CASE REPORT

Successful carotid artery stenting with a double-layer micromesh stent for spontaneous extracranial internal carotid artery dissection: a case report

Taro Okumura[1,2], Kenichi Hattori[2], Hisashi Hatano[2], Shigeru Fujitani[2],
Kentaro Wada[2], Yoshiki Sato[2] and Masahiro Wakabayashi[2]

[1]*Department of Neurosurgery, Nagoya University Graduate School of Medicine, Nagoya, Japan*
[2]*Department of Neurosurgery, Japanese Red Cross Aichi Medical Center Nagoya Daiichi Hospital, Nagoya, Japan*

ABSTRACT

Extracranial internal carotid artery dissection is a relatively rare disease in Japan. We herein report a case of a 60-year-old woman with spontaneous left internal carotid artery dissection with a dilated and dissected cavity. Following the identification and measurement of the true and false lumens using intravascular ultrasound, a double-layer micromesh stent (Casper stent; Microvention, Terumo, Tustin, CA, USA) was deployed for post-dilation. No perioperative complications were observed, and the patient was discharged on postoperative day 6.

Keywords: double-layer micromesh stent, extracranial carotid artery dissection, carotid artery stenting

Abbreviations:
CAS: carotid artery stenting
IVUS: intravascular ultrasound

INTRODUCTION

Extracranial internal carotid artery dissection is a relatively rare disease in Japan. Takagi reported that cerebral artery dissections occur predominantly in the vertebrobasilar artery system (83%) and carotid artery system (17%) and that intracranial carotid dissections account for approximately half of all carotid dissections.[1] However, with the widespread adoption of screening tests for the cervical carotid artery, we are more likely than ever to encounter asymptomatic extracranial internal carotid artery dissections, which are considered a risk factor for ischemic stroke and aneurysm formation. With regard to stenotic lesions, there is no contraindication to

surgical intervention in cases of progressive stenosis or symptomatic cases after ischemic stroke. Nevertheless, there are no established treatment strategies for dilated lesions, and there are many reports of carotid artery stenting (CAS), coil embolization, and follow-up being used as a treatment strategy.[2,3] However, for the treatment of intracranial cerebral aneurysms, flow diverter devices are widely used, and good initial results have been reported for dissecting lesions.[4]

We herein report a case of extracranial internal carotid artery dissection with a false lumen, which had expanded to approximately 10 mm, that was successfully treated with CAS using a double-layer micromesh stent (Casper stent; Microvention, Terumo, Tustin, CA, USA) instead of a conventional stent.

CASE PRESENTATION

A 60-year-old woman presented to our hospital with a chief complaint of headache. There were no relevant characteristics in her medical history or history of trauma. She had been aware of left occipital pain for several years, although the pain had worsened in the past month; thus, she visited her doctor. There were no symptoms other than a headache. Magnetic resonance angiography showed wall irregularity and dilation of the left extracranial internal carotid artery, suggestive of dissection (Fig. 1). There were no foci of cerebral infarction in the cranium. Spontaneous extracranial internal carotid artery dissection was suspected, and cerebral angiography revealed a double-lumen sign with entry several millimeters distal to the carotid bifurcation. The maximum dilation of the false lumen reached approximately 10 mm (Fig. 2A). There was no discernible reentry, and the false lumen had a blind-end structure. Three-dimensional computed tomography angiography was also performed, although the entire false lumen was visualized, and there was no discernible thrombus formation. Two treatment options were presented to the patient: continued medical treatment or CAS, and the patient opted for CAS.
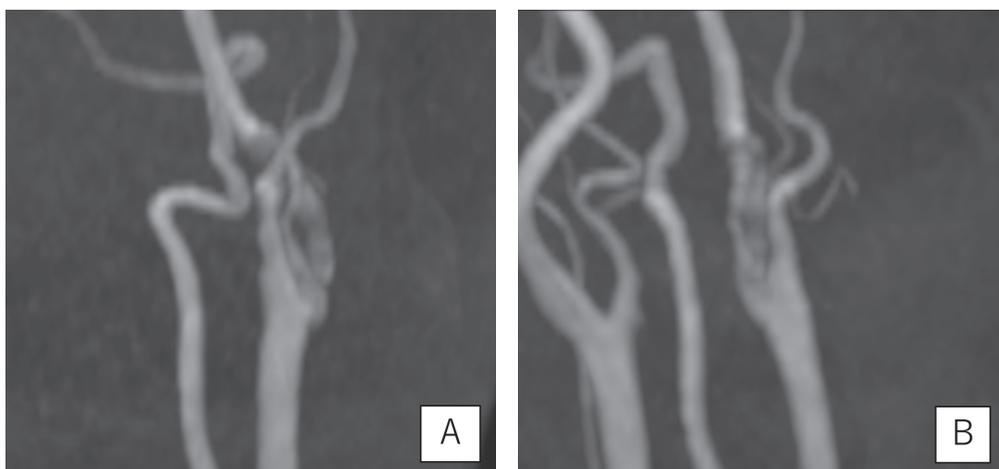

Fig. 1 Neck magnetic resonance angiography
Enlarged vessel diameter is observed with a dissected cavity in the left internal carotid artery.
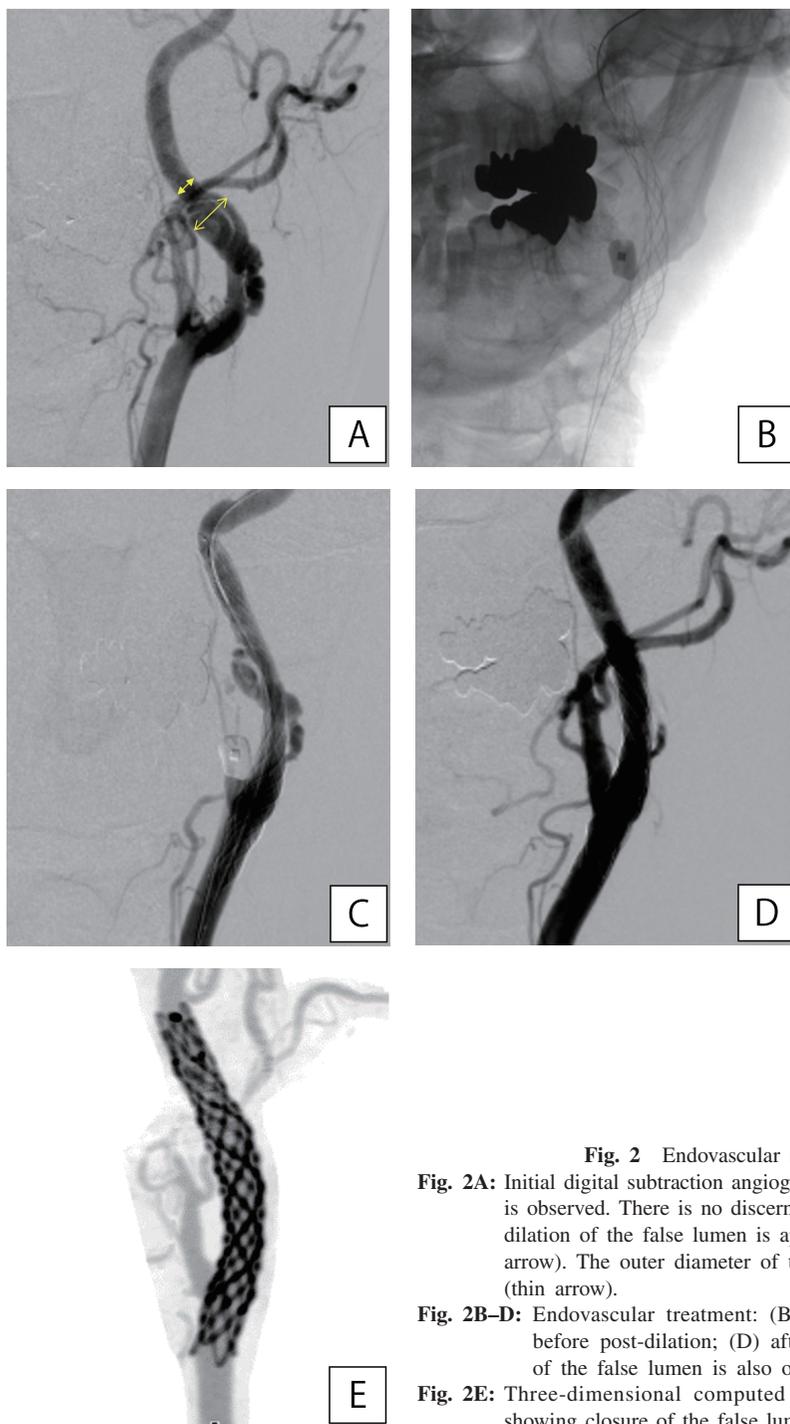**Fig. 1A:** Frontal view
Fig. 1B: Lateral view

Fig. 2 Endovascular treatment

Fig. 2A: Initial digital subtraction angiography. A double-lumen sign is observed. There is no discernible reentry. The maximum dilation of the false lumen is approximately 10 mm (thick arrow). The outer diameter of the distal vessel is 5.6 mm (thin arrow).

Fig. 2B–D: Endovascular treatment: (B) Casper deployment; (C) before post-dilation; (D) after post-dilation. Shrinkage of the false lumen is also observed.

Fig. 2E: Three-dimensional computed tomography angiography showing closure of the false lumen on postoperative day 5.

Endovascular treatment

Aspirin (100 mg) and clopidogrel (75 mg) were administered daily for 2 weeks before the scheduled surgery. At the time of admission, platelet aggregation was considerably inhibited by MCM Hema Tracer 712 (MC Medical, Tokyo, Japan). Surgery was performed under local anesthesia (Fig. 2B–D). A 9-Fr sheath with a length of 25 cm was inserted into the right femoral artery to guide a Mo.Ma Ultra proximal cerebral protection device (Medtronic, Minneapolis, MN, USA) from the left external carotid artery to the common carotid artery. A 4-Fr sheath with a length of 25 cm was inserted into the left femoral vein to allow for flow reversal during proximal protection, and a Chikai 14 micro-guidewire (Asahi Chikai 14; Asahi Intecc, Nagoya, Japan) was guided into the suspected true lumen. Intravascular ultrasound (IVUS) was performed using an IVUS catheter (Volcano Corporation, San Diego, CA, USA) to identify and to measure the true and false lumens (Fig. 3). A 9×30-mm Casper catheter was implanted without pre-dilation under proximal protection with the Mo.Ma device. After temporal removal of the protection, while the true lumen was soundly widened and the blood flow in the false lumen was reduced, digital subtraction angiography revealed the entire false lumen, and IVUS showed that a part of the Casper catheter was not expanded. Therefore, under proximal protection, a 5×20-mm Sterling PTA balloon catheter (Boston Scientific, Marlborough, MA, USA) was used to dilate the entire stented area of the internal carotid artery at 8 atm for 20 s. After post-dilation, digital subtraction angiography and IVUS were performed again, and the procedure was completed after confirming that the false lumen had almost completely disappeared, with only a small amount of blood flow at the entry point.
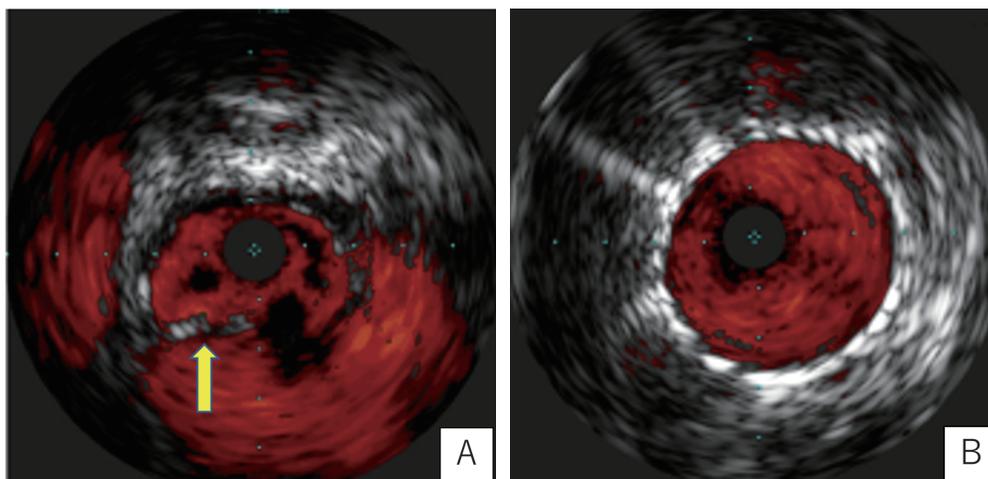

Fig. 3 Intravascular ultrasound
Fig. 3A: An intimal flap is floating (arrow) before stenting.
Fig. 3B: Post-dilation performed after stenting. The false lumen is reduced.

Postoperative course

There were no postoperative neurologic abnormalities, and no foci of new cerebral infarctions were found on diffusion-weighted magnetic resonance images. Carotid ultrasonography performed on the day after the surgery revealed the absence of blood flow into the false lumen. On postoperative day 5, three-dimensional computed tomography angiography revealed that the

contrast medium, which remained in the false lumen at the entry site immediately after surgery, had disappeared (Fig. 2E). The patient had a good postoperative course and was discharged with a modified Rankin scale score of 0 on postoperative day 6.

The chief complaint of headaches had disappeared.

DISCUSSION

The possible causes of internal carotid artery dissection include a history of infection, trauma, medical origins, connective tissue diseases such as Ehlers-Danlos syndrome, or fibromuscular dysplasia.[5-8] An elongated styloid process has also been reported to be involved in carotid artery dissection.[9] In the present case, the styloid process was 32 mm long, slightly longer than normal (Fig. 4). However, since the styloid process and entry of the dissection were far apart, the involvement of the styloid process was determined to be small. Therefore, since there were no other predisposing factors, the patient was diagnosed with spontaneous internal carotid artery dissection.

Fig. 4 Computed tomography coronal section of the head and neck
A 32-mm left stalk is observed (arrows).

The surgical indications for extracranial internal carotid artery dissection are controversial. Endovascular treatment is considered for patients who are refractory to drugs, have experienced stroke complications, or have contraindications to antithrombotic therapy as the criteria for surgical treatment.[3] Houser et al reported that approximately 80% of cases with spontaneous carotid artery dissection showed complete remission or improvement, whereas 20% of these cases resulted in progressive stenosis or complete occlusion.[10] With regard to extracranial carotid artery dissection with stenosis, surgical treatment is considered for cases in which the stenosis progresses, or ischemic stroke occurs and becomes symptomatic. On the other hand, there is no established treatment for lesions with a dilated false lumen because the prognosis and natural

history of these lesions are still unknown. However, it is necessary to be careful when selecting a treatment strategy because reports have shown the progression of aneurysm-like dilatation during follow-up of the carotid artery dissection.[11] Though our plan was to perform CAS if the aneurysm dilation progressed after continuing medical treatment, CAS was performed in this case because the patient strongly agreed to it, following our proposal.

In previous reports, the single-layer Carotid Wallstent (Boston Scientific, Natick, MA, USA; Schneider, Minneapolis, MN, USA) was frequently used for the stenting of internal carotid artery dissections.[9] Although the effectiveness of the Casper stent for internal carotid artery stenosis has been demonstrated in reports outside Japan,[12] there have been no reports of its use for extracranial internal carotid artery dissection.

The Casper stent is a double-layer stent that combines an outer-layer stent and a fine-mesh inner-layer stent to inhibit plaque encroachment into the lumen of the vessel.[13] It has been reported that the flow diverter effect can be observed by stacking the LVIS stent (MicroVention-Terumo, Tustin, CA, USA) even when a flow diverter is not used.[14] In the present case, it is suspected that the fine mesh inner layer stent acted as a flow diverter to reduce the blood flow into the false lumen. In addition, we expected to observe the flow diverter effect since the Casper stent's mesh design is finer than the Wallstent.

The Casper stent also has the characteristics of a closed-cell stent, which allows for more straightening of the vessel after stenting. In the present case, the direction of blood flow into the false lumen at the entry site existed as the terminal type before stenting (Fig. 2A). However, after stenting, the direction of blood flow changed to the side wall type (Fig. 2C) due to straightening of the vessel. We believe this was also hemodynamically effective in reducing blood flow into the false lumen. Although preoperative ultrasonography, three-dimensional computed tomography angiography, and digital subtraction angiography showed no obvious thrombus in the false lumen, it was practically impossible to rule out the presence of a thrombus; thus, a finer mesh stent was desired to prevent thrombus dispersal into the blood vessels. For the above reasons, we preferred the Casper stent over conventional stents in this case.

Furthermore, we used flow reversal in addition to proximal protection. Maximum protection was deemed necessary because it was practically impossible to rule out the presence of a thrombus. The PROFI study by Bijuklic et al reported that proximal balloon occlusion is more effective than filter protection in reducing thrombus dispersal during CAS.[15] In addition, the double-layer Casper stent (Terumo, Tokyo, Japan) was reported to be more effective than the Wallstent in reducing microembolization when performing CAS, and the combined use of the former with proximal protection further reduced microembolization.[16] In the present case, flow reversal was used, as a precaution, in addition to the combined use of proximal protection and double-layer stents, resulting in a successful procedure.

IVUS is useful for measuring vessel diameter and identifying plaque characteristics during CAS. In the present case, IVUS was performed to identify the false and true lumens as well as the normal internal carotid artery diameter distal to the dissection. The intima-media complex of the normal vessel was observed to be in continuity with the dissection flap, forming a normal dissection structure in which the internal elastic lamina is disrupted and the tunica media ruptures. However, the maximum dilation of the false lumen was beyond the measurement range of IVUS, and accurate measurement was not possible. The cervical carotid artery has an external elastic lamina and is considered structurally robust, unlike cerebral blood vessels. However, endovascular surgery was selected in this case for several reasons. First, as the maximum dilation was > 10 mm, there was a high risk of the dissection cavity evolving into an aneurysm in the future. Second, it has been reported that the load on the flap is higher in patients with no reentry in the aorta than in patients with reentry.[17] Therefore we speculated that, since no reentry was found

in our case, the load on the flap was likely to be higher, which amplified the concern that the dissection cavity might expand in the future.

In the present case, the diameter of the distal internal carotid artery was 5.6 mm, and the total dissection length was 30 mm. The 9×30-mm Casper stent was selected because it has an effective length of 43 mm and a total length of 58 mm when placed at a diameter 2 mm smaller than the outer diameter of the stent, according to the manufacturer's instruction. After stent deployment, the flow remained in the entire false lumen; thus, a 5×20-mm Sterling catheter was used to post-dilate the entire length of the stent three times at 8 atm for 20 s, and IVUS was performed again. As a result, the flow in the false lumen was substantially reduced. Because the diameter of the false lumen was larger than that of the implanted Casper stent, it was speculated that the stent did not push the flap toward the outer membrane and occlude the false lumen; rather, the adherence of the Casper stent inhibited the blood flow into the false lumen due to the micromesh effect. Since the false lumen was expected to thrombose spontaneously, no additional treatment was performed. Postoperative carotid ultrasonography and three-dimensional computed tomography angiography confirmed the closure of the false lumen.

We preferred the Casper stent over conventional stents in this case. If we consider only the effect of blocking blood flow to the false lumen, a stent graft can be considered an option. There are case reports of internal carotid artery aneurysms successfully treated with Viabahn (W.L. Gore, Flagstaff, AZ, USA) implantation.[2] However, although stent grafting is expected to close the false lumen better, there is a concern that it may increase the risk of restenosis. Eugenio et al reported that the 1-year postoperative restenosis rate of Casper stents implanted in the internal carotid artery was approximately 4%,[12] whereas Takao et al reported that the 1-year postoperative restenosis rate of Viabahn stents implanted in the shallow femoral artery was approximately 12%,[18] which means that stent grafting is an inferior option in terms of restenosis rate.

It is believed that there is some conflict between the flow diverter effect as defined by pore size and restenosis rate, and a desirable stent should meet the eclectic requirements of both factors. In the West, stents with a smaller pore size than the Casper, such as CGuard (InspireMD, Tel Aviv, Israel), have been used clinically,[12] and appropriate selection of patients will be necessary when they are introduced in Japan in the future.

LIMITATIONS

Although the Casper has a high mesh density and can be expected to serve as a flow diverter, the microcatheter cannot pass through the mesh. Therefore, adding coils will be difficult if the dissected false lumen does not disappear after stenting or if the dissecting space increases after stenting. If additional treatment is needed, endovascular therapists will have no option other than stent layering.

Accumulation of cases is needed, as only a small number of patients have undergone Casper stenting for extracranial internal carotid artery dissection and long-term follow-up data are lacking.

CONCLUSION

We reported a case of spontaneous extracranial internal carotid artery dissection with a dilated and dissected cavity that was successfully treated with the Casper stent.

ACKNOWLEDGEMENT

DISCLOSURE STATEMENT

The authors declare no conflicts of interest associated with this manuscript.

REFERENCES

1 Takagi M. Cerebral arterial dissection [in Japanese]. *No To Shinkei*. 2006;58(11):963–970.

2 Chen Z, Chen L, Zhang J, et al. Management of extracranial carotid artery aneurysms: A 6-year case series. *Med Sci Monit*. 2019;25:4933–4940. doi:10.12659/MSM.914374.

3 Pham MH, Rahme RJ, Arnaout O, et al. Endovascular stenting of extracranial carotid and vertebral artery dissections: a systematic review of the literature. *Neurosurgery*. 2011;68(4):856–866. doi:10.1227/NEU.0b013e318209ce03.

4 Yoshimura S. Clinical evidence of flow diverters. *J Neuroendovascular Therapy*. 2017;11(3):165–172. doi:10.5797/jnet.ra-diverter.2016-0007.

5 Hovsepian DA, Sriram N, Kamel H, Fink ME, Navi BB. Acute cerebrovascular disease occurring after hospital discharge for labor and delivery. *Stroke*. 2014;45(7):1947–1950. doi:10.1161/STROKEAHA.114.005129.

6 Koleilat I, Gandhi R, Boulos A, Bonville D. Traumatic bilateral carotid and vertebral artery dissection. *J Emerg Trauma Shock*. 2014;7(1):47–48. doi:10.4103/0974-2700.125640.

7 Debette S, Leys D. Cervical-artery dissections: predisposing factors, diagnosis, and outcome. *Lancet Neurol*. 2009;8(7):668–678. doi:10.1016/S1474-4422(09)70084-5.

8 Schievink WI. Spontaneous dissection of the carotid and vertebral arteries. *N Engl J Med*. 2001;344(12):898–906. doi:10.1056/NEJM200103223441206.

9 Raser JM, Mullen MT, Kasner SE, Cucchiara BL, Messe SR. Cervical carotid artery dissection is associated with styloid process length. *Neurology*. 2011;77(23):2061–2066. doi:10.1212/WNL.0b013e31823b4729.

10 Houser OW, Mokri B, Sundt TM, Baker HL, Reese DF. Spontaneous cervical cephalic arterial dissection and its residuum angiographic spectrum. *AJNR Am J Neuroradiol*. 1984;5(1):27–34.

11 Uno H, Ueda S, Shinno K, Nishitani K. Management and long-term follow-up results in patients with carotid artery dissection [in Japanese]. *Neurolog Surg*. 1997;25(5):417–423.

12 Stabile E, de Donato G, Musialek P, et al. Use of dual-layered stents for carotid artery angioplasty 1-year results of a patient-based meta-analysis. *JACC Cardiovas Interv*. 2020;13(14):1709–1715. doi:10.1016/j.jcin.2020.03.048.

13 Diaz O, Lopez G, Roehm JO, De la Rose G, Orozco F, Almeida R. The Casper carotid artery stent: a unique all metal micromesh stent designed to prevent embolic release. *J Neurointerv Surg*. 2018;10(2):133–136. doi:10.1136/neurintsurg-2016-012913.

14 Wang C, Tian Z, Liu J, et al. Flow diverter effect of LVIS stent on cerebral aneurysm hemodynamics: a comparison with Enterprise stents and the Pipeline device. *J Transl Med*. 2016;14(1):199. doi:10.1186/s12967-016-0959-9.

15 Bijuklic K, Wandler A, Hazizi F, Schofer J. The PROFI Study (Prevention of Cerebral Embolization by Proximal Balloon Occlusion Compared to Filter Protection During Carotid Artery Stenting): a prospective randomized trial. *J Am Coll Cardiol*. 2012;59(15):1383–1389. doi:10.1016/j.jacc.2011.11.035.

16 Montorsi P, Caputi L, Galli S, et al. Carotid Wallstent versus Roadsaver stent and distal versus proximal protection on cerebral microembolization during carotid artery stenting. *JACC Cardiovasc Interv*. 2020;13(4):403–414. doi:10.1016/j.jcin.2019.09.007.

17 Canchi S, Guo X, Phillips M, et al. Role of re-entry tears on the dynamics of type B dissection flap. *Ann Biomed Eng*. 2018;46(1):186–196. doi:10.1007/s10439-017-1940-3.

18 Ohki T, Kichikawa K, Yokoi H, et al. Outcomes of the Japanese multicenter Viabahn trial of endovascular stent grafting for superficial femoral artery lesions. *J Vasc Surg*. 2017;66(1):130–142.e1. doi:10.1016/j.jvs.2017.01.065.