± 25.4	70.4 ± 27.1	0.645
Hemodialysis	2 (6.9)	1 (8.3)	1 (5.9)	1.0
Serum creatinine (mg/dL)	1.25 ± 0.71	1.29 ± 0.88	1.22 ± 0.59	0.789
Cancer	2 (6.9)	2 (16.7)	0 (0)	0.163
Dyslipidemia	15 (51.7)	6 (50)	9 (52.9)	1.0
Hypertension	25 (86.2)	10 (83.3)	15 (88.2)	1.0
BMI	26.1 ± 3.6	26.5 ± 4.2	25.7 ± 3.1	0.578
Obesity	6 (6.3)	4 (8.2)	2 (4.3)	0.447
Previous stroke/TIA	6 (20.7)	2 (16.7)	4 (23.5)	1.0
Other				
ASA Score				0.701
2	2 (6.9)	0 (0)	2 (11.8)	
3	19 (65.5)	8 (66.7)	11 (64.7)	
4	8 (27.6)	4 (33.3)	4 (23.5)	
SVS Score	1 (1–5)	2.5 (1–11)	1 (1–3)	0.152
DTA tortuosity	4 (13.8)	3 (25.0)	1 (5.9)	0.279
Concomitant FET procedures	20 (69)	7 (58.3)	13 (76.5)	0.422
DTA length of coverage from LSA (mm)	114.6 (95.10–144.45)	108.9 (92.9–142.7)	114.6 (96.0–145.3)	0.444
FET stent-graft diameter (mm)	31.6 ± 5.2	35.2 ± 5.4	29.1 ± 3.4	**0.003**
FET stent-graft oversizing (%)	10.7 (2.7–29.5)	11.9 (0–89.1)	10.7 (4.1–21.1)	0.824
dSINE requiring intervention	7 (24.1)	0 (0)	7 (41.2)	0.797
FET device utilized				0.498
E-Vita	2 (6.9)	0 (0)	2 (11.8)	
Thoraflex	27 (93.1)	12 (100)	15 (88.2)	

Data are expressed as n (%), mean ± standard deviation, or median (interquartile range).
Bold values indicate significative P value at statistical analysis.
FET, frozen elephant trunk; DTA, descending thoracic aorta; DM, diabetes mellitus; CAD, coronary artery disease; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; BMI, body mass index; TIA, transient ischemic attack; ASA, American Society of Anesthesiologists; SVS, Society of Vascular Surgery; LSA, left subclavian artery.

was the predominating indication for TEVAR (7 patients, 37%), followed by enlargement of false lumen at thoracic level (2 patients, 11%). Two patients suffered from uncontrolled pain, and thus, TEVAR was released to obtain false lumen depressurization with complete relief of the symptoms.

Among the patients undergoing TAA-EVAR, the most frequent indication for treatment was thoraco-abdominal aortic aneurysm Crawford-Type 2 (3 patients, 25%) and false lumen enlargement at abdominal level (6 patient, 35%) in the aneurysm and dissection groups, respectively.

Demographic characteristics are described in detail in Table I.

Patients in the aneurysm group are older (68.8 ± 9.1 years) with a higher Society of Vascular Surgery Score (2.5, IQR 1–11) compared with patients of the dissection group (61.7 ± 10.1 years and 1, IQR 1–3, respectively). A significant difference was found for FET stent-graft diameter (35.2 ± 5.4 mm in the aneurysm group versus 29.1 ± 3.4 mm in the dissection group; $P = 0.003$), but no difference regarding FET stent-graft oversizing (11.9%, IQR: 0–89% in the aneurysm group versus 10.7%, IQR: 4.1–21.1% in the dissection group; $P = 0.824$). Thoraflex device (ThoraflexTM, Vascutek, Terumo, Inchinnan, Scotland, UK) was institutionally preferred (27, 93.1%) over E-Vita device (Jotec GmbH, Hechingen, Germany) (2, 6.9%).

Table II. Anatomical and procedural characteristics

Variables	Total ($n = 29$)	Aneurysm ($n = 12$)	Dissection ($n = 17$)	P value
Preprocedural				0.502
DTA max diameter (mm)	45.8 ± 12.8	49.7 ± 14.6	43 ± 10.9	0.166
DTA true lumen max diameter (mm)	24.6 ± 5.6		24.6 ± 5.6	
DTA false lumen max diameter (mm)	25.2 ± 11.3		25.2 ± 11.3	
Max aortic diameter (mm)	46.2 ± 12.2	49.4 ± 15.6	44.1 ± 9.4	0.328
False lumen max diameter (mm)	28.3 ± 12.1		28.3 ± 12.1	
True lumen min diameter (mm)	15.1 ± 5.8		15.1 ± 5.8	
Tortuous DTA	4 (13.8)	3 (25)	1 (5.9)	0.279
Procedural				
TEVAR	29 (100)	12 (100)	17 (100)	1.0
Technical success first stage	29 (100)	12 (100)	17 (100)	1.0
TEVAR distal landing zone oversize (%)	15 (6.7−21.4)	12 (−8.1-19.4)	13.3 (5.1−20.1)	0.412
TAA-EVAR (BEVAR)	3 (10.3)	2 (16.7)	1 (5.9)	
TAA-EVAR (FEVAR)	6 (20.7)	1 (8.3)	5 (29.4)	
TAA-EVAR (Total)	9 (31)	3 (25)	6 (35.3)	
Technical success second stage	6 (66.7)	1 (33.3)	5 (83.3)	1.0
Concomitant procedures	3 (10.3)	1 (8.3)	2 (11.8)	1.0
General anesthesia	19 (65.5)	7 (58.3)	12 (70.6)	0.694
Spinal drainage	0	0	0	
Total operation time first stage (min)	60 (50−73)	50 (40−60)	70 (59.25−95)	**0.039**
Fluoroscopy time first stage (min)	9.1 (6−12)	8 (4−11.5)	9.2 (6.575−15.250)	0.330
Radiation dose first stage (cGycm2)	258 (136−964)	136 (75−458)	465 (168−1003)	**0.036**
Contrast dose first stage (mL)	110 (80−150)	100 (70−120)	120 (85−165)	0.563
Total operation time second stage (min.)	312 (207.5−360)	310 (185−420)[a]	335.5 (213.25−360)	1.0
Fluoroscopy time second stage (min)	173 (117.25−204.75)	189 (157−210)[a]	104 (104−104)	0.180
Radiation dose second stage (cGycm2)	4496 (2575−5647)	4808 (1938−9150)[a]	4414 (2975−5252.5)	0.655
Contrast dose second stage (mL)	450 (310−900)	500 (320−900)[a]	425 (300−925)	0.696
ICU LOS (days)	1 (1−1.5)	1 (1−1.75)	1 (0.5−1.5)	0.826
Hospital LOS first stage (days)	8 (6−14.5)	9.5 (7−15.75)	8 (6−12.5)	0.374
Hospital LOS second stage (days)	0 (0−8)	0 (0−5.25)	0 (0−9)	0.589

Data are expressed as n (%), mean ± standard deviation, or median (interquartile range).
Bold values indicate significative P value at statistical analysis.
FET, frozen elephant trunk; DTA, descending thoracic aorta; TEVAR, thoracic endovascular aneurism repair; cEVAR, complex endovascular aneurism repair; BEVAR, branched endovascular aneurism repair; FEVAR, fenestrated endovascular aneurism repair; LOS, length of stay; ICU, intensive care unit; dSINE, distal stent-graft-induced new entry.
[a]Data are presented as median (min-max) since the low number of cases.

Early Outcomes

Technical success of the first stage (TEVAR) was fully achieved in both groups as well as for the second stage (TAA-EVAR). Periprocedural and procedural characteristics of distal extension are summarized in Table II.

The aneurysm group had a higher mean aortic diameter (49.4 ± 15.6 mm) and showed a higher grade of DTA tortuosity, both without statistical significance ($P = 0.328$ and 0.279, respectively). During the first postoperative 30 days, no patient expired or required reinterventions in both groups. Major adverse event rate was 5.9% (1/17) in the dissection group, while no adverse events were recorded in the aneurysm group. One patient suffered from acute kidney injury which was treated conservatively and showed complete relief at discharge without the need of hemodialysis. There were 3 access-related complications (10.3%), 2 accounted for the aneurysm group (16.7%) and 1 for the dissection group (5.9%). One patient experienced a false aneurysm of the right common femoral access which was lately treated with thrombin injection. One patient had a failure of the Perclose ProGlide System (Abbott Vascular, Santa Clara, CA) of right femoral access, resulting in active bleeding from the groin which was treated by surgical repair with pericardium patch-plasty. In one case, a minor groin bleeding was detected in left femoral access by

Table III. Target vessels specifications of the 9 patients who undergone F/BEVAR as second-stage procedure

Variables	Total target vessels ($n = 38$)	Aneurysm ($n = 12$)	Dissection ($n = 26$)	P value
N° Stented vessels	36 (94.7)	10 (83.3)	26 (100)	0.318
N° Fenestrations	20 (52.6)	1 (8.3)	19 (73.1)	**0.038**
N° of branches	18 (47.4)	11 (91.7)	7 (26.9)	0.348
N° of scallops	0	0	0	
N° Stent overall	48 (126.3)	17 (1.42 ± 2.9)	31 (1.82 ± 2.6)	0.696
N° of BeGraft	35 (92.1)	13 (1.08 ± 2.2)	22 (1.3 ± 1.9)	0.786

Data are expressed as n (%) or mean ± standard deviation.
Bold values indicate significative P value at statistical analysis.

ultrasound at the first postoperative day but stayed without the need of further intervention.

Target Vessels Specifications

In TAA-EVAR group, 36 out of 38 target vessels were stented (94.7%) with a primary patency of 97.4% at 36 months. Specifications of target vessels of the 9 patients who have undergone TAA-EVAR are listed in Table III.

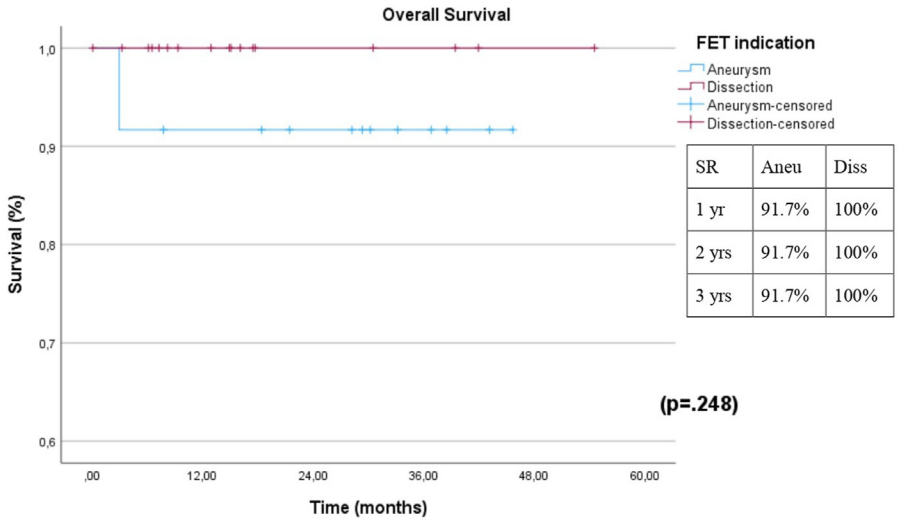
Mid-Term Outcome

The median follow-up was 29.8 months in the aneurysm group (IQR 19.2−38.1) and 14.9 months in the dissection group (IQR 6.9−24.1). During this period, in the aneurysm group only one patient affected by pancreas cancer died because of a rapid worsening of clinical conditions. No other deaths were registered during the follow-up period. In 7 patients (41.2%), a dSINE after FET implantation was detected and, therefore, received TEVAR with full resolution. The Kaplan−Meier survival estimation showed a nonsignificant log-rank value ($P = 0.248$) with a survival rate of 91.7% and 100% at 12, 24, and 36 months each for aneurysm and dissection groups, respectively (illustrated in Fig. 2). Freedom from reintervention was 90%, 90%, and 72% at 12, 24, 36 months for the aneurysm group, while in the dissection group, it was 85.6%, 64.2%, and 64.2% with no statistical difference between 2 groups ($P = 0.477$). A total of 5 reintervention (17.2%) were recorded of whom 3 were aortic-related. One patient had a right renal artery relining after 1 year due to an in-stent stenosis. In one case, a thoracic stent-graft was placed to fix a type IIIa endoleak between thoracic endograft and stented portion of the FET. The third patient suffered of right limb occlusion and endoleak type Ib after FEVAR with no clinical evidence of ischemia, eventually he was operated after 1 month with thrombectomy of right iliac axis, right limb relining, and bilateral iliac branch. Freedom-from-reintervention estimation is shown in Figure 3.

DISCUSSION

The synergy between aortic arch surgery and the endovascular treatment of the DTA was finally reached with the introduction of FET technique. Nevertheless, very often, an endovascular extension is required to complete the repair in case of complex thoraco-abdominal aorta aneurysm and dissection cases. Our cohort of 29 patients is comparable to others series available in literature[6] and presents the outcomes of endovascular extension after a previous FET. This series represent a rare pathology, including complicated cases predominantly characterized by false lumen origin of target vessels and tortuous anatomies. All of the patients received thoracic endovascular extension proximal to celiac trunk. In 9 cases, a second stage was planned to complete the repair with complex endovascular thoraco-abdominal procedures using fenestrated/branched endovascular aneurism repair. Our data are supported by a study of Hostalrich et al.,[7] who documented feasibility and outcomes in 30 patients receiving TEVAR after previous FET followed by F-BEVAR if needed. Rate and typology of the reinterventions are comparable (17.2% in our cohort versus 16.7% in Hostalrich's cohort), including disconnection between FET and thoracic endograft, but overall mortality is lower in our series (3.4% in our cohort versus 6.7% in Hostalrich's cohort).

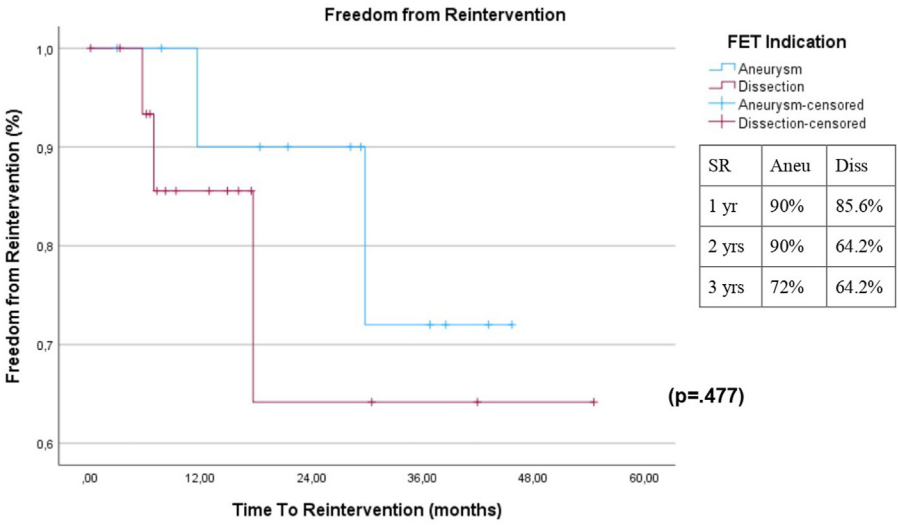
We obtained a full technical success after thoracic extension either in the aneurysm or dissection group. Apparently the underlying pathology does not interfere with the outcomes of the procedure



SR	Aneu	Diss
1 yr	91.7%	100%
2 yrs	91.7%	100%
3 yrs	91.7%	100%

N at risk	0 m	12 m	24 m	36 m
Aneurysm	12	10	8	4
Dissection	17	10	4	3

Fig. 2. Kaplan–Meier survival estimation.



SR	Aneu	Diss
1 yr	90%	85.6%
2 yrs	90%	64.2%
3 yrs	72%	64.2%

N at risk	0 m	12 m	24 m	36 m
Aneurysm	12	9	7	4
Dissection	17	8	3	2

Fig. 3. Freedom-from-reintervention.

in our cohort. However during follow-up, a patient experienced a type IIIa endoleak between stented portion of FET and thoracic endograft. In fact, TEVAR and FET provoke changes in aortic geometry which have been analyzed by Andic et al.[8] Results show that the following aortic elongation may influence the endoprosthesis position resulting in TEVAR failure. These findings seem not to be replicated in

dissected patients who underwent TEVAR after conventional arch replacement despite no data from large series are available in literature.[9] Therefore, further data are required to establish a significant role of FET in endoleak type III appearance after thoracic endograft placement. Interestingly, 7 patients in the dissection group had dSINE after FET which required TEVAR to seal the entry of the false lumen. Many studies investigated major risk factors of dSINE onset as it potentially results in serious life-threatening consequences,[10] carrying high morbidity and mortality. Main implication of dSINE is the persisting flow into the false lumen resulting in its enlargement with the onset of symptoms. TEVAR seems to provide good results achieving the new entry sealing and false lumen thrombosis in the thoracic aorta[11] with low rate of complications. In an analysis of an international multicenter registry (EuREC registry—European Registry of Endovascular Aortic Repair Complications), small true lumen diameter, a more accentuated oval true lumen morphology, and a higher degree of stent graft oversizing were frequent features in patients who developed dSINE.[12] Conversely, other authors have found the elevated wall shear stress and cranial movement of FET distal edge to be more likely predicting factors for the development of dSINE.[13,14] Group of Czerny has also showed a major stiffness of Thoraflex device compared with E-Vita, particularly on the distal ring. This may have a potential role in occurrence of dSINE.[15] European Society of Vascular Surgery guidelines for the treatment of thoracic aortic pathologies involving the aortic arch[9] suggests zone 2 as the optimal site for distal anastomosis of ET and FET subsequently. Stented portion of ET/FET should be accessible in zones 4 and 5 in order to provide enough length for additional stent-graft deployment. Nevertheless, FET sizing remains controversial and consequently the choice of the graft reflects the own institutional standards leading to high variability on clinical outcomes.[16] A slight oversize, around 10%, is preferred among the surgeons and seems to be safe minimizing endoleaks or reinterventions.[17] Smaller grafts are associated with early thrombosis[18] and can provoke dramatic issues when the oversize is not appropriate.[19]

In 9 cases, the distal extension with TEVAR was not sufficient, and a TAA-EVAR was needed to seal the false lumen or the aneurysm. Even though the complexity of the repair was quite high, especially in dissected patients, the technical success rate was satisfying. Patients who received TAA-EVAR after FET are more prone to require reinterventions as other authors mentioned.[20] This finding is confirmed also in our series where 3 out of 5 reinterventions are aortic-related. The absence of a control group and the small cohort cannot reveal whether the FET plays a role in the reintervention, necessitating further studies in the future. Lifelong monitoring, preferably with computed tomography angiography scan, is therefore advocated for such patients to detect in advance any sort of complications. Regardless from type and length of aortic coverage, no event of spinal cord ischemia (SCI) was registered during the perioperative time and follow-up. Debate is still ongoing regarding major risk factors, but staged procedure seems to be a protective factor against SCI.[21] Our results confirmed the benefit of staging a complex TAA-EVAR, reducing temporary or permanent paraplegia rate. However, this strategy alone may not be adequate for all patients, and protection against SCI can differ widely. Shalan and colleagues[22] observed a significant risk of either complete or partial SCI after F/BEVAR in their 39 patients' cohort. Indeed, a staged repair did not prevent SCI in 6 patients emphasizing its positive correlation with an extended aortic coverage.

Limitations of the Study

The main limitation of the study was its retrospective nature and the small number of patients. Heterogeneity of the population in terms of indication and type of the received treatment might also limit the validity of our results. However, endovascular extension after FET represents a rare procedure, and this series remains as one of the largest study presenting early outcomes in this scenario.

CONCLUSION

In conclusion, distal TEVAR or TAA-EVAR after FET repair seems to be feasible with low perioperative morbidity and mortality, regardless FET underlying patology. Technical success rate of endovascular extension is high but aortic-related reintervention rate remains quite consistent; therefore, a close follow-up is advocated for such patients. The dSINE occurrence after FET is still frequent despite the improved knowledge raised in the field and needs a proper management for a full resolution.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Salvatore Bruno: Writing — review & editing, Writing — original draft, Methodology, Investigation, Formal analysis, Data curation,

Conceptualization. **Daniel Becker:** Writing − review & editing, Methodology, Conceptualization. **Carlota F. Prendes:** Writing − review & editing, Supervision, Methodology, Formal analysis. **Gian Franco Veraldi:** Writing − review & editing. **M. Pichlmaier:** Writing − review & editing. **Sven Peterss:** Writing − review & editing, Visualization. **Nikolaos Tsilimparis:** Writing − review & editing, Supervision, Methodology, Data curation, Conceptualization.

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