

A novel technique to visualize true lumen in endovascular treatment of the occlusive carotid dissection and the usefulness of external–internal carotid collateral channel

Keiji Murata¹, Shigeru Yamauchi¹, Yuta Kaneshiro¹, Yumiko Urano¹,
Keishi Yamagata² and Toshihiro Takami³

Abstract

Background: Dissection of the internal carotid artery (ICA) can cause occlusion or severe stenosis and is known to be one of the major causes of ischemic stroke in the young. Endovascular treatment is one of the useful options for carotid dissections, but passing the guidewire through the occlusion (lesion-cross) and confirmation of the true lumen are sometimes difficult. **Case presentation:** A 40-year-old right-handed man complaining of dysarthria and gait disturbance consulted our hospital. Magnetic resonance imaging and angiography revealed right ICA dissection. Because of worsening symptoms with conservative treatment, we performed endovascular treatment. Prior to the lesion-cross, a microcatheter was navigated to the third segment of the internal maxillary artery and a balloon-guiding catheter was navigated to the proximal ICA. Under balloon occlusion of the ICA, superselective angiography via the ipsilateral maxillary artery and slow evacuation from the balloon-guiding catheter were performed. Thereafter, the course of the true lumen was clearly visualized, and we were able to navigate another microcatheter without difficulty. Subsequently, angioplasty and stent placement were successfully accomplished.

Conclusion: We presented a case of ICA dissection and demonstrated a novel technique for a safe lesion-cross for occlusive ICA dissection.

Keywords

Carotid artery dissection, endovascular treatment, external–internal carotid collateral channel

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Introduction

Carotid artery dissection, which can cause occlusion or severe stenosis of the internal carotid artery (ICA), is one of the major causes of ischemic stroke in the young^{1–3} and is currently usually treated by catheter intervention.^{4–10} Although endovascular treatment is effective, passing the guidewire through the occlusion (lesion-cross) and confirmation of the true lumen, especially on the distal end of the lesion, can be difficult in some cases.

Case presentation

A 40-year-old right-handed man, with no particular medical history, developed sudden dysarthria and gait disturbance upon waking up in the morning. He consulted a nearby clinic, where emergency magnetic resonance imaging (MRI) revealed an acute ischemic lesion on the right insular cortex. Magnetic resonance

angiography (MRA) performed at this clinic poorly demonstrated the right anterior circulation (Figure 1(a) to (c)). Thereafter, the patient was transferred to our hospital for further evaluation and management.

On admission at our institution, his blood pressure was normal, heart rate was 72 beats/min sinus rhythm, and neck bruit was audible on the right side. There was partial improvement of his symptoms. Neurologic examination showed only mild disturbance of the

¹Department of Neurosurgery, Shimada Municipal Hospital, Shimada, Japan

²Stroke Unit, Shimada Municipal Hospital, Shimada, Japan

³Department of Neurosurgery, Osaka City University Graduate School of Medicine, Osaka, Japan

Corresponding author:

Keiji Murata, Department of Neurosurgery, Shimada Municipal Hospital, 1200-5 Noda, Shimada, Shizuoka 427-8502, Japan.

Email: kmurata@municipal-hospital.shimada.shizuoka.jp

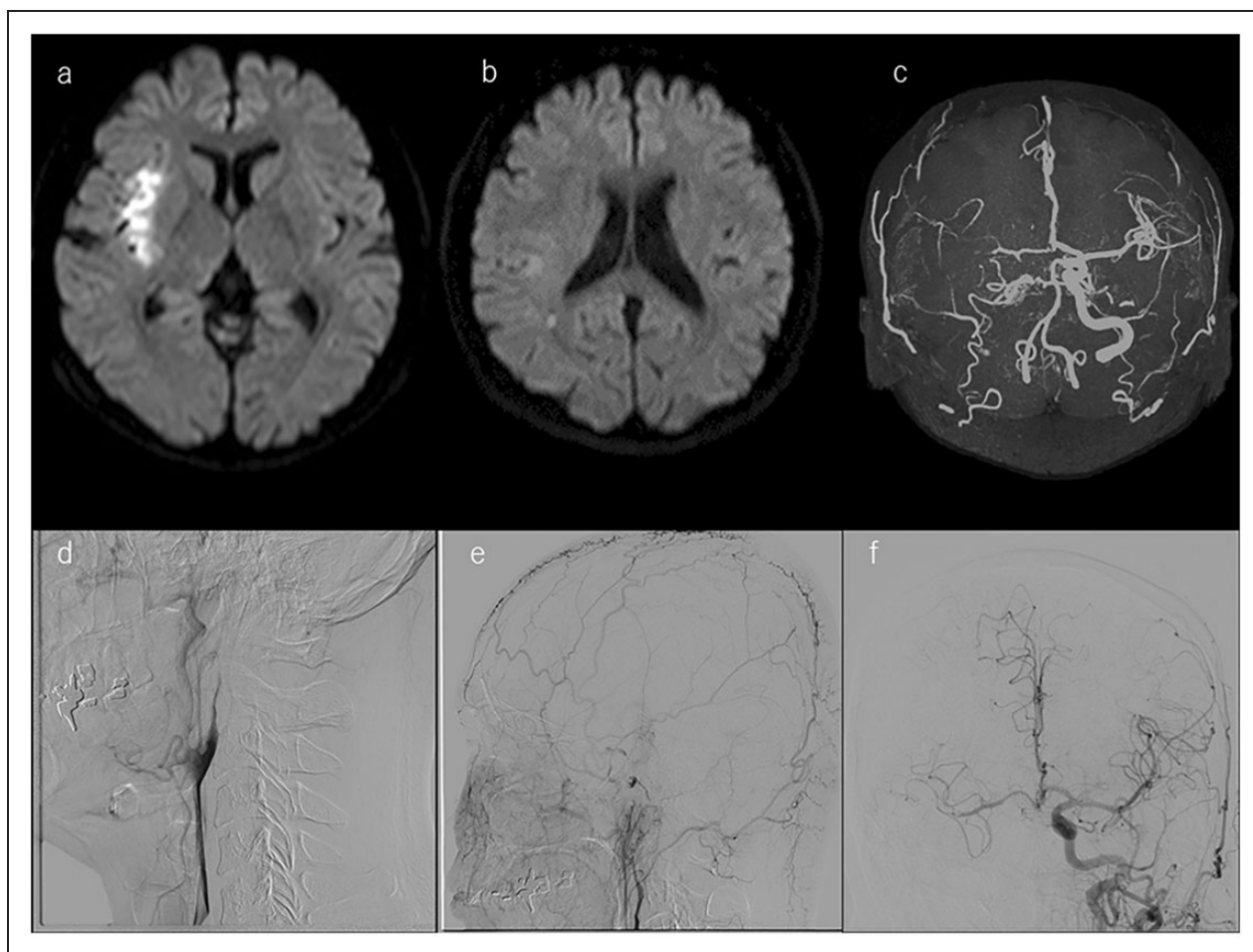


Figure 1. Studies on admission.

Diffusion-weighted magnetic resonance imaging on admission shows (a) an acute ischemic lesion on the insular cortex and (b) only a small ischemic lesion on the posterior watershed area at the level of the corona radiata. (c) Magnetic resonance angiography shows poor visualization of the right anterior circulation. On admission, angiography shows (d) a tapering occlusion of the right ICA on right common carotid angiogram; (e) the distal ICA is visualized via the external-internal carotid anastomosis. (f) Left common carotid angiogram shows a cross flow via the anterior communicating artery and right cerebral hemisphere supply from the leptomeningeal anastomosis via the anterior cerebral artery.

cortical sensation, and his National Institutes of Health Stroke Scale (NIHSS) score was 1.

Immediately after admission, cerebral angiography was performed and revealed a tapered occlusion at the distal cervical portion of the right ICA on the right common carotid angiogram; the intracranial ICA was slightly depicted via the external-internal carotid anastomosis (Figure 1(d) and (e)). The left common carotid artery angiogram showed that the right cerebral hemisphere was supplied by a cross flow through the anterior communicating artery (A-com) and the leptomeningeal blood supply was from the distal anterior cerebral artery (Figure 1(f)). Carotid sonography revealed an intimal flap at the cervical ICA. On the basis of these findings, he was diagnosed as having carotid artery dissection.

Because his symptoms were mild, treatment was initially conservative, such as blood pressure control and heparinization. However, 2 days after the onset of symptoms, he developed motor weakness and disorientation, and his NIHSS score increased to 8.

Diffusion-weighted MRI showed new lesions on the posterior watershed area. MRA showed a slight change in the visualization of the middle cerebral artery (MCA) territory (Figure 2(a) to (c)). To prevent the progression of the infarction, we decided to perform endovascular treatment.

A bilateral femoral puncture was performed under local anesthesia. Prior to the procedure, a left common carotid angiogram was performed to check the cross flow via the A-com. The right MCA territory was visualized, but the flow of the MCA was worse than that shown on initial angiography (Figure 2(d)). At this time, an artery-to-artery embolism was suspected. Next, two guiding catheters were inserted via the bilateral femoral approach; one was a 6-Fr guiding catheter (Envoy; Codman Neurovascular, Raynham, Massachusetts, USA), which was placed at the right external carotid artery, whereas the other was a 9-Fr balloon-guiding catheter (Optimo; Tokai Medical, Kasugai, Aichi, Japan), which was placed at the proximal right ICA (Figure 2(e)). Initially, a microcatheter

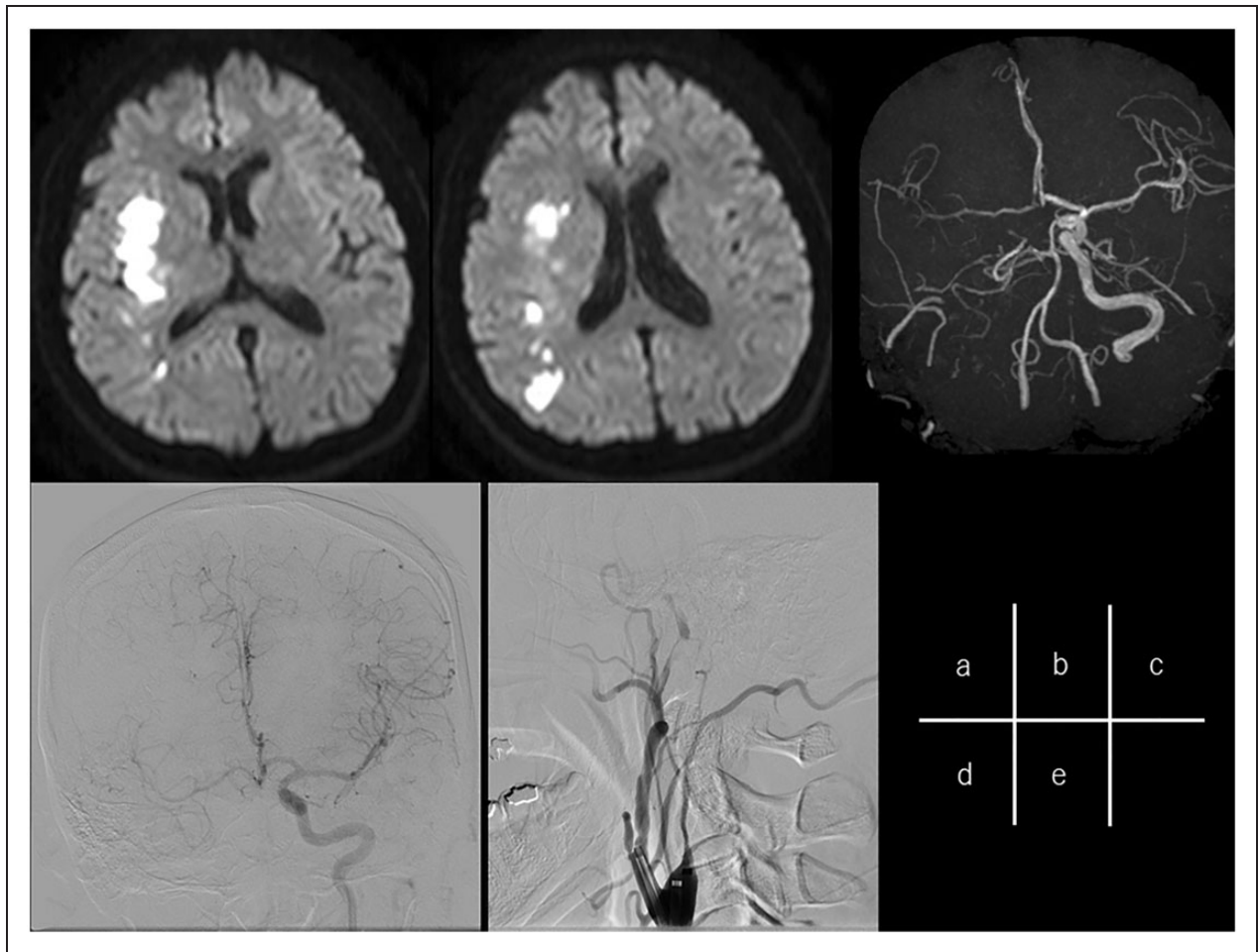


Figure 2. Studies on deterioration.

(a) and (b) Magnetic resonance imaging obtained during deterioration shows increase in the area of the acute ischemic lesion, compared with that on symptom onset. (c) Magnetic resonance angiography shows a slight change in the visualization of the middle cerebral artery (MCA). (d) Left common carotid angiogram shows worse visualization of the right MCA territory, compared with that on symptom onset. (e) After positioning two guiding catheters, right internal carotid angiogram shows the position of the tips of the two guiding catheters.

was navigated to the third segment of the internal maxillary artery (IMA). Superselective angiography using this catheter enabled visualization of the distal ICA via the vidian artery (Figure 3(a)). Although another microcatheter was used in an attempt to cross the lesion in the usual manner, it easily entered the false lumen, and lesion-cross with the usual technique was found to be difficult. To visualize the true lumen, we decided to use a brand-new technique that contains the following several maneuvers. Initially, the proximal ICA was occluded by balloon inflation of the 9-Fr guiding catheter; then, superselective angiography via the ipsilateral IMA was performed while aspirating the blood through the balloon-guiding catheter. With this technique, the course of the true lumen was clearly visualized (Figure 3(b) and (c)), and under this guidance, we were able to cross the lesion without difficulty (Figure 3(d)). Subsequently, angioplasty and stent placement were successfully accomplished (Figure 3(e)). A final angiography revealed distal embolism in the M4 portion of the MCA, which was likely present preoperatively;

therefore, we did not perform further intervention (Figure 4(a) and (b)).

After the procedure, we continued heparinization for several days. A follow-up MRI on the eighth day after the procedure showed no remarkable new ischemic lesions and good visualization of the right MCA territory (Figure 4(c) and (d)). His symptoms gradually improved, and he recovered to a modified Rankin Scale score of 1 three months later.

Discussion

Carotid artery dissection is a condition in which the intima and the internal elastic lamina of the ICA are torn off the vessel wall, which leads to the formation of abnormal structures, such as intimal flap, false lumen, and intramural thrombus.^{3,5} These abnormal structures may obstruct the true lumen of the ICA and restrict blood flow, thereby predisposing to ischemic stroke (Figure 5(a)).

Several recent reports showed the usefulness of catheter intervention for the treatment of the carotid artery

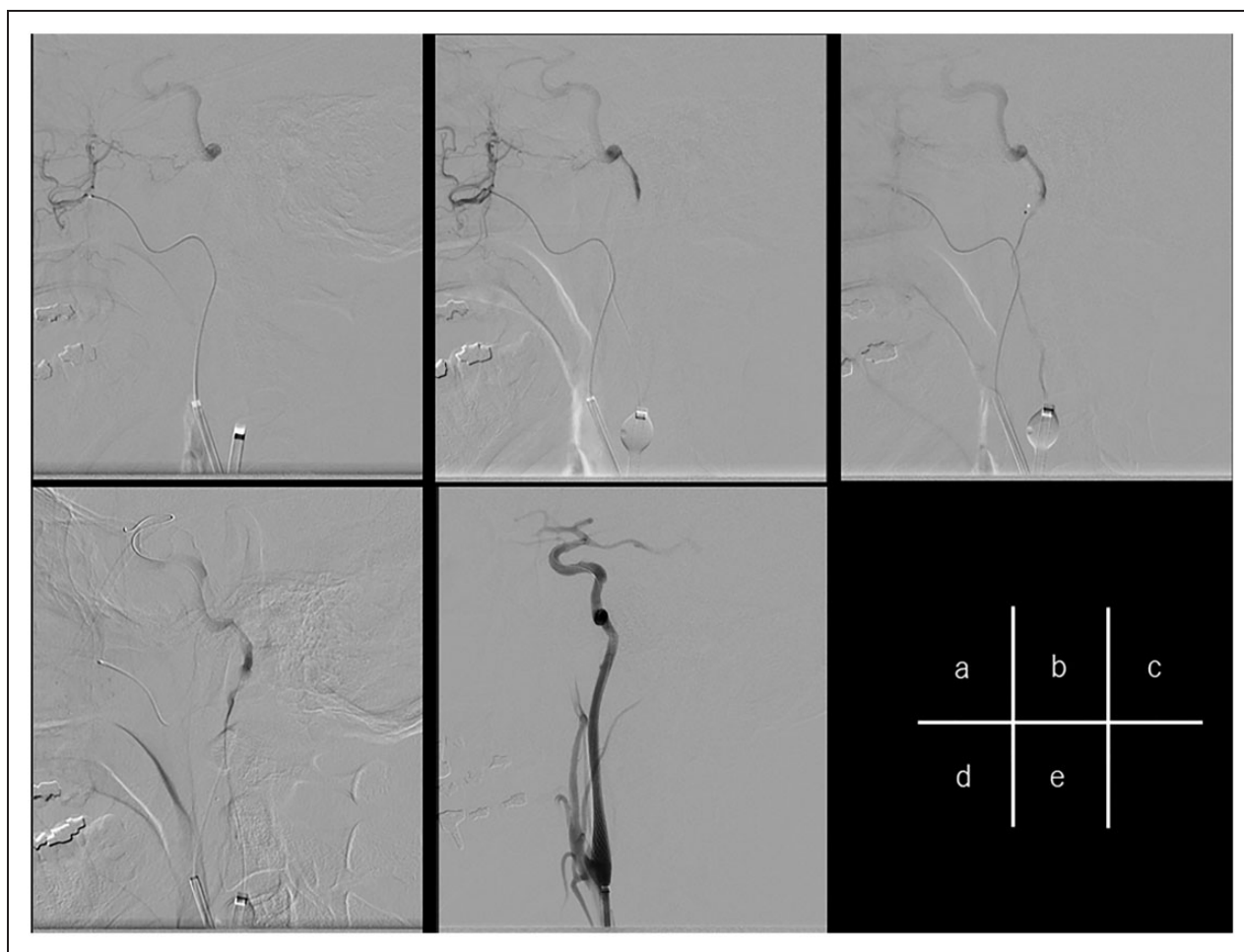


Figure 3. Angiography during the endovascular treatment.

Superselective angiography via the right internal maxillary artery (IMA), (a) taken without balloon occlusion, shows the distal internal carotid artery (ICA) with the external-internal carotid anastomosis via the vidian artery. (b) and (c) Early and late phases of the IMA angiogram, which are taken under balloon occlusion of the proximal ICA, and suction from the guiding catheter demonstrate the proximal ICA and the true lumen. (d) IMA angiogram with same technique as (c) which was taken after crossing the lesion with micro guidewire shows that the micro guidewire successfully crossed the lesion keeping the true lumen. (e) Common carotid angiogram after the stent placement shows successful reconstruction of the ICA.

dissection,⁴⁻¹⁰ with stent placement being the most frequent procedure. During stent placement, one of the most important steps is to cross the lesion using a micro guidewire, which should be kept inside the true lumen in order to place back the intimal flap to the vessel wall (Figure 5(b) and (c)). If the crossing guidewire penetrates the false lumen during stent placement, the false lumen will be dilated, and the surrounding media might induce in-stent thrombosis (Figure 5(d) and (e)). Notably, staying inside the true lumen when crossing an occlusive lesion can be difficult sometimes. In cases with near or total occlusion, the true lumen might be severely compressed with the intimal flap and the false lumen, whereas the false lumen might be relatively large. Under such conditions wherein identification of the small orifice of the true lumen is difficult, the micro guidewire can easily enter the false lumen and inadvertently penetrate the intimal flap.

In this case, the use of proximal balloon occlusion and suction from the guiding catheter enabled us to

successfully reduce the pressure of the false lumen and enlarge the orifice of the true lumen (Figure 6(a) to (c)). Under this maneuver, superselective angiography via the IMA clearly visualized the course of the true lumen on retrograde flow. Thereafter, we could achieve an ideal lesion-cross without difficulty and accomplish the stent placement (Figure 6(d) and (e)). Although an extra-carotid artery angiogram might lead to the acceptable visualization of the true lumen, the superselective angiography can help the surgeons to see the main target vessels more clearly without confusing them with other non-target vessels. Unfortunately, at that time, we could not perform a cone beam computed tomography (CT) due to the motion of the patient. If cone beam CT were available in good quality, our technique might more effectively visualize the course of the true lumen.

Certainly, our technique might have several limitations and, theoretically, might not work in some cases. For example, our technique might fail to make the false



Figure 4. Studies after endovascular treatment.

(a) Anterior-posterior and (b) lateral views of the right common carotid angiogram show distal embolism of the distal middle cerebral artery (MCA) territory. (c) One week after the procedure, diffusion-weighted magnetic resonance imaging shows no new and apparent lesion and (d) magnetic resonance angiography shows normal visualization of the MCA.

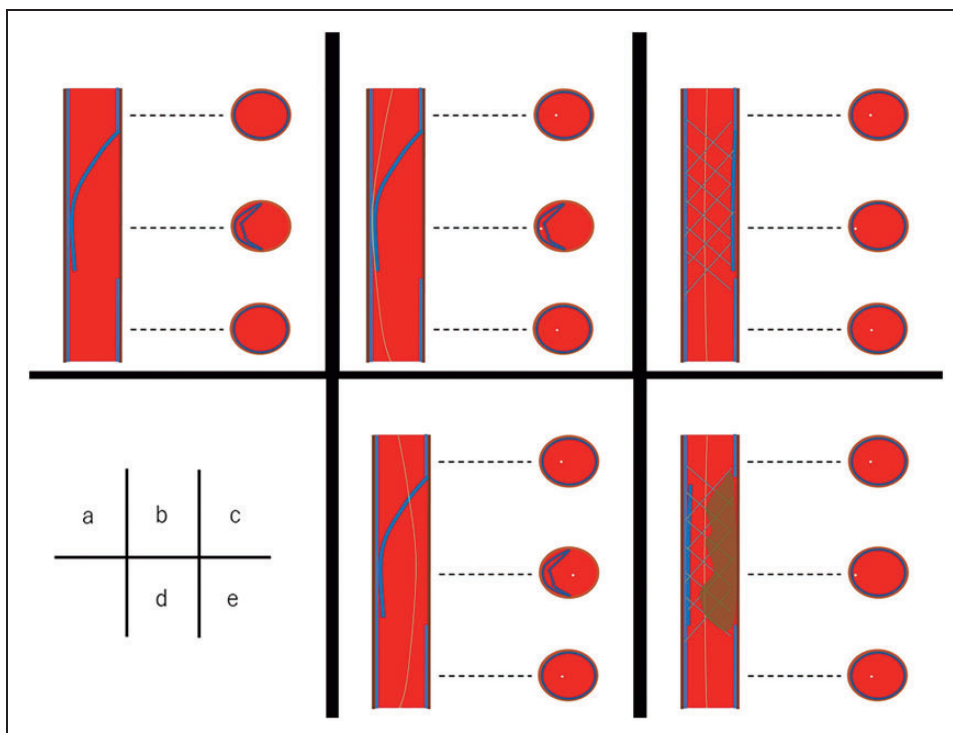


Figure 5. Schematic drawings of the stenting for the dissection.

(a) Schematic drawing of the dissection. (b) Schematic drawing of an ideal lesion-cross, in which the guidewire is kept inside the true lumen. (c) Schematic drawing indicating the ideal stenting that can be achieved in an ideal lesion-cross. (d) Schematic drawing of a non-ideal lesion-cross, in which the guidewire penetrates the false lumen. (e) Schematic drawing indicating a non-ideal stenting and the formation of an in-stent thrombosis caused by a non-ideal lesion-cross.

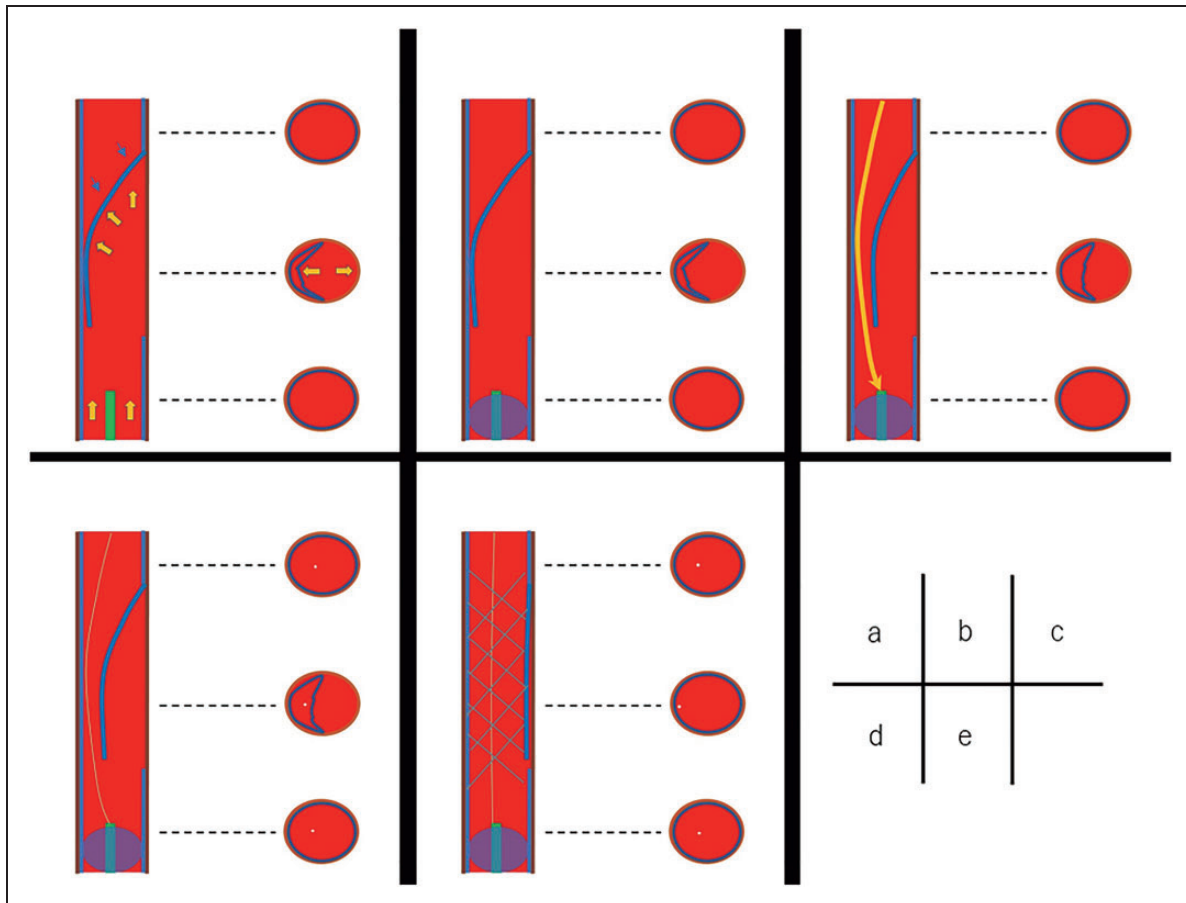


Figure 6. Schematic drawings of the concept of the new technique.

(a) This schema represents the hemodynamics of an occlusive dissection. The yellow arrows represent systemic blood pressure and the blue arrows represent the pressure of the collateral flow. Systemic blood pressure may enlarge the false lumen and compress the true lumen. (b) This schema represents the hemodynamics under proximal balloon occlusion and suction from the guiding catheter. As the blood pressure in the false lumen decreases with the maneuver, the pressure of the collateral flow overcomes the pressure of the false lumen. (c) Thereafter, the true lumen becomes open and is visualized by collateral flow via the vidian artery. The ideal (d) lesion-cross and (e) stent placement become possible with this technique.

lumen collapse in cases with small entry and long lesion or those with tight intramural thrombus. Moreover, the additional time needed to guide the microcatheter into the IMA may further compromise severely ischemic brain and lead to infarction.

Nevertheless, to the best of our knowledge, this was the first report on a technique to cross an occlusive lesion in carotid artery dissection. Although intravascular ultrasonography (IVUS) has been reported to be useful for the treatment of dissection at other locations, such as the coronary arteries and the aorta,^{11–18} its application to carotid artery dissection might not be feasible. Anatomically, carotid dissection sometimes involves the petrosal segment of the ICA,³ which is covered by a bony and tortuous carotid canal; therefore, cannulation of the slightly stiff IVUS catheter up to the intracranial carotid artery might be difficult.

The usefulness of our novel technique needs to be verified by further accumulation of cases. Nevertheless, this case showed the potential of our technique of crossing the lesion as one of the treatment options for

occlusive carotid artery dissection in which lesion-cross is difficult.

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