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Case Report

Asymptomatic Complete Spiral Stent Fracture in Subclavian Artery with Progressive Restenosis in the Early Postoperative Period: A Case Report

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Objective: Stent fractures may be a risk factor for delayed restenosis, but it is difficult to diagnose asymptomatic stent fractures in the subclavian artery (SCA). We report a rare case of percutaneous transluminal angioplasty and stenting (PTAS) for SCA stenosis with asymptomatic severe stent fracture that showed progressive in-stent stenosis in the early postoperative period.

Case Presentation: A 70-year-old woman presented with left arm claudication. Magnetic resonance imaging at the time of admission showed SCA stenosis with severe calcification. Because of the left subclavian steal phenomenon on ultrasonography of the left vertebral artery, she underwent PTAS using a balloon-expandable stainless stent. Ultrasonography the day after treatment showed appropriate stent placement. Computed tomography angiography (CTA) 30 days after PTAS showed an asymptomatic complete spiral stent fracture at the mid-portion of the stent. The in-stent stenosis then gradually progressed on follow-up ultrasonography at the site of the stent fracture. Nine months after the first PTAS, a second PTAS using a self-expandable nitinol stent was performed because the peak systolic velocity exceeded 300 cm/s on Doppler ultrasound. Two years after the second PTAS, no neurological symptoms and no stent deformation were observed.

Conclusion: PTAS with a balloon-expandable stainless stent for SCA stenosis with severe calcification may lead to stent fracture. In the case of severe stent fracture, careful follow-up may be needed for the detection of asymptomatic in-stent stenosis in the early postoperative period.

Keywords asymptomatic stent fracture, subclavian artery, percutaneous transluminal angioplasty and stenting, calcification, balloon-expandable stent

Introduction

Percutaneous transluminal angioplasty with stenting (PTAS) for subclavian artery (SCA) stenosis is a useful revascularization, especially for proximal SCA stenosis, because the SCA is large and easily accessible with the femoral or brachial approach. However, the durability of these devices is unknown, and many reports refer to stent fractures and in-stent restenosis. There are only a few reports of complete stent fractures in the SCA that led to symptomatic in-stent stenosis and pseudoaneurysms,[1–4] but detection of asymptomatic SCA stent fractures may be difficult. A rare case of an asymptomatic, severe stent fracture in an SCA with progressive restenosis in the early postoperative period is presented, and the mechanism of stent fracture is discussed.

Case Presentation

A 70-year-old woman with hypertension and hyperlipidemia was admitted with a 2-month history of left upper limb claudication. Her left radial pulse was weaker than her right one. Left brachial blood pressure was 85/52 mmHg, but that of the right one was 138/82 mmHg. Magnetic

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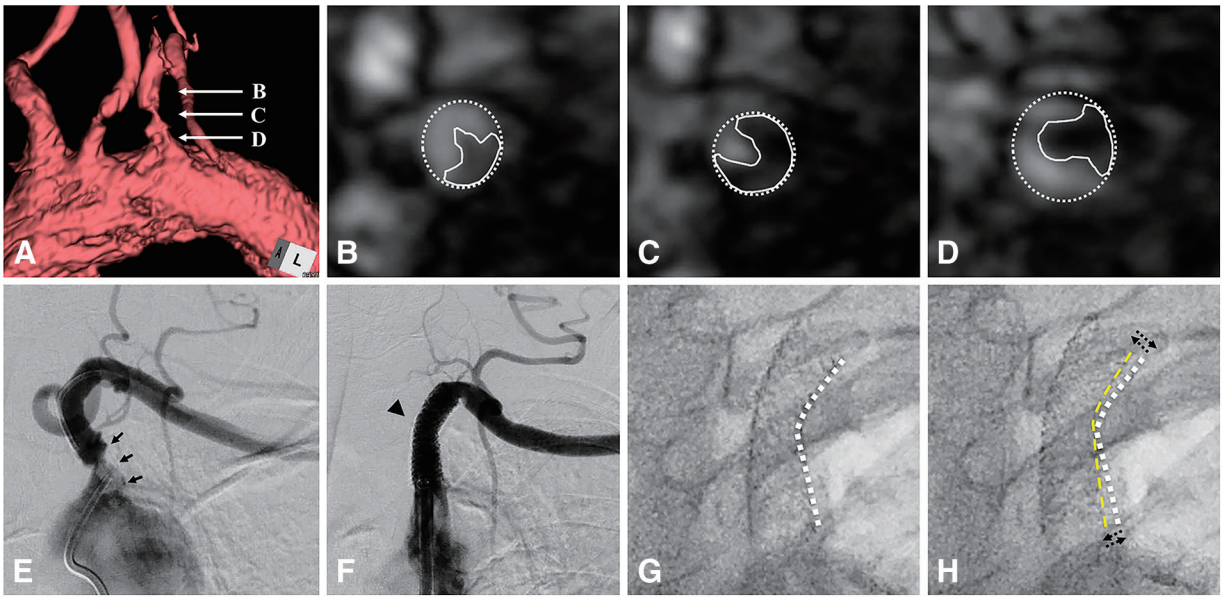

Fig. 1 MRA volume rendering images at the time of admission (**A**) show left SCA stenosis. The white arrows B, C, and D indicate the axial-section images of the two-dimensional time-of-flight MRA (**B**), (**C**), and (**D**), respectively. The axial view of the MRA (**B–D**) shows a twisted lesion with severe calcification (hypo-intensity regions within the white line). Preoperative angiography (**E**) shows left SCA stenosis with the origin calcification (black arrow). Postoperative angiography (**F**): The SCA stenosis improves after a balloon-expandable stainless stent is deployed, but the twisted proximal SCA is straightened, and the left VA is asymptomatically occluded (arrowhead). On postoperative fluoroscopy, the dotted line represents the lesser stent curve for the flexed stent (**G**), and the dashed line represents the lesser stent curve for the extended stent (**H**). In these findings, moderate hinge motion is seen at the mid-portion of the implanted stent with the pulsation of the SCA (**G**, **H**: dashed arrows). SCA: subclavian artery; VA: vertebral artery

resonance angiography (MRA) with the volume rendering technique showed severe stenosis of the left proximal SCA (**Fig. 1A**). The axial view of the two-dimensional time-of-flight MRA showed severe twisted calcification at the origin of the SCA (**Fig. 1B–1D**). PTAS was performed for symptomatic SCA stenosis.

Endovascular treatment

A bolus of 5000 IU of heparin was administered intravenously. Under local anesthesia, 6-Fr Parent Plus (Medikit, Tokyo, Japan) was inserted into the orifice of the left SCA at the right femoral artery approach, and 4-Fr sheath was inserted into the left brachial artery. A snare wire with a 7-mm diameter loop (Goose-Neck Snare; Medtronic, Minneapolis, MN, USA) was introduced through the left brachial artery into the left SCA. A 0.035-inch 300-cm guidewire was inserted from the 6-Fr Parent Plus. The 0.035-inch guidewire was guided through the stenotic lesion and into the left brachial artery, then the tip of the guidewire was passed through the loop of the snare wire. The 0.035-inch guidewire was captured in the left brachial artery and pulled out of the left brachial 4-Fr sheath. Under this pull-through system, pre-percutaneous transluminal angioplasty (PTA) balloon (6 mm × 40 mm, Mustang; Boston Scientific, Marlborough, MA, USA) was inflated at 10 atm pressure, and a stainless balloon-expandable stent (8 mm × 27 mm, Express LD; Boston Scientific) was deployed at 8 atm pressure in a position where it did not protrude into the aorta without left vertebral artery (VA) protection (**Fig. 1E** and **1F**). Postoperative angiography showed good angiographic dilatation, but the twisted vessel was straightened and the left VA was asymptomatically occluded (**Fig. 1F**). On postoperative fluoroscopy, moderate hinge motion was observed at the mid-portion of the implanted stent with the pulsation of the SCA (**Fig. 1G** and **1H**).

Postoperative clinical course

Follow-up Doppler ultrasound the day after PTAS showed normal peak systolic velocity (PSV) and antegrade flow of the VA (**Fig. 2A** and **2B**). Fluoroscopic examination and Computed tomography angiography (CTA) with the volume rendering technique 30 days after PTAS demonstrated a complete spiral stent fracture (**Fig. 2C–2G**). Because it was an asymptomatic stent fracture, it was followed conservatively. On follow-up Doppler ultrasound 3 to 9 months after PTAS, PSV at the fractured stent increased gradually (**Fig. 2H** and **2I**).

Despite the asymptomatic stent fracture, the in-stent stenosis gradually worsened on Doppler ultrasound, and

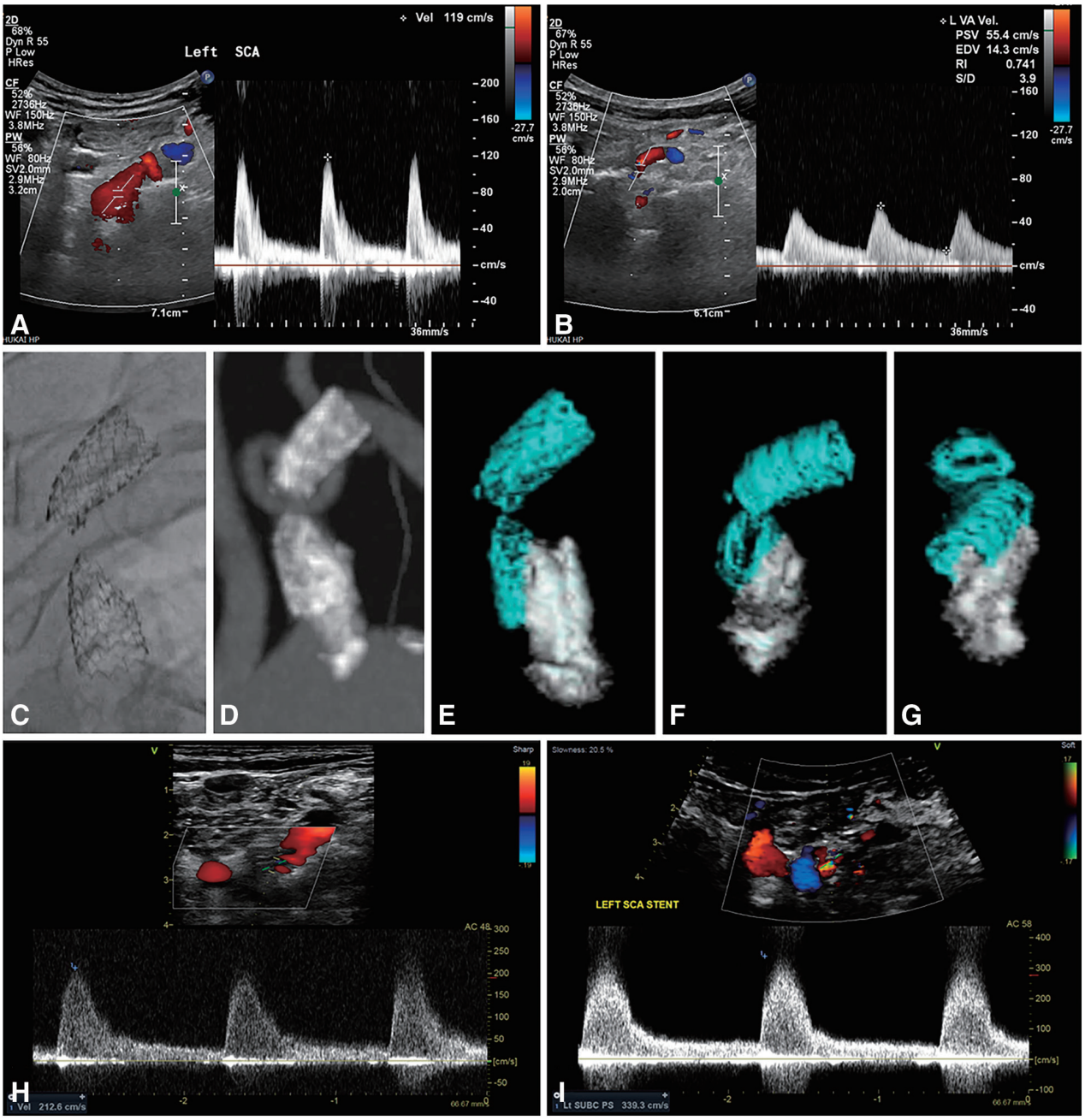

Fig. 2 Follow-up Doppler ultrasound the day after initial PTAS shows a normal PSV (**A**) and antegrade flow of the VA (**B**). Imaging 30 days after PTAS on fluoroscopy (**C**) and CTA on the maximum intensity projection image (**D**) show a stent fracture at the mid-portion. CTA of the volume rendering images shows a crushed and twisted stent with severe calcification (**E**: posterior-anterior view, **F**: cranial view, **G**: caudal view). Follow-up Doppler ultrasound 3 months (**H**) and 9 months (**I**) after PTAS shows progressively increased PSV at the fractured stent (212.6–339.3 cm/s). CTA: computed tomography angiography; PSV: peak systolic velocity; PTAS: percutaneous transluminal angioplasty and stenting; VA: vertebral artery

the left radial pulse was weaker than the right one; thus, the patient retreated. Although there was a risk of ischemic complication associated with the left VA occlusion when the stent-in stent was performed, an additional PTAS without left VA protection was planned for the second treatment because of ischemic tolerance to the left VA occlusion.

Second endovascular treatment

A bolus of 5000 IU of heparin was administered intravenously. Under local anesthesia, 6-Fr ASAHI FUBUKI Dilator Kit (ASAHI INTECC. CO., LTD., Aichi, Japan) was inserted into the orifice of the left SCA at the right femoral artery approach, and 5/6-Fr Glidesheath Slender

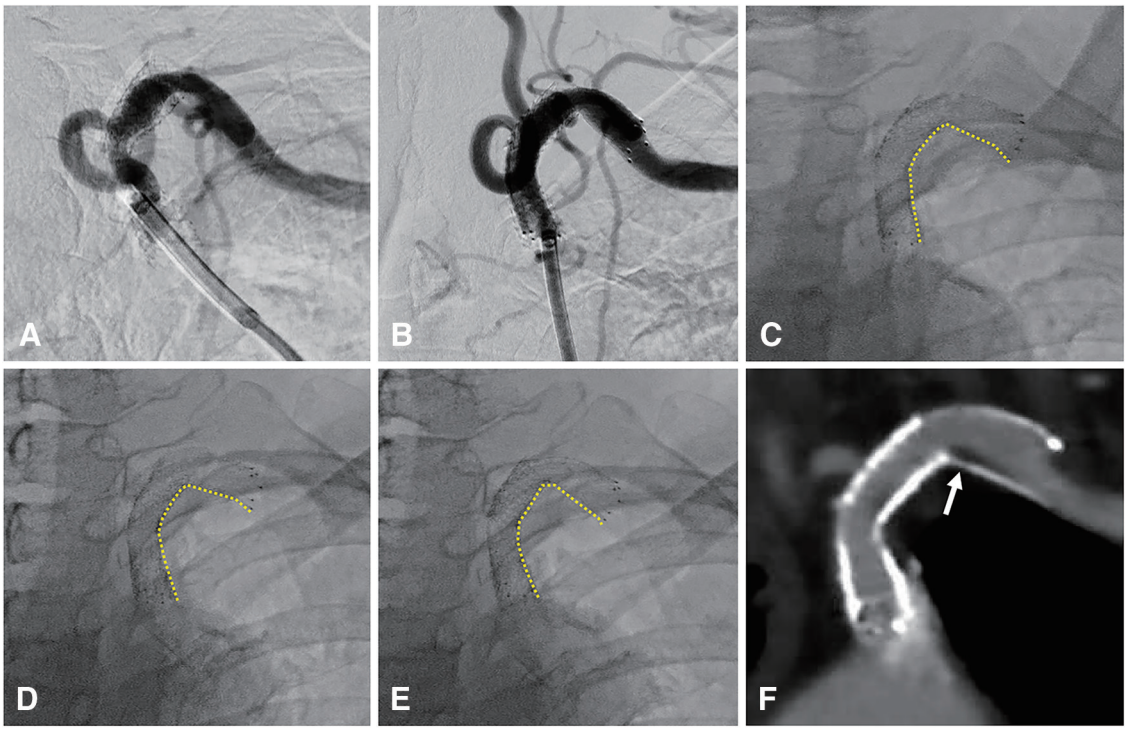

Fig. 3 Preoperative angiography at the time of the second PTAS shows slow flow in the VA and in-stent stenosis due to stent fracture and intimal hyperplasia (**A**). Postoperative angiography of the second PTAS shows that the in-stent stenosis and blood flow in the VA have improved (**B**). Follow-up fluoroscopy the day after the second PTAS shows no stent deformation. In addition, the implanted stents do not show a hinge motion with upper limb movement (**C** and **D**) but have an apparent hinge motion with SCA pulsation (**D** and **E**). Follow-up CTA on the coronal section image two years after the second PTAS shows excellent patency, no stent re-fracture (**F**), but mild intimal hyperplasia at the site of hinge motion (white arrow). CTA: computed tomography angiography; PTAS: percutaneous transluminal angioplasty and stenting; SCA: subclavian artery; VA: vertebral artery

(Terumo, Tokyo, Japan) was inserted into the left brachial artery. On preoperative angiography, a stent fracture was identified slightly distal to the previously treated stenosis site, and in-stent stenosis due to stent deformation and intimal hyperplasia was observed at the fractured part. Under the pull-through system as the first treatment, a pre-PTA balloon (7 mm × 40 mm, SHIDEN HP, KANEKA Medics, Osaka, Japan) was inserted from 6-Fr. FUBUKI and inflated at 10 atm pressure. A self-expandable stent (10 mm × 40 mm, S.M.A.R.T. CONTROL; Cordis, Miami Lakes, FL, USA) was retrogradely inserted from 5/6-Fr Glidesheath Slender and deployed in a position where it did not protrude into the aorta (**Fig. 3A** and **3B**).

Clinical course of the second postoperative period

Fluoroscopy the day after the second PTAS did not show stent deformation due to upper limb movement (**Fig. 3C** and **3D**), but it showed hinge motion with SCA pulsation (**Fig. 3D** and **3E**). Two years after the second PTAS, there were no symptoms and no stent deformation, but mild intimal hyperplasia was observed at the site of the hinge motion on CTA (**Fig. 3F**).

Discussion

A rare case of a complete spiral stent fracture with rapid progression of in-stent stenosis after PTAS for SCA stenosis was described. There have been no reports of rapid progression of in-stent restenosis in a severe stent fracture that was closely followed up.

Stent fractures are not rare complications after PTAS in various vascular sites: 1.6%–28.8% of coronary arteries, 1.7%–65.5% of superficial femoral arteries, 15.1%–37.2% of femoropopliteal arteries, 7.7%–25.0% of vertebral arteries, and 5.4%–29.0% of carotid arteries.[5–7] The incidence of stent fractures has been associated with long lesions, twisted lesions, severe calcified lesions, and frequently pulsating lesions.[4,8] Stainless steel stents, long stents, multiple stents, and overlapping stents were also correlated with stent fractures.[9]

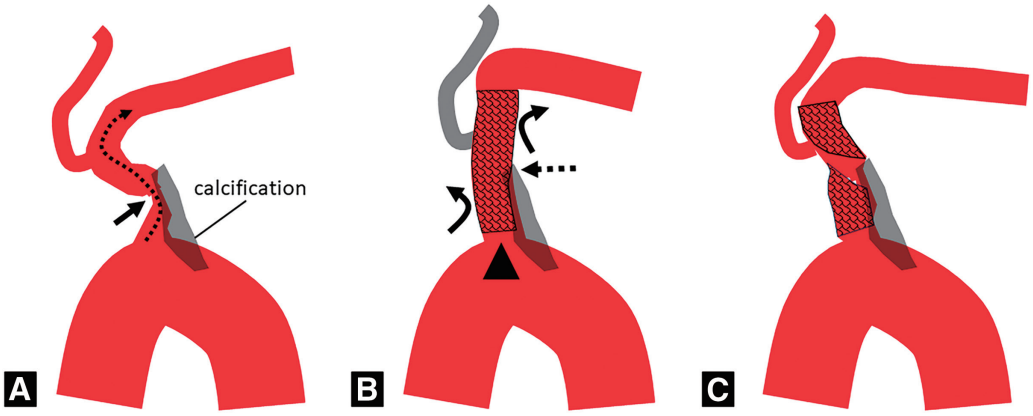

Fig. 4 Schema of factors causing stent fracture. (**A**) A stenotic lesion (arrow) and the axis of the vessel (dashed arrow) are in a torsional position. (**B**) The stenotic lesion and vessel were straightened after stent placement. The burden of returning to the torsional position (arrow), the local anchoring force due to severe calcification (dashed arrow), and continuous pulsation (arrowhead) combined to cause hinge motion in the middle portion of the stent. (**C**) Because the balloon-expandable stent lacked flexibility, repeated, hinging motions caused spiral fracture due to metal fatigue at the distal site of calcification.

Jaff et al. reported the classification of stent fractures in the femoropopliteal territory into five types: type I (single strut fracture); type II (multiple strut fractures without deformation); type III (multiple strut fractures with deformation); type IV (multiple strut fractures with acquired transection but without gap); and type V (multiple strut fractures with acquired transection with a gap in the stent body, or stent fracture in a transaxial spiral configuration).[10] In some reports, more than type III complex/severe stent fractures were rare, and such cases are associated with symptomatic in-stent stenosis or pseudoaneurysms.[1–5]

Hüttl et al. reported the incidence of stent fracture in 108 patients who underwent PTA for SCA, in which 38 cases of stent fracture were observed: including 89.5% (34 of 38 patients) with balloon-expandable stents and 10.5% (4 of 38 patients) with self-expandable nitinol stents.[2] In this report, SCA stent fractures occurred in 35.2% of patients undergoing PTAS, and they were assessed by a previous classification: type I in 12.0%, type II in 11.1%, type III in 5.6%, type IV in 3.7%, and type V in 2.8%.[10] They noted that a high incidence of SCA stent fractures was associated with long lesions and severe calcified lesions. According to some previous reports, the primary patency rates were significantly worse, and balloon-expandable stents were used more often in patients with complex stent fractures (types III–V) than with simple stent fractures (types I and II).[2,10]. In addition, isolated cases of delayed pseudoaneurysm formation at the SCA severe stent fracture were also reported.[3,4] Whether to follow up conservatively, repeat PTAS (balloon-expandable stainless stent or self-expandable nitinol stent) or open revascularization is controversial in the management of stent fractures.[1–4]

In the present case, the first PTAS was performed with a balloon-expandable stainless stent, which was not a long stent. In addition, fluoroscopy after PTAS demonstrated no deformation of the stent due to movement of the left upper limb, but hinge motion in the mid-portion of the stent was observed due to pulsation. This means that the movement and posture of the upper limb do not always lead to compression and deformation of the implanted stent in the SCA, which may be related to the anatomical relationship between the SCA and adjacent bone structures (i.e., clavicle and first rib). There was at least no relationship between stent fracture and compression with the adjacent bone structures in the present case. Furthermore, SCA stenosis involved a twisted vessel and severely calcified lesions; this twisted vessel was once straightened just after PTAS, but the straightened vessel returned to the original twisted shape with a type V stent fracture in 30 days. The cause of early in-stent stenosis may have been narrowing at the fractured part of the stent and the development of intimal hyperplasia caused by intimal injury due to severe stent fracture. Then, we considered the stent fracture in the present case may be due to metal fatigue associated with the poor flexibility of a balloon-expandable stainless stent, a twisted vessel, severe calcification, and the hinge motion with continuous pulsation (**Fig. 4**).

When PTAS using a balloon-expandable stainless stent is performed for a twisted lesion with severe calcification,

the implanted stent may be fractured in the early postoperative period due to poor flexibility. In these cases, even for asymptomatic stent fractures, close follow-up is needed to prevent symptomatic stent-related adverse events, such as in-stent restenosis and pseudoaneurysms.

Conclusion

A rare case of an asymptomatic complete spiral stent fracture after PTAS for SCA stenosis was presented. PTAS using a balloon-expandable stainless stent for twisted vessels with severely calcified lesions may lead to stent fracture in the early postoperative period. In such cases, even for asymptomatic stent fractures, close follow-up is needed because in-stent restenosis may progress rapidly.

Disclosure Statement

None of the authors have any conflicts of interest to disclose regarding this article.

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