Ann Vasc Dis Vol. 17, No. 3; 2024; pp 222–227
Online August 21, 2024
doi: 10.3400/avd.oa.24-00078

*Original Article*

# Mid-Term Outcomes Following TEVAR for Chronic Type B Aortic Dissection

**Masato Ohno, MD,[1] Nobuya Zempo, PhD,[1] Yuki Jinzai, MD,[1] Hideki Sakashita, PhD,[1] Tomohiko Uetsuki, MD,[2] and Takayuki Okada, PhD[2]**

**Objective:** To evaluate the mid-term outcomes following thoracic endovascular aortic repair (TEVAR) for chronic type B aortic dissection (TBD), especially to know which re-entry closure affects the thoracic false lumen remodeling in the late chronic TBD.
**Methods:** From April 2017 to April 2022, 25 patients with chronic TBD underwent TEVAR. The late chronic TBD received the re-entry closure including stent-graft deployment in the renal artery, infrarenal aorta, and unilateral or bilateral iliac artery.
**Results:** Complete shrinkage of the thoracic false lumen was accomplished in 67% of the early chronic cases but only 13% of the late chronic cases. The thoracic false lumen shrinkage over 5 mm in diameter was obtained in 78% of the early chronic cases and 69% of the late chronic cases. Univariate and multiple logistic regression analyses revealed the re-entry closure of common or external iliac artery affects the thoracic false lumen remodeling.
**Conclusion**: The re-entry closure in the common or external iliac artery could affect the thoracic false lumen remodeling following TEVAR for the late chronic TBD. (This is a translation of Jpn J Vasc Surg 2023; 32: 351–356)

***Keywords:*** chronic type B aortic dissection, TEVAR, remodeling, re-entry closure

[1]*Division of Vascular Surgery, Kansai Medical University Hospital, Hirakata, Osaka, Japan*
[2]*Department of Cardiovascular Surgery, Kansai Medical University, Hirakata, Osaka, Japan*

Received: July 16, 2024; Accepted: July 16, 2024
Corresponding author: Masato Ohno, MD. Division of Vascular Surgery, Kansai Medical University Hospital, 2-3-1 Shinmachi, Hirakata, Osaka 142-8666, Japan
Tel: +81-072-804-0101
E-mail: ohnomas@takii.kmu.ac.jp

This is a secondary publication from Jpn J Vasc Surg 2023; **32**: 651-356. The corresponding author was Nobuya Zempo in the original version in Jpn J Vasc Surg.

This study was presented at the 50th Annual Meeting of the Japanese Society for Vascular Surgery (Kokura, Japan, May 26, 2022).



## Introduction

Thoracic endovascular aortic repair (TEVAR) for Stanford type B aortic dissection (TBD) has dramatically increased the number of cases since commercially manufactured TEVAR was approved in Japan for complicated acute TBD on November 7, 2014, and for complicated chronic TBD (cTBD) including dissecting type B aortic aneurysm on February 28, 2019. We have reported that TEVAR for early cTBD from 2 weeks to 3–4 months after onset resulted in thrombosis and complete shrinkage of the thoracic false lumen, so-called remodeling, in nearly 90% of cases. However, the remodeling effect of TEVAR in patients with late chronic disease 6 or more months after onset remains controversial, and there is no consensus regarding reentry closure. This paper aimed to examine the remodeling effect of TEVAR in the late chronic stage and the effect of reentry closure and to identify the influencing factors.

## Subjects and Methods

Of 39 TBD patients who underwent TEVAR at the Department of Vascular Surgery, Kansai Medical University Hospital, between Apr 2017 and 2022, 2 acute cases, 1 case of infection, 1 case of traumatic injury, 9 cases of ulcer-like projection, and 1 case of distal stent graft-induced new entry tear (SINE) were excluded, and 25 patients with cTBD were included in the study. The patients were divided into 2 groups: the early chronic group, which included 9 patients between 2 weeks and 4 months after onset, and the late chronic group, which included 16 patients more than 4 months after onset (**Table 1**).

The indications for surgery in the early chronic group were true + false lumen diameter ≥55 mm in 2 patients, high-risk indicators in 6 patients (true + false lumen diameter ≥40 mm in 5 patients, false lumen diameter ≥22 mm in 4 patients, entry diameter ≥10 mm in 6 patients, and partial thrombosis of the false lumen in 2 patients), and true lumen narrowing in 1 patient. In the late chronic group, the indications were true + false lumen diameter ≥55 mm in 11 patients, true + false lumen diameter ≥40 mm in 4

**Table 1** Patient characteristics

| | Early chronic (n = 9) | Late chronic (n = 16) |
|---|---|---|
| Age | 63 (45–85) | 61 (43–78) |
| Male:female | 6:3 | 14:2 |
| Comorbidities | | |
| Stroke | 0 (0) | 1 (6) |
| IHD | 10 (11) | 0 (0) |
| Hypertension | 8 (89) | 15 (94) |
| Dyslipidemia | 2 (22) | 10 (63) |
| CKD | 1 (11) | 3 (19) |
| COPD | 1 (11) | 1 (6) |
| Smoking | 6 (67) | 12 (75) |

IHD: ischemic heart disease; CKD: chronic kidney disease; COPD: chronic obstructive pulmonary disease

**Table 2** TEVAR indication

| | Early chronic (n = 9) | Late chronic (n = 16) | p |
|---|---|---|---|
| TEVAR from onset | 52 (31–93) days | 42 (7–156) months | 0.025 |
| TL + FL ≥ 55 mm | 2 | 11 | |
| High-risk indicators | 6 | 4 | |
| TL + FL ≥ 40 mm | (5) | (4) | |
| FL ≥ 22 mm | (4) | (4) | |
| Entry ≥ 10 mm | (6) | (4) | |
| FL partial thrombosis | (2) | (0) | |
| Malperfusion | 0 | 1 | |
| TL narrowing, CTO | 1 | (1) | |

TL: true lumen; FL: false lumen; CTO: complete total occlusion; TEVAR: thoracic endovascular aortic repair

patients, and malperfusion in 1 patient. There were significantly more cases of dissecting aortic aneurysm in the late chronic group (p = 0.025) (**Table 2**).

In principle, a stent-graft tip was placed in a non-dissecting aorta in the proximal landing zone. Stent graft sizes were decided based on 110% of the aortic diameter on the proximal side, the longest diameter of the true lumen on the distal side in the two-lumen structure, and the aortic diameter in the area without false lumen, and the 100%–110% and 100% graft diameters were selected in the early and late chronic stages, respectively.

For prevention of postoperative paraplegia, mean blood pressure was maintained at or above 80 mmHg immediately after stent graft placement, and antihypertensive medication was halted for 2 to 3 days after surgery. Contrast-enhanced computed tomography (CT) examinations were performed on the fifth postoperative day to detect endoleak and measure the vessel diameters. Then, contrast-enhanced CT examinations were performed 3 months, 6 months, and 1 year postoperatively on an outpatient basis and every year thereafter if there were no problems.

**Table 3** TEVAR + re-entry closure

| | Early chronic (n = 9) | Late chronic (n = 16) | p |
|---|---|---|---|
| TEVAR | | | |
| TXD | 2 | 0 | |
| CTAG | 7 | 16 | |
| Dissection stent | 2 | 1 | |
| Ax-Ax bypass | 2 | 3 | |
| Re-entry closure | | | |
| RA VIABAHN | 2 | 6 | |
| RA VBX | 0 | 1 | |
| Aorta extender (AFX2) | 2 | 11 | |
| Unilateral iliac extender | 0 | 8 | 0.005 |
| Bilateral iliac extender (VBX) | 0 | 2 | 0.005 |

Ax: axillary artery; RA: renal artery; TEVAR: thoracic endovascular aortic repair

Statistical tests were performed using JMP Pro 16 (SAS Inc, Cary, NC, USA). Pearson's chi-square test was used to compare the proportions between the two groups, and the Wilcoxon test was used to compare continuous variables. Multiple logistic regression analysis was used for multivariate analysis, and a significance level of <0.05 was considered significant.

## Results

The median time from onset to TEVAR was 52 days (31–93 days) in the early chronic group and 42 months (7–156 months) in the late chronic group (**Table 2**). The grafts used in the early chronic group were CTAG in 7 patients and TXD in 2 patients, and dissection stent was used simultaneously with TXD. In the late chronic group, CTAG was used in 16 patients, while a dissection stent was used in only 1 patient. The proximal landing zone was zone 2 in 2 patients, zone 3 in 7 patients in the early chronic group, zone 2 in 3 patients, and zone 3 in 13 patients in the late chronic group. Five patients in whom the proximal landing zone was zone 2 simultaneously underwent right and left axillary crossover bypass surgery. For reentry closure, a covered stent was placed in a unilateral renal artery, and an aorta extender was placed in the infrarenal abdominal aorta only in two patients with a true + false lumen diameter of ≥55 mm in the early chronic group. In the late chronic group, a covered stent was placed in a unilateral renal artery in 7 patients, an aorta extender was placed in the infrarenal abdominal aorta in 11 patients, an iliac extender was placed in a unilateral common or external iliac artery in 8 patients, and iliac extenders were placed in bilateral common or external iliac arteries in 2 patients. No covered stent was placed in the celiac or superior mesenteric artery for reentry closure (**Table 3**).

**Table 4** Early outcomes

| | Early chronic (n = 9) | Late chronic (n = 16) | p |
|---|---|---|---|
| Op duration (min) | 75 (51–124) | 125 (64–225) | 0.0054 |
| Blood loss (g) | 32 (0–42) | 62 (15–256) | |
| Contrast medium volume (ml) | 110 (60–155) | 217 (105–433) | 0.0032 |
| Fluoroscopy duration (min) | 9 (6–52) | 24 (9–94) | |
| ICU stay (day) | 1 | 1 | |
| Postop hospital stay (day) | 7 | 7 (6–13) | |
| Stroke | 0 | 0 | |
| Spinal cord ischemia | 0 | 0 | |
| In-hospital death | 0 | 0 | |
| Type 1a endoleak | 1 | 1 | |

**Table 5** Mid-term outcomes

| | Early chronic (n = 9) | | Late chronic (n = 16) | | p |
|---|---|---|---|---|---|
| F/U duration | 9 (1–48) | | 24 (6–54) | | NS |
| Thoracic false lumen | | | | | |
| Complete shrinkage | 6 | 77.8% | 2 | 68.8% | 0.005 |
| Shrinking ≥ 5 mm | 1 | | 9 | | NS |
| No change | 2* | | 2 | | |
| Enlargement ≥ 5 mm | | | 2 | | |
| Rupture | | | 1 | | |
| Type Ia endoleak | 1 | | 1 | | |
| re TEVAR | 2** | | 1 | | |

*F/U period less than 3 months.

**Marfan's syndrome underwent David's operation and AAA open repair before TEVAR.

TEVAR: thoracic endovascular aortic repair

The median operative duration was 75 (51–124) minutes in the early chronic group and 125 (64–225) minutes in the late chronic group, and the median contrast medium volume used was 110 (60–155) mL in the early chronic group and 217 (105–433) mL in the late chronic group. The operative duration was significantly longer, and the contrast medium volume used was significantly greater in the late chronic group (p = 0.0054, p = 0.0032). The X-ray irradiation time was 9 (6–52) minutes in the early chronic group and 24 (9–94) minutes in the late chronic group. The irradiation time in the latter group was longer, but the difference between the two groups was not significant. In both groups, the length of postoperative intensive care unit stay was 1 day, and the median length of postoperative hospital stay was 7 days, showing no differences. Postoperative cerebral and spinal cord infarctions were not observed, and there were no in-hospital deaths (**Table 4**).

The mean (median) duration of observation was 9 (1–48) months for the early chronic group and 24 (6–54) months for the late chronic group. Complete shrinkage of the thoracic false lumen was observed in 6 patients (67%) in the early chronic group and only 2 patients (13%) in the late chronic group, with a significantly higher complete shrinkage rate in the early chronic group (p = 0.005). Remodeling, including ≥5 mm shrinkage, was achieved in 7 patients (78%) in the early chronic group and 11 patients (69%) in the late chronic group, with no significant difference. There were no cases with enlargement of thoracic false lumen in the early chronic group, but 2 cases (13%) had ≥5 mm enlargement in the late chronic group. One of these patients had ruptured due to enlargement of the thoracic false lumen and underwent candy-plug placement in the thoracic false lumen and closure of the residual external iliac artery reentry on an emergency basis (**Table 5**).

**Table 6** Thoracic aorta remodeling and visceral branch originating from false lumen and re-entry (late chronic cases)

| | Univariate analysis p | Multiple logistic regression analysis p |
|---|---|---|
| CA from FL | 0.4281 | |
| SMA from FL | 0.7847 | |
| Rt. RA from FL | 0.2616 | |
| Lt. RA from FL | 0.7981 | |
| Infrarenal Ao re-entry | 0.4321 | |
| Rt. C/EIA re-entry | 0.0780 | NS |
| Lt. C/EIA re-entry | 0.0766 | 0.0558 |
| Postop type 1a endoleak | 0.0992 | NS |
| Postop CA from FL | 0.4281 | |
| Postop SMA from FL | 0.7847 | |
| Postop Rt. RA from FL | 0.7847 | |
| Postop Lt. RA from FL | 0.8679 | |
| Postop infrarenal Ao re-entry | 0.3279 | |
| Postop Rt. C/EIA re-entry | 0.3051 | |
| Postop Lt. C/EIA re-entry | 0.0003 | 0.0346 |

CA: celiac axis; SMA: superior mesenteric artery; RA: renal artery; Ao: aorta; C/EIA: common or external iliac artery

In 16 patients in the late chronic group, the preoperative abdominal visceral branch originating from the false lumen strongly suggests the presence of reentry at the root of the branch. Therefore, univariate analysis and multiple logistic regression analysis were performed based on whether the preoperative abdominal visceral branches were branched from the false lumen, whether there was the reentry of the infrarenal abdominal aorta and the left and right common and external iliac arteries, and whether there was type Ia endoleak postoperatively; reentry was considered not present when a covered stent was placed in the abdominal visceral branches, when an aorta extender was placed in the infrarenal abdominal aorta, and when iliac extenders were placed in the left and right common and external iliac arteries. Univariate analysis showed that preoperative left and right common

**Table 7** Relationship between re-entry and false lumen shrinkage (late chronic case)

| Case # | CA | SMA | Rt. RA | Lt. RA | Infra Ao | Rt. C/EIA | Lt. C/EIA | EL at discharge | pCA | pSMA | p rt. RA | p lt. RA | p infra Ao | p rt. C/EIA | p lt. C/EIA | Remodeling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | T | T | T | B | P | N | P | N | T | T | T | B | P | N | N | Shrinkage |
| 2 | T | T | T | T | P | P | P | N | T | T | T | T | P | P | P | Enlarge |
| 3 | T | T | T | T | P | P | P | N | T | T | T | T | P | P | N | Shrinkage |
| 4 | T | T | F | T | P | N | P | N | T | T | T | T | P | N | N | Shrinkage |
| 5 | T | T | T | T | N | N | P | N | T | T | T | T | N | N | N | Shrinkage |
| 6 | F | T | T | T | P | N | N | N | F | T | T | T | P | N | N | Stable |
| 7 | T | T | F | T | P | P | P | N | T | T | T | T | P | N | P | Enlarge |
| 8 | T | T | T | NA | P | P | P | N | T | T | T | NA | P | N | N | Shrinkage |
| 9 | F | T | F | T | N | N | N | N | F | T | F | T | N | N | N | Shrinkage |
| 10 | F | T | T | F | N | N | N | N | F | T | T | T | N | N | N | Shrinkage |
| 11 | T | T | T | T | P | N | P | N | T | T | T | T | N | N | N | Shrinkage |
| 12 | T | T | F | T | P | N | N | N | T | T | T | T | P | N | N | Shrinkage |
| 13 | T | T | B | B | P | P | P | P | T | T | T | B | P | N | P | Enlarge |
| 14 | T | T | T | T | P | P | P | N | T | T | T | T | P | N | N | Shrinkage |
| 15 | F | B | T | F | P | N | N | N | F | B | T | F | N | N | N | Shrinkage |
| 16 | T | T | F | T | P | P | N | N | T | T | T | T | N | P | N | Stable |

Blue characters show re-entry closure with stent grafts. Red characters show thoracic false lumen enlargement case with a visceral branch from the false lumen and re-entry in the infrarenal aorta or common/external iliac artery.
CA: celiac axis; SMA: superior mesenteric artery; RA: renal artery; Ao: aorta; C/EIA: common or external iliac artery; EL: endoleak; p: postop; T: branch from true lumen; F: branch from false lumen; B: branch from true and false lumen; NA: not available (post-nephrectomy); P: entry proved; N: no entry

and external iliac artery reentry and postoperative type Ia endoleak and left common and external iliac artery reentry tended to influence the remodeling of the thoracic false lumen. Multiple logistic regression analysis indicated that postoperative left common and external iliac artery reentry was the only factor significantly affecting remodeling ($p = 0.0346$) (**Table 6**). **Table 7** shows the individual cases. The three patients with enlarged thoracic false lumen had reentries in the infrarenal abdominal aorta and the left common and external iliac arteries postoperatively. All cases in which the thoracic false lumen shrank had no reentry in the left common or external iliac artery postoperatively, and the false lumen shrank even if reentry existed in the infrarenal abdominal aorta in some cases (**Table 7**).

## Discussion

Today, the efficacy of TEVAR for acute complicated TBD is well established. Furthermore, in early chronic uncomplicated TBD, factors predictive of thoracic false lumen enlargement in the near future, that is, high-risk indicators,[1] include the presence of an entry on the lesser curvature side on CT scan at the time of onset,[2] partial thrombosis of the false lumen,[3] true + false lumen diameter of ≥40 mm,[4] false lumen diameter of ≥22 mm,[5] and entry diameter of ≥10 mm,[6] and are considered good indications for preemptive TEVAR. We have also reported that complete remodeling can be achieved within 1 year after TEVAR in nearly 90% of patients with early cTBD.[7,8]

Meanwhile, indications in treatment of late cTBD were a true + false lumen diameter of ≥55 mm and an annual expansion of ≥4 mm in the 2013 European Expert Consensus, while they were a true + false lumen diameter of ≥60 mm and an annual expansion of ≥10 mm in the Japanese Circulation Society 2020 Guideline on Diagnosis and Treatment of Aortic Aneurysm and Aortic Dissection.[9] In any case, TEVAR for dissecting aortic aneurysms in the late chronic stage after the false lumen enlargement gives a lower rate of false lumen shrinkage than in the early chronic stage, even if thrombosis of the thoracic false lumen is achieved postoperatively. In the early chronic stage, entry closure by TEVAR alone, without reentry closure, results in shrinkage of the thoracic false lumen in 80%–90% of cases. This is because of upward blood flow in the false lumen from the larger reentry in the late chronic stage.[10] To address this problem, the candy-plug technique has been attempted to suppress upward blood flow in the false lumen.[11,12] Furthermore, there is a method to completely occlude the reentry with a fenestrated or branched stent graft for thoracoabdominal aortic aneurysm, but these medical materials have not been approved by the regulatory authorities, and there are many problems before they can be widely used in general.[13]

If reentry was present in the infrarenal abdominal aorta, an aorta extender was placed, and if reentry was present in the common or external iliac artery, an iliac extender was placed. If reentry was present in the infrarenal abdominal aorta, an aorta extender was placed, and if reentry was present in the common or external iliac artery, an

iliac extender was placed. When reentry exists in bilateral common and external iliac arteries, obstruction of bilateral internal iliac arteries by iliac extenders always results in the appearance and persistence of symptoms of gluteal claudication. Thus, we limited obstruction to one side in relatively young patients with TBD. In this study, univariate and multivariate analyses revealed that the presence of reentry in the left and right common and external iliac arteries tended to affect the remodeling of the thoracic false lumen more than preoperative reentry in the abdominal visceral branch roots and infrarenal abdominal aorta, namely the lumbar artery and inferior mesenteric artery roots, and the presence of reentry in the left common and external iliac arteries had the greatest influence on the remodeling. Of the 16 patients in the late chronic group, 1 patient had common and external iliac artery reentries on the right side only, 4 patients had the reentries on the left side only, and 6 patients had the reentries on both sides preoperatively. Among the 6 bilateral cases, the selected access vessel for TEVAR was the right common femoral artery in 4 cases and the left common femoral artery in 2 cases, and all cases of false lumen enlargement had residual left common and external iliac artery reentries after surgery. Therefore, it is essential to close the reentries in the left and right common and external iliac arteries to avoid a dissecting aortic aneurysm rupture. Moreover, closure of all reentries with fenestrated or branched stent grafts simultaneously with TEVAR may have a risk of inducing spinal cord ischemia.[13)]

Besides the upward blood flow from the reentry, factors related to the biological properties of the intimal flap, that is, vascular biology-related factors, may influence remodeling. Levels of decline in vessel wall compliance and thrombus regression in the thoracic false lumen in the late chronic stage may differ from those in the early chronic stage.

Peripheral stent graft sizing was 100%–110% in the early chronic cases and 100% in the late chronic cases to avoid oversizing and prevent distal SINE because the elasticity and compliance of the intimal flap in the late chronic stage were considered to be lower than those in the early chronic stage.

There were some limitations in the analysis due to a small number of cases because this was a single-center retrospective study. We await the results of future studies.

## Conclusion

In TEVAR for cTBD, complete shrinkage of the thoracic false lumen was achieved in 67% of the early-stage cases and 13% of the late-stage cases, with a significantly higher complete shrinkage rate in the early-stage cases. However, the remodeling rate of >5 mm did not differ between the two groups. In TEVAR for late cTBD, closure of reentries in the left common and external iliac arteries was considered the most important factor in promoting mid-term false lumen remodeling.

## Ethical Statement

This study was approved by the Research Ethics Review Committee of Kansai Medical University Hospital on June 27, 2023 (reference number 2023004).

## Disclosure Statement

All authors and co-authors have no conflicts of interest.

## Author Contributions

Study conception: Masato Ohno
Data collection: all authors
Data analysis: all authors
Investigation: all authors
Manuscript preparation: Masato Ohno
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors.

## References

1) Dake MD. An algorithmic strategy for the evaluation and management of type B dissections. Endovascular Today 2014; **13**: 42–52.
2) Loewe C, Czerny M, Sodeck GH, et al. A new mechanism by which an acute type B aortic dissection is primarily complicated, becomes complicated or, remains uncomplicated. Ann Thorac Surg 2012; **93**: 1215–22.
3) Tsai TT, Evangelista A, Nienaber CA, et al. Partial thrombosis of the false lumen in patients with acute type B aortic dissection. N Engl J Med 2007; **357**: 349–59.
4) Kato M, Bai H-Z, Sato K, et al. Determining surgical indications for acute type B dissection based on enlargement of aortic diameter during the chronic phase. Circulation 1995; 92 Suppl: II107–12.
5) Song J-M, Kim S-D, Kim J-H, et al. Long-term predictors of descending aorta aneurysmal change in patients with aortic dissection. J Am Coll Cardiol 2007; **50**: 799–804.
6) Evangelista A, Salas A, Ribera A, et al. Long-term outcome of aortic dissection with patent false lumen: predictive role of entry tear size and location. Circulation 2012; **125**: 3133–41.
7) Mizoguchi T, Zempo N, Kaneda Y. Early and mid-term outcomes following TEVAR for chronic type B aortic dissection. Jpn J Vasc Surg 2016; **25**: 233–9. (in Japanese)
8) Mizoguchi T, Zempo N, Kaneda Y. Early and mid-term outcomes following TEVAR for chronic type B aortic dissection. Ann Vasc Dis 2017; **10**: 345–50.
9) JCS. 2020Guideline on Diagnosis and Treatment of Aortic Aneurysm and Aortic Dissection. https://www.j-circ.or.jp/cms/wp-content/uploads/2020/07/JCS2020_Ogino.pdf.

10) Roselli EE, Sepulveda E, Pujara AC, et al. Distal landing zone open fenestration facilitates endovascular elephant trunk completion and false lumen thrombosis. Ann Thorac Surg 2011; **92**: 2078–84.
11) Kölbel T, Lohrenz C, Kieback A, et al. Distal false lumen occlusion in aortic dissection with a homemade extra-large vascular plug: the candy-plug technique. J Endovasc Ther 2013; **20**: 484–9.
12) Miletic KG, Kindzelski BA, Hodges KE, et al. Impact of endovascular false lumen embolization on thoracic aortic remodeling in chronic dissection. Ann Thorac Surg 2021; **111**: 495–501.
13) Kitagawa A, Greenberg RK, Eagleton MJ, et al. Fenestrated and branched endovascular aortic repair for chronic type B aortic dissection with thoracoabdominal aneurysms. J Vasc Surg 2013; **58**: 625–34.