Efficacy of Stenting for High Cervical Internal Carotid Artery Dissection Presenting with Cerebral Ischemia: A Report of Three Cases

Mai Azumi,1 Shunji Matsubara,1 Keita Kinoshita,1 Satoshi Hirai,1 Nobuhisa Matsushita,1 Hiroyuki Toi,1 Mami Hanaoka,3 Osamu Takimoto,2 Masaaki Obayashi,2 Shinji Nagahiro,3 and Masaaki Uno1

Objective: In this report, three patients with cervical internal carotid artery dissection (cICAD) successfully treated with stenting are presented, and the relevant literature is discussed.

Case Presentations: Case 1: A 47-year-old man developed dysarthria, right facial palsy, right paresthesia, and left photophobia lasting for half an hour. MRI showed no new infarction, but angiography demonstrated a severe high cervical internal carotid artery (ICA) stenosis with a false lumen. He underwent stenting on the 9th day, and the lesion disappeared completely. His postoperative course was uneventful, and no recurrence has been observed to date. Case 2: A 34-year-old man noted episodes of mild headache and a transient left visual field defect and was brought to the hospital by ambulance. Initial diffusion-weighted MRI showed left ICA occlusion. Although his symptoms improved with iv rt-PA, global aphasia and right hemiparesis occurred after 4 h. Since his emergent DSA showed left cICAD with nearly complete occlusion, he underwent stenting. His symptoms improved dramatically, and he recovered fully in 3 months. Case 3: A 63-year-old man developed two transient episodes of mild right hemiparesis. Due to his recurrent symptoms, DSA was performed, and dissection was found at left cervical ICA of C1 level. Endovascular intervention with a stent was conducted, and no recurrence has been observed to date.

Conclusion: Endovascular intervention using stent may play an important role in patients with cICAD having severe stenosis or recurrent ischemic stroke.

Keywords ➤ cervical internal carotid artery dissection, stent angioplasty, ischemic stroke

Introduction

Cervical internal carotid artery dissection (cICAD) is a relatively rare disorder. While its incidence is lower in Japan than in Western countries, it is a cause of juvenile cerebral infarction, and its diagnosis and treatment in the acute period are important. Medical treatment is the first choice, and the course is favorable in about 75% of the patients,13 but some patients are resistant to medical treatments. There have been various reports of revascularization by stent placement as an alternative for medical treatment, but diagnostic imaging in the acute period or perioperative management has not been fully established. We report three patients in whom revascularization was successfully achieved by stent placement with a review of the literature.

Case Presentation

Case 1
The patient was a 47-year-old man who suddenly noted dysarthria, drooping of the right angle of the mouth, hypesthestia of the right upper extremity, and photophobia of the left eye. The symptoms persisted for about 30 min and disappeared. On the same day, the patient consulted a local physician and was emergently admitted. At the initial examination, a diagnosis
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of the left internal carotid artery stenosis was made by head MRI, and cerebral angiography and $^{123}$I-IMP-SPECT were subsequently performed. SPECT showed a decrease in the blood flow of the left cerebral hemisphere. Cerebral angiography demonstrated marked stenosis in a high region of the internal carotid artery, and the patient was referred to our hospital for treatment on the 8th day after the onset. He had no history of trauma or experience of contact sports but had a habit of rotating the neck.

**Symptoms on admission**
The Glasgow Coma Scale was 15 (E4V5M6), and cranial nerve palsy or motor paralysis was negative.

**Imaging findings**
Concerning the findings on diagnostic imaging, head MRI performed by the previous physician showed no new cerebral infarction, but the delineation of the left internal carotid artery and middle cerebral artery was poor on MRA (Fig. 1A), and marked stenosis was noted in a high portion of the cervical internal carotid artery on CTA (Fig. 1B). Cerebral angiography performed on the day of admission to our hospital (the 8th day after the onset) revealed high long-segment cervical internal carotid artery stenosis in the frontal view of the left common carotid arteriography and an intimal flap in the bilateral 45° oblique views (Figs. 1C and 1D), and delineation of intracranial vessels was delayed. A diagnosis of cervical internal carotid artery dissection was made. The primary site of the lesion was above the origin of the internal carotid artery and was at the level of the 2nd to the 1st cervical vertebra (Fig. 1E). In 3-D maximum intensity projection (MIP) images, a flap-like structure was noted at the level of the 2nd cervical vertebra (Figs. 2A–2C), and marked stenosis was noted at the level of the 1st cervical vertebra (Figs. 2D and 2E).
confirmatory angiography after the end of devascularization showed stenosis persisting near the stent, a second Precise 6 mm × 30 mm was deployed by overlapping it by about 5 mm again under protection. Stenosis was completely relieved (Fig. 2F), and delay of intracranial blood flow disappeared (Fig. 2G). No perioperative complications were noted, and the patient was discharged on the 17th day after the onset with a modified Rankin Scale (mRS) score of 0. Five months after discharge, no recurrence of ischemic symptoms had been noted, and delineation of intracranial vessels was satisfactory on head MRA.

**Case 2**

The patient was a 34-year-old man who suddenly developed headache and transient visual impairment. Since right hemiplegia appeared after 14 h, the patient consulted a local physician. He was diagnosed with cerebral infarction associated with pseudo-occlusion of the left internal carotid artery by head MRI, and intravenous tissue plasminogen activator (t-PA) therapy was performed. While the symptoms were temporarily alleviated, they were exacerbated after 4 h, and the patient was transported to our hospital for additional treatment.
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The patient had no history of trauma or experience of contact sports.

Symptoms on admission
The Glasgow Coma Scale was 14 (E4V4M6), and right hemiparesis and motor aphasia were noted.

Imaging findings
Head MRI performed at our hospital showed fresh cerebral infarction in the left cerebral hemisphere in diffusion weighted images (DWI) (Figs. 3A and 3B) and extensive decrease in blood flow in the area supplied by the left middle cerebral artery in perfusion weighted images (PWI) (Fig. 3C) with a DWI/PWI mismatch. Emergency cerebral angiography showed high cervical internal carotid artery stenosis from the C1 level to the orifice of the internal carotid canal on left carotid arteriography, a string sign presumably indicating dissection, and a marked delay in the intracranial blood flow (Figs. 3D and 3E).

Fig. 3  (A and B) Diffusion-weighted images show extensive infarction in the left internal border zone. (C) Perfusion-weighted image (PWI) shows hypoperfusion of the whole left middle cerebral artery territory. (D and E) Preoperative left carotid arterial angiograms (lateral view) demonstrate severe stenosis at mainly C1 level (arrow). (F and G) Postoperative angiograms show complete reconstruction of the stenotic lesion (arrow). (H) Postoperative PWI shows sufficient perfusion of the left cerebral hemisphere after stenting.
A cerebral infarction, stenosis was noted in the left high cervical internal carotid artery. While he was treated by oral administration of aspirin at 100 mg and clopidogrel at 75 mg, a similar transient ischemic attack (TIA) occurred after 1 month, and the patient was urgently transported again.

History of trauma
He was bruised in the chest due to a traffic accident 3 years before, but there was no trauma in the neck region. He used to play golf until 10 years before. He had a habit of rotating the neck.

Condition at present
The Glasgow Coma Scale was 15 (E4V5M6), and cranial nerve palsy and motor paralysis were negative.

Therapeutic course
To salvage the extensive reversible ischemic area, revascularization surgery was judged to be necessary, and, after loading with aspirin 200 mg and clopidogrel 300 mg, emergency stenting was decided to be performed. With a road-map, PercuSurge GuardWire (Medtronic, Minneapolis MN, USA) was advanced across the lesion, and distal protection was made in the petrous segment of the internal carotid artery. After predilation using a PTA balloon (Savvy, Johnson and Johnson) 3.5 mm × 40 mm, Precise 8 mm × 30 mm was deployed (Fig. 3F). The stenotic lesion was relieved and the intracranial blood flow was significantly recovered (Fig. 3G). Postoperative PWI confirmed the improvement of blood flow in the left cerebral hemisphere (Fig. 3H). No perioperative complications were observed, and the patient was discharged with only mild motor aphasia persisting and an mRS score of 1. The symptoms were completely resolved after 3 months.

Case 3
The patient was a 63-year-old man. As transient paraplegia of the right upper and lower extremities appeared, he was transported emergently. Although head MRI showed no fresh cerebral infarction, stenosis was noted in the left high cervical internal carotid artery. While he was treated by oral administration of aspirin at 100 mg and clopidogrel at 75 mg, a similar transient ischemic attack (TIA) occurred after 1 month, and the patient was urgently transported again.
Therapeutic course
Since ischemic symptoms recurred even during antiplatelet therapy, an indication for revascularization was judged to be present, and stent placement was performed 3 months after the initial attack (2 months after the 2nd attack). Since cerebral angiography performed immediately before the procedure showed 80% stenosis of the left internal carotid artery (North American Symptomatic Carotid Endarterectomy Trial (NASCET)) at the C1 level and a flap-like structure in the 45° left anterior oblique view, cervical internal carotid artery dissection was strongly suspected (Figs. 4C and 4D). Also, the double lumen sign could be confirmed in 3D MIP images (Figs. 4E–4H), and a diagnosis of dissecting lesion was made. In revascularization, a roadmap was prepared in the working angle that allowed observation of the true lumen (45° left anterior oblique view), and the true lumen was secured with PercuSurge GuardWire. PercuSurge GuardWire was guided to the petrous portion of the internal carotid artery, distal protection was performed, and, after predilation with a PTA balloon (Jackal RX: Kaneka Medix, Osaka) 3.0 mm × 40 mm, Precise 6 mm × 30 mm was placed (Fig. 4I). Stenosis was relieved, and adequate blood flow into the cranium was restored. No perioperative complications were observed, and the patient was discharged with an mRS score of 0. There have been no ischemic attacks during a 4-year follow-up period after discharge.

Discussion
Table 1 summarizes the three cases presented in this report. In all three patients, the lesion was seated primarily in the cervical internal carotid artery at and around the C1 level, and the disorder occurred without a clear history of cervical trauma. Stenting could be completed without perioperative ischemic complications by using antiplatelet drugs from before surgery and performing the procedure under protection.

Internal carotid artery dissection is classified into ICAD with underlying disorders, such as trauma and Marfan syndrome, and unexplained idiopathic ICAD with no underlying disorders. However, the ICAD has been reported to have occurred after coughing or sports, such as swimming, and mild overstretching or flexion of the neck has been suggested to cause the disorder. In the three patients reported here, also, there was no clear history of trauma or underlying disorder. Case 1 and 3 had a habit of rotating the neck as a stretching exercise, and repetition of mild neck exercise may have been involved in the etiology.

According to Stringer et al., the primary site of dissecting lesions is the C2–C3 level, at which the internal carotid artery is over stretched by the body of the upper vertebra during contralateral flexion of the neck. In our three patients, dissection invariably occurred primarily at the C1 level, slightly higher than has been reported. The internal carotid artery is fixed to the cranial base by the carotid canal and has little mobility. However, its proximal parts move constantly with head and neck movements. Particularly, the 1st cervical vertebra (atlas) forms the atlanto-axial joint with the 2nd cervical vertebra (axis) and bears rotational movements of the head. The internal carotid artery runs immediately on the ventral side of the transverse process of the atlas at this level (Figs. 1E and 2J). For this reason, the transverse process of the atlas, which markedly projects laterally, compresses the internal carotid artery in contralateral rotation of the head, and the internal carotid artery is stretched in
ipsilateral rotation. Therefore, they speculated that the wall of the internal carotid artery at this level is prone to minor injuries leading to vascular dissection. The habit of rotating the neck observed in Cases 1 and 3 is considered to be in agreement with this speculation.

All 3 cases presented here were diagnosed with internal carotid artery stenosis by emergency head MRI performed at the initial appearance of ischemic symptoms, but dissection was disclosed by cerebral angiography. In younger patients with cervical internal carotid artery stenosis with no particular history such as Case 2 and middle-aged or older patients with high internal carotid artery stenosis such as Cases 1 and 3, aggressive angiography is recommended with the possibility of dissection in mind. However, accurate detailed evaluation of the lesion may be impossible in 3D volume rendered images as in Case 1, and 2D images from multiple angles (frontal, lateral, bilateral oblique) and 3D MIP images should be carefully examined for flap-like structures or double lumens. There have been reports that the sensitivity of original MIP images of CTA was 100% and that CTA was effective for the diagnosis while DSA is a standard diagnostic modality. Also, the identification of the true and false lumens and the judgment of the presence or absence of intramural hematomas may have been possible by the concomitant use of intraoperative endovascular ultrasonography and optical coherence tomography although we did not use them in these patients.

Concerning the indications of revascularization for cervical internal carotid artery dissection, Biondi et al. suggested the following as patient selection criteria for stent placement: (1) Resistance to medical treatment, (2) presence of ischemic symptoms associated with the hemodynamics or distal embolization, (3) the use of anticoagulants contraindicated due to intracranial or truncal hemorrhage, (4) symptomatic thromboembolism, (5) occlusion/stenosis or necessity for future occlusion of the contralateral carotid artery, and (6) necessity of avoiding an increase in the blood flow of the anterior communicating artery due to aneurysm. Also, Ohta et al. retrospectively evaluated 44 cases of internal carotid artery dissection treated by stent placement. According to their report, they performed stenting by selecting the patients by three criteria: (1) traumatic internal carotid artery dissection, (2) presence of symptoms in the acute phase of ischemia, and (3) resistance to medical treatment, and achieved recanalization in 95.5% of the patients and a postoperative mRS score of 0–2 in 83.7%.

In stenting of the coronary artery, the safety was higher in the group orally administered aspirin (325 mg) and ticlopidine (250 mg) than in the group administered aspirin (325 mg) and clopidogrel (300 mg loading), and the preventive effect on postoperative ischemic events was comparable. There is also a report that the incidence of perioperative complications was lower in stenting of the carotid artery when clopidogrel was administered preoperatively at a loading dose (300 mg) in addition to aspirin (75 mg) and continued at 75 mg compared with a combination of heparin and aspirin. On the basis of these reports, at our hospital, loading was made with aspirin (300 mg) and clopidogrel (300 mg) for emergency stent placement, and inhibition of platelet aggregation was confirmed using VerifyNow. Since Maruyama et al. reported that the PRU was reduced by adding cilostazol in patients intolerant to clopidogrel, the addition of cilostazol is also considered at our hospital if the aggregation control is insufficient by examining the PRU.

Since little plaque is present in cervical internal carotid artery dissection unlike atherosclerotic lesions, the risk of intraoperative distal embolization associated with dilation is considered to be lower than in atherosclerotic lesions. However, as there is the possibility of perioperative complications such as embolism, attention to appropriate antithrombotic therapy is necessary.

### Conclusion

Three cases of cervical internal carotid artery dissection successfully revascularized by stenting are presented. In patients
with high cervical internal carotid artery stenosis, dissection should be suspected regardless of the presence or absence of trauma, and detailed evaluation of the lesion is necessary. In patients with marked stenosis or drug-resistant lesions, revascularization by stenting may be an option.

Disclosure Statement

The first author and all the co-authors have no conflict of interest.

References