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Case Report

Prevention of Stroke with Closed-Cell Stent-in-Stent for Carotid Artery Stenosis Due to Stent Fracture

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Objective: Stent fracture is a risk factor for stroke. It has not been fully elucidated whether stent-in-stent procedures can effectively treat stent fractures.

Case Presentation: An 80-year-old man underwent carotid artery stenting (CAS) with an open-cell stent to treat asymptomatic right internal carotid artery (ICA) stenosis. Type III stent fracture occurred during CAS. Six months later, in-stent stenosis progressed on DSA. Repeat CAS with a closed-cell stent was performed. CT showed expansion of the narrowed lumen. The patient remained stroke-free and carotid artery restenosis did not occur for 3 years postoperatively.

Conclusion: Repeat CAS with a closed-cell stent is a viable treatment option for stent fracture.

Keywords ▶ carotid artery stenosis, restenosis, stent fracture, stent deformity, stroke prevention

Introduction

Stent fracture and deformation are complications of carotid artery stenting (CAS), as it can lead to in-stent stenosis and stroke.[1] The stent-in-stent technique has been tested for the treatment of stent fracture[2,3]; however, its ability to prevent future strokes is unclear. The present study reports a case of successful stroke prevention for 3 years after repeat CAS for stent fracture with a closed-cell stent.

Case Presentation

An 80-year-old man was referred to our neurosurgery department for asymptomatic right internal carotid artery (ICA) stenosis detected on screening echocardiography during a hospital stay for acute myocardial infarction. The patient underwent CAS under local anesthesia. The results of preoperative DSA and CTA are depicted in **Fig. 1**. The diameter of right common carotid artery (CCA) was 7.2 mm, that of right ICA was 4.9 mm, and that of the lesion was 1.3 mm. Prior to surgery, the patient was on dual antiplatelet therapy. An 8-Fr Optimo Balloon Guiding Catheter (Tokai Medical Products, Kasugai, Aichi, Japan) was placed in the right CCA using a right femoral artery approach. A Carotid GuardWire PS (Medtronic, Minneapolis, MN, USA) was then deployed to the right ICA for distal protection. The lesion was pre-dilated with a Genity 3.0 × 40-mm (Kaneka Medix, Osaka, Japan). A Precise 10 × 40 mm (Cordis, Santa Clara, CA, USA) was deployed over the ICA to the CCA. The lesion was then post-dilated with an Aviator Plus 4.0 × 20-mm balloon (Cordis). On DSA after post-dilation, stent fracture was observed (**Fig. 2A**). The stent lumen was not narrowed on DSA (**Fig. 2B**). The CAS procedure was finished without causing any neurological symptoms. Algatroban and ozagrel sodium were initiated and kept on the patient for 2 days. Dual antiplatelet therapy was continued thereafter. Postoperative MRI did not detect any brain infarction.

Six months later, follow-up DSA and cone-beam CT showed in-stent stenosis at the site of stent deformity (**Fig. 3A**–**3C**). The patient was free from strokes and transient ischemic attacks at that time. Repeat CAS was then performed on the patient. Informed consent was obtained for experimentation with human subjects. With the same approach as was used in the first procedure, an 8-Fr Optimo

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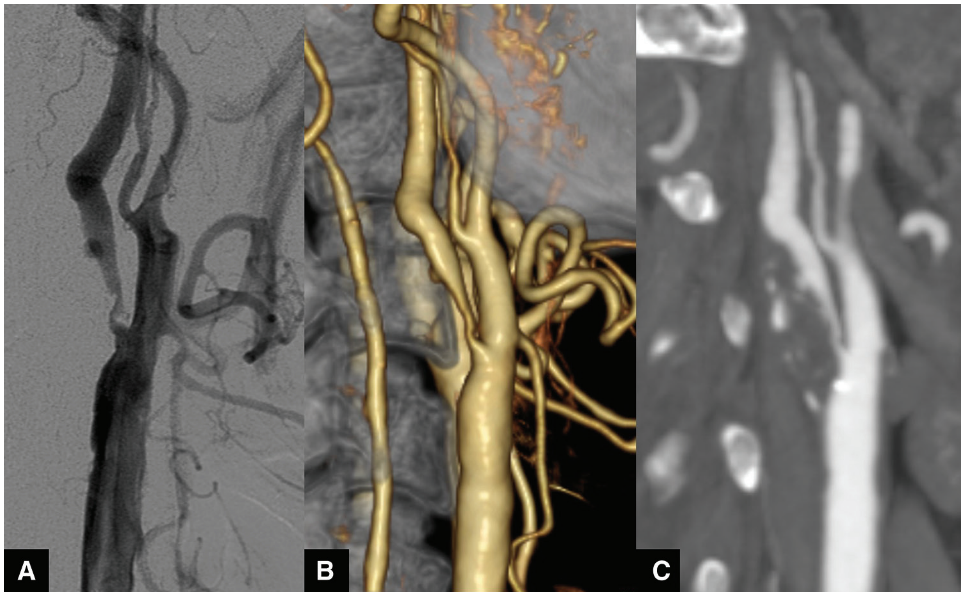

Fig. 1 Preoperative DSA (**A**) and CTA (**B, C**) reveal stenosis of the ICA and the CCA. Calcification is observed at the site of stenosis (**C**). CCA: common carotid artery; ICA: internal carotid artery

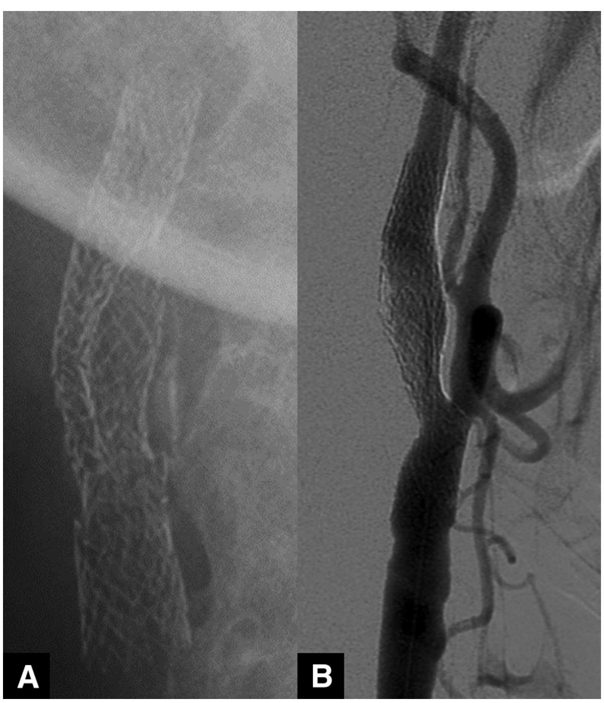

Fig. 2 Stent fracture is seen on postoperative X-ray (**A**). Improved blood flow on DSA (**B**).

Balloon Guiding Catheter was deployed to the CCA and a Guardwire was placed in the ICA. The diameter of right CCA was 7.5 mm and that of right proximal ICA was 6.5 mm. The fractured stent is depicted in a 3D fashion (**Fig. 3F**). Balloon percutaneous transluminal angioplasty (PTA) was performed with an Aviator Plus 4.0 × 20-mm balloon, followed by a Genity 6.0 × 20-mm. In-stent stenosis did not improve after PTA. Therefore, a Wallstent 10 × 24-mm carotid stent (Wallstent; Boston Scientific, Natick, MA, USA) was deployed. Post-dilation was performed using a Genity 6.0 × 20 mm. Postoperative DSA cone-beam CT showed expansion of the narrowed lumen (**Fig. 3D**, **3E**, and **3G**). Algatroban was initiated and kept on the patient for 2 days. Dual antiplatelet therapy has been on the patient so far. Postoperative MRI did not detect any brain infarction. The patient's postoperative course was uneventful. The latest carotid artery duplex scan examined 3 years after repeat CAS did not show carotid artery restenosis (**Fig. 4**).

Discussion

In the current case of stent fracture, we identified two important clinical results. First, when stent deformity leads to in-stent stenosis, repeat CAS is effective to prevent strokes in the medium term. Second, a closed-cell stent is a useful device that can be used to expand the narrowed lumen after stent fracture.

The stent-in-stent technique is effective for stroke prevention in patients with progressive carotid artery restenosis caused by stent fracture. Stent fracture and deformity are not uncommon CAS device complication.[4,5] Although a randomized trial did not identify an association between stent fracture and stroke,[6] other publications have

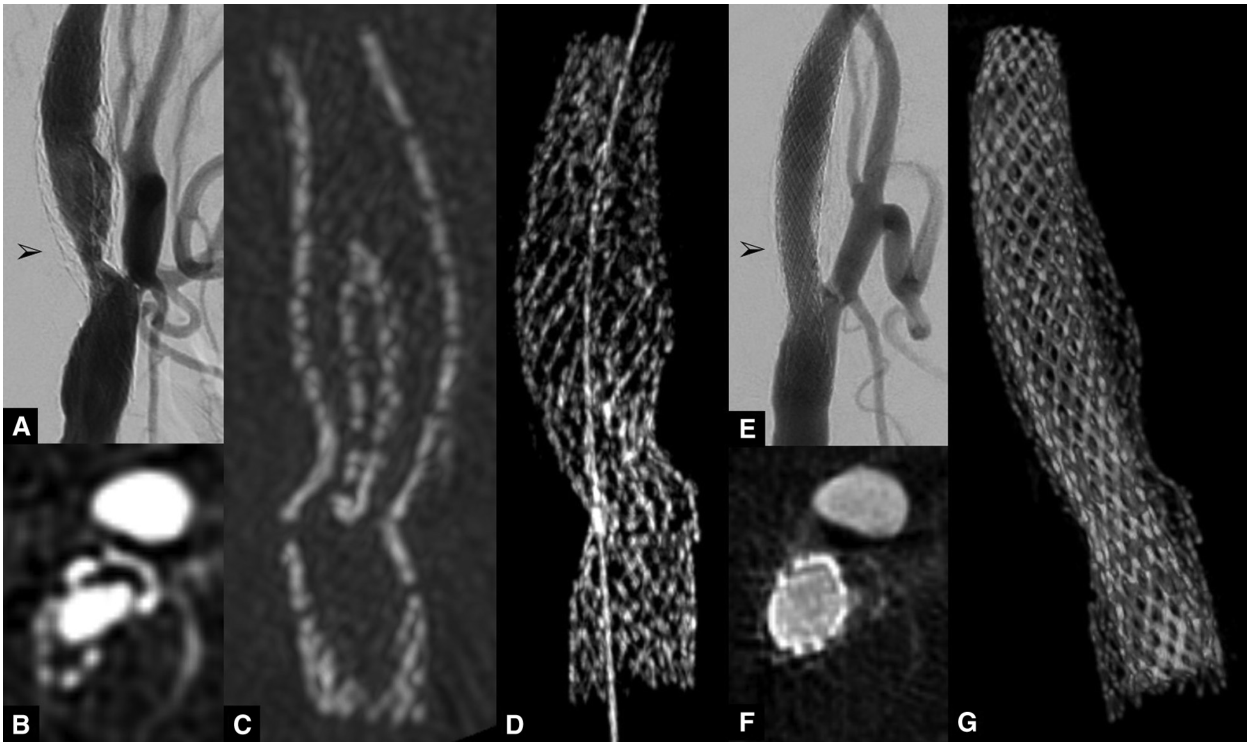

Fig. 3 On DSA (**A**), the stent lumen is markedly narrowed compared with that observed in **Fig. 2B**. Cone-beam CT (**B**) depicts the cross-section at the arrowhead (**A**). Illustration of the lateral view of a stent fracture at the site of calcification by CT (**C**). In-stent stenosis is effectively improved on postoperative angiography (**E**). Cone-beam CT (**F**) depicts the cross-section at the arrowhead (**E**). A 3D view (**G**) depicts the expansion of the narrowed lumen (**D**).

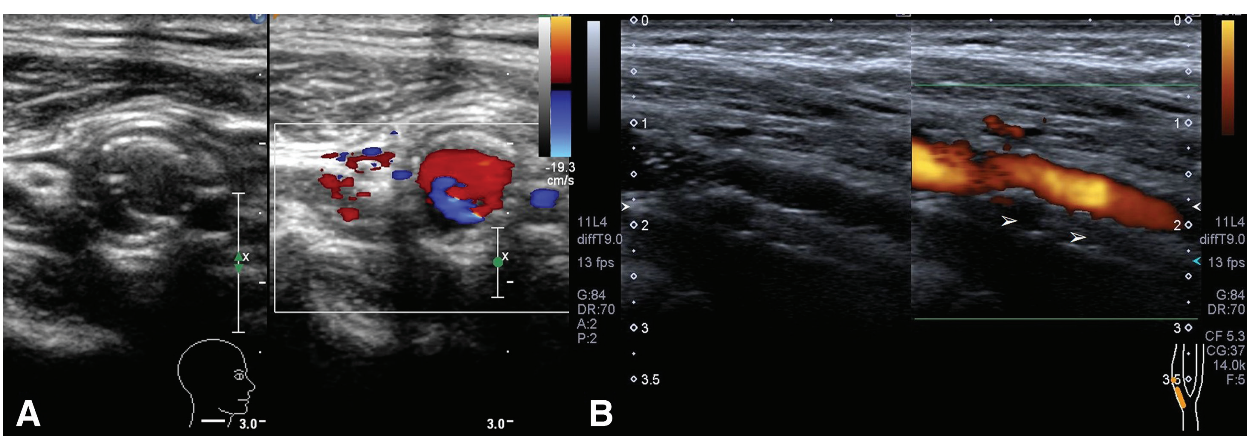

Fig. 4 The latest carotid artery duplex scan depicts an expanded lumen of the right carotid artery (**A**: a short-axis view, **B**: a long-axis view, arrowheads: the space between Precise and Wallstent).

demonstrated the possibility of restenosis[7] and stroke events.[1] The management of stent fracture or deformity is divided into observation with anti-platelet agents,[1] surgical removal,[8] and repeat CAS.[2,3] At first, close follow-up with dual antiplatelet therapy was chosen in the present case because stent fracture did not immediately cause carotid artery restenosis. Close follow-up revealed progression of the in-stent stenosis after 6 months due to which repeat CAS was performed. To the best of our knowledge, this is the longest follow-up case report of repeat CAS for stent fracture.

A closed-cell stent is useful to expand the in-stent stenosis caused by open-cell stent fracture. Open-cell stents are more flexible than closed-cell stents because the free-cell areas between struts are larger.[9] In spite of their flexibility, folding deformation of open-cell stents occur when excessive pressure is on them. The deformation of PROTÉGÉ and PRECISE has been reported to establish at the site of calcification[10,11] or of a thick shaft of a protection device.[12] When the non-uniform pressure is on an open-cell strut, it tends to fold inwardly. In the current case, calcification was the risk of stent deformation, and post-dilation seems to have induced the deformation. On the other hand, the strut configuration of closed-cell stents may provide better scaffolding to vessels compared with open-cell stents.[13] Here, we place more emphasis on scaffolding than flexibility because the in-stent vessel lumen is relatively straight. Besides, the radial force was proved to be stronger in Wallstent than that in Precise or in Protégé.[14] With a stronger radial force, the better it seems for a stent to stand the compression during the operative procedure. Once an open-cell stent is fractured, it is reasonable to utilize a differently designed stent with balloon dilation to add a greater radial force.

The present case demonstrates the possibility of preventing future stroke events in patients with carotid artery stent fracture. In cases of stent deformity, close follow-up is necessary to detect progressive restenosis, which can be safely treated using a closed-cell stent placement. With the advent of new stent devices, further reports should be accumulated to determine the optimal stent device for re-stenting.

Conclusion

In conclusion, repeat CAS with a closed-cell stent is a viable treatment option for progressive in-stent stenosis caused by stent fracture.

Acknowledgment

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Disclosure Statement

The authors declare that they have no conflict of interest.

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