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Case Report

Usefulness of the Double-Lumen Super-Compliant Balloon Catheter "Super-Masamune" for Balloon-Assisted Coil Embolization of Carotid–Cavernous Fistulas

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Objective: Transarterial embolization (TAE) of the cavernous sinus (CS) via a fistula formed in the internal carotid artery (ICA) is the standard for carotid-cavernous fistulas (CCFs). Depending on the fistula, an adjunctive technique using a balloon or stent is effective. We report a case in which the balloon-assisted technique using the super-compliant balloon catheter "Super-Masamune" was effective.

Case Presentation: A 44-year-old woman who sustained head trauma from a traffic accident 1 month prior presented with diplopia, conjunctival chemosis, and proptosis of the left eye. Digital subtraction angiography (DSA) revealed a left CCF with a reflex to the left superior ophthalmic vein (SOV). During TAE with the Super-Masamune assistance, we tightly embolized around the fistula using a small volume of coils and the CCF was obliterated.

Conclusion: The balloon of the Super-Masamune is made of a styrene-based elastomer, which has excellent compliance. Therefore, it is possible to reduce the volume of coils because the balloon is in close contact with the ICA or fistula. This may reduce the incidence of postoperative cranial nerve palsy and cost of treatment materials.

Keywords ▶ super-Masamune, carotid-cavernous fistula, detection, herniation, balloon assist

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Introduction

For the treatment of carotid-cavernous fistulas (CCFs), Serbinenko first reported the success of transarterial embolization (TAE) with a detachable balloon in 1970.[1,2] Thereafter, a method to guide a detachable balloon into the cavernous sinus (CS) through a fistula of the internal carotid artery (ICA) via blood flow and expand it in the CS for embolization was primarily adopted.[2] After detachable balloons became unavailable at the beginning of 2000, detachable coils and liquid embolic materials were primarily used as embolic materials. However, in some cases, the embolic material migrated into the ICA, inducing parent artery occlusion or distal embolism, or a coil mass overlapped with the ICA, making the patency of a parent artery unclear. Several studies reported the necessity of adjunctive techniques such as balloon-[3,4] and stent-assisted[5] techniques.

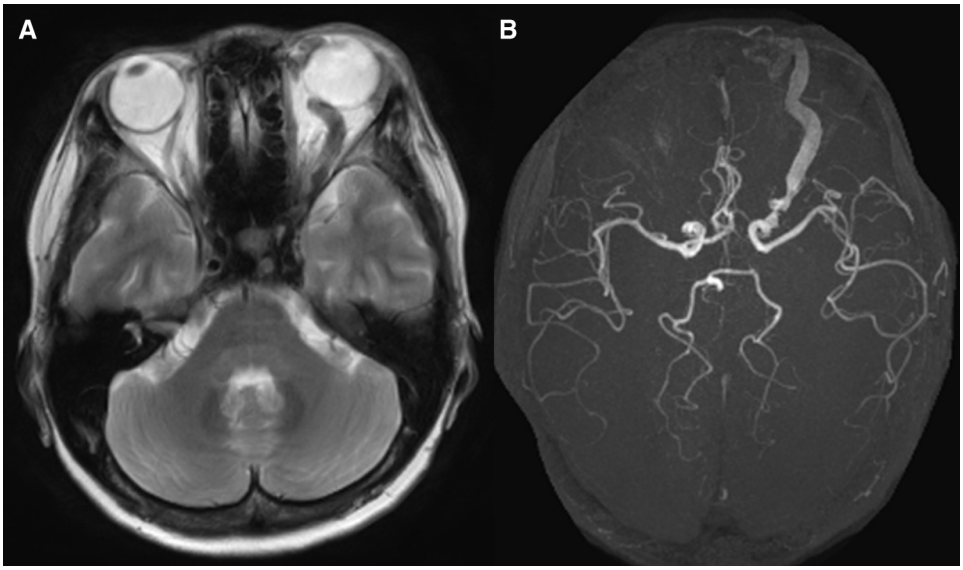

Fig. 1 Preoperative MRI and MRA. T2-weighted MRI (**A**) and MRA (**B**) demonstrate the dilated left SOV. SOV: superior ophthalmic vein

In this study, we report a patient in whom balloon-assisted TAE with a double-lumen (DL) balloon microcatheter (BMC), "Super-Masamune," was performed, leading to favorable results.

This article was approved by the Clinical Research Ethics Review Board of Tohoku University Hospital.

Case Presentation

Patient: A 44-year-old woman.

Complaints: Diplopia, left exophthalmos, and conjunctival chemosis.

Present illness: Diplopia, left conjunctival chemosis, exophthalmos, and left pulsatile tinnitus developed 1 month after admission due to multiple traffic accident-related traumas.

Neurological findings at the time of onset: Consciousness was clear. The right pupil measured 2.5 mm and the left pupil measured 2.5 mm. Light reflex was prompt on both sides. Left oculomotor apraxia, left palpebral edema, left bulbar conjunctival congestion, and left eye/temporal murmurs were noted.

Radiological findings at the time of onset: T2-weighted MRI (**Fig. 1A**) and MRA (**Fig. 1B**) demonstrated dilation of the left superior ophthalmic vein (SOV). Digital subtraction angiography (DSA) of the left ICA revealed a CCF with reflux to the SOV (**Fig. 2A** and **2B**). Rearranged sagittal sections on 3D-rotational DSA suggested fistula formation involving the C4 to C5 portions of the left ICA (**Fig. 2C**).

Neuroendovascular treatment: Under general anesthesia, an 8-Fr FUBUKI (ASAHI INTECC, Aichi, Japan) was guided into the left ICA. A Super-Masamune (Fuji Systems, Tokyo, Japan) and Chikai Black 0.014" (ASAHI INTECC) were coaxially guided. To search for the fistula, the Super-Masamune was dilated around the C3 to C5 portions of the ICA to reduce anterograde blood flow. Internal carotid angiography was performed through the guiding catheter. However, sufficient flow control was difficult and the fistula was unable to be identified (**Fig 3A–3D**). The balloon position was adjusted to the C4 to C5 portions and it was dilated. The balloon anterolaterally invaginated from the ICA at the C5 portion, which was consistent with the site of the fistula suspected on rearranged preoperative DSA images (**Fig. 3E** and **3F**). The balloon was deflated and placed at the same site. Coaxially guiding Rester (Medico's Hirata, Osaka, Japan) and Chikai 0.014" (ASAHI INTECC) were placed in the CS beyond the fistula, where the site of balloon invagination. After balloon invagination (**Fig. 4B**), there were no marked changes in angiographic findings of the left ICA involving visualization of the periphery in comparison with those before balloon invagination (**Fig. 4A**). At the SOV outflow area of the CS, coiling was started, but a coil migrated into the ICA through the fistula, and its deviation was prevented by inflating the Super-Masamune in the parent artery adjacent to the fistula and adhering it to the ICA involving the fistula (**Fig. 5A** and **5B**). While repeating balloon inflation and deflation, the intra-CS cavity was embolized with a total of five coils

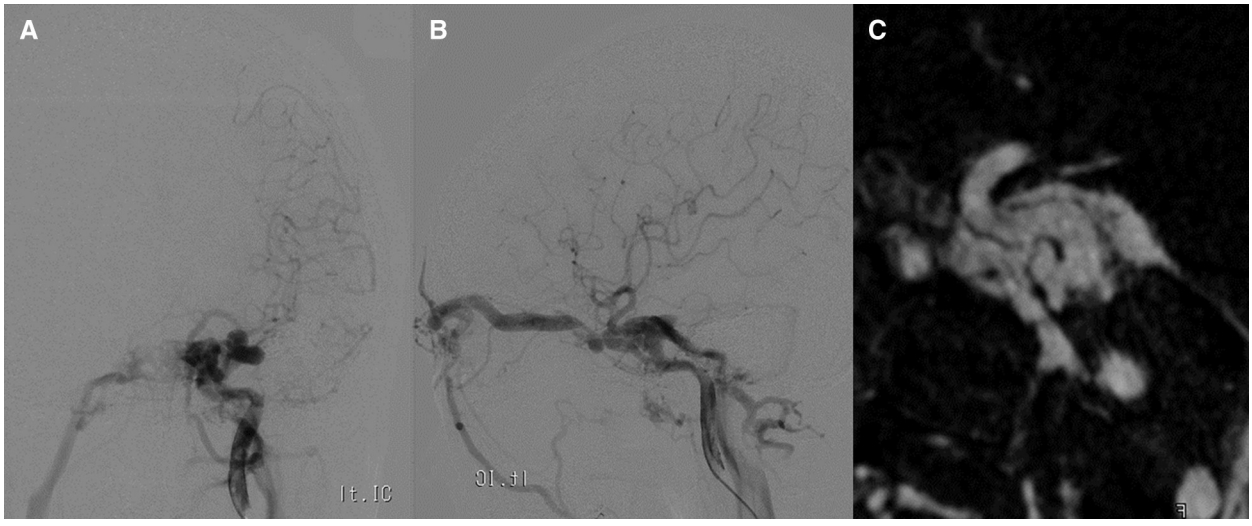

Fig. 2 Preoperative DSA of the left ICA. The anteroposterior (**A**) and lateral (**B**) views demonstrate a left CCF and venous reflux to the left SOV. (**C**) Sagittal reconstruction of the 3D rotational DSA. This suggests that the fistula formed in the C4–C5 portion. CCF: carotid-cavernous fistula; DSA: digital subtraction angiography; ICA: internal carotid artery; SOV: superior ophthalmic vein

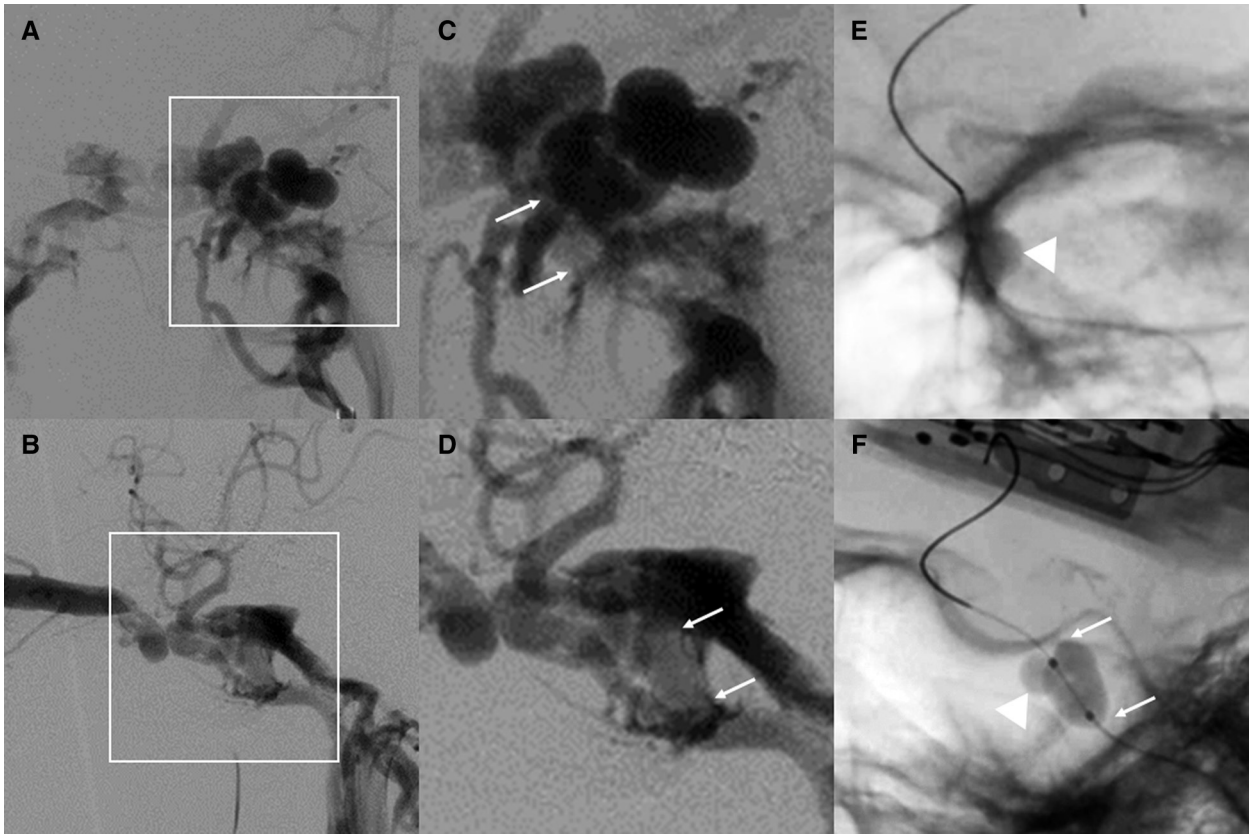

Fig. 3 Intraoperative view of the Super-Masamune inflated in the C5 portion. **A** (AP view), **B** (lateral view): Flow control is insufficient and the fistula is not revealed. (**C, D**) The enlarged image of the square portion of **Fig. 3A** and **3B** (arrows; balloon marker). **E** (AP view), **F** (lateral view): X-ray image during balloon inflation (arrows, balloon marker; arrowhead, herniation of the balloon). A part of the balloon protrudes, suggesting the fistula. AP: anteroposterior

(95 cm) in order for them be piled back to the fistula along the inferior wall of the ICA (**Fig. 5C** and **5D**).

Postoperative DSA confirmed the disappearance of the CCF. The left SOV was preserved and it changed to

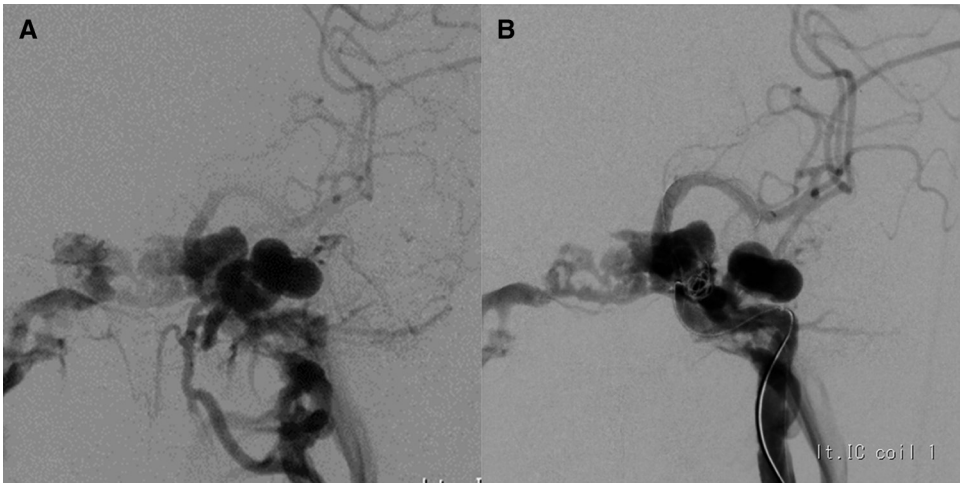

Fig. 4 Left internal carotid angiography before and after balloon herniation. (**A**) AP view before the Super-Masamune was herniated. (**B**) AP view after the Super-Masamune was herniated. No obvious difference in presentation between **A** and **B** reflects no enlargement of the fistula due to balloon herniation. AP: antero-posterior

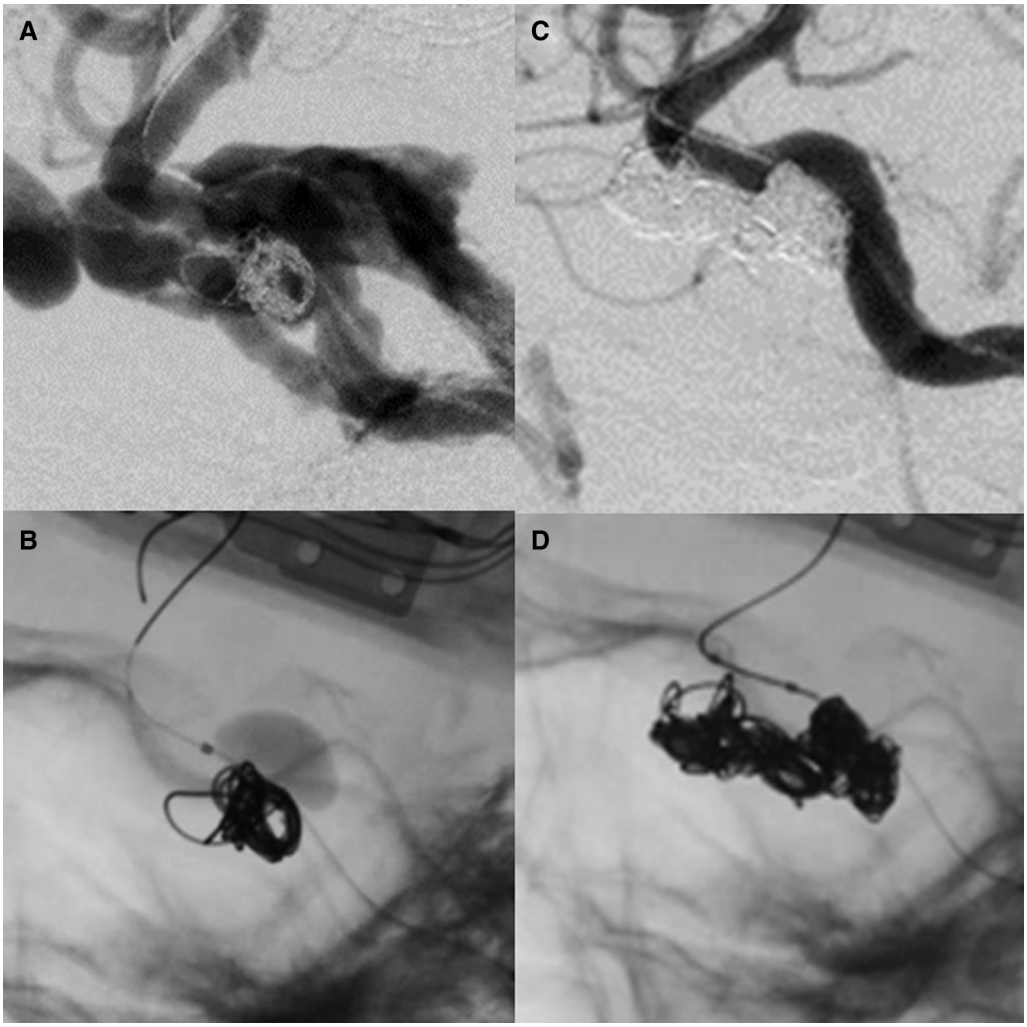

Fig. 5 Intraoperative lateral image. **A** (Left ICAG), **B** (X-ray): First coil fulfilled with balloon assist. **C** (Left ICAG), **D** (X-ray): Last coil fulfilled. ICAG: internal carotid angiography

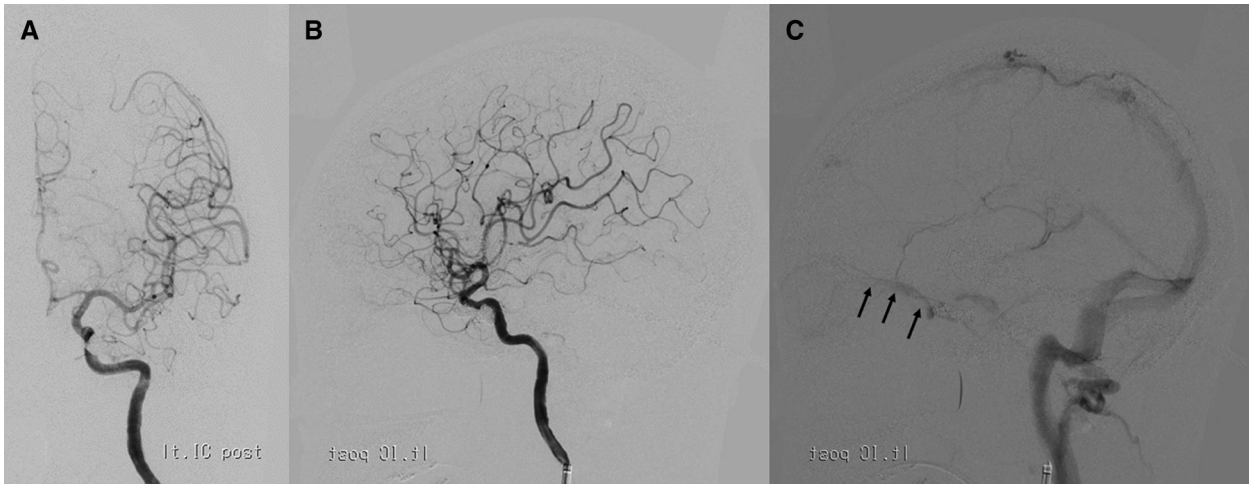

Fig. 6 Postoperative DSA of the left ICA. (**A**) AP view. (**B**) Lateral view of the arterial phase. (**C**) Lateral view of the venous phase (arrows: SOV). The CCF disappeared. The left SOV was spared and recovered to normal. AP: anteroposterior; CCF: carotid-cavernous fistula; DSA: digital subtraction angiography; ICA: internal carotid artery; SOV: superior ophthalmic vein

perfusion in the normal direction (**Fig. 6**). The symptoms reduced within 1 week after the treatment.

Discussion

The Super-Masamune is a DL-BMC measuring 4.0 mm in balloon length and 8.0 mm in maximum diastolic diameter. The balloon material is a styrene-based elastomer. Its compliance is favorable in comparison with a Hyperform (Medtronic, Minneapolis, MN, USA), which is made from a polyolefin-based elastomer, and arterial wall injury is less frequent.[6] The Super-Masamune has a characteristic of more frequently invaginating into the intra-aneurysmal space or peripheral branches during embolization of cerebral aneurysms.[7]

There are two roles of balloon catheters in CCF treatment: "flow control," in which anterograde blood flow is blocked to reduce it, thereby facilitating searching for a fistula when it is unclear on standard angiography due to excessive shunt blood flow, and "assist balloon," in which parent artery occlusion or distal embolism related to the migration of an embolic material into a parent artery is prevented. The former can be utilized for a method to visualize a fistula using anterior communicating artery-mediated blood flow through the contralateral ICA by inserting a balloon catheter into the affected ICA to block anterograde blood flow (Mehringer–Hieshima maneuver) and a method of performing angiography via the posterior communicating artery through the vertebral artery (Heuber maneuver).[8] Furthermore, there is a method to perform angiography through the guidewire lumen by blocking the affected ICA with a DL-BMC.[9] The Super-Masamune is also a DL-BMC, being available for flow control. However, in the present case, the balloon invaginated while searching for the fistula under flow control, leading to the detection of a fistula. Samaniengo et al. also reported balloon invagination into a fistula. They suggested that balloon dilatation involving a fistula deteriorates it.[3] As the visualization of the middle/anterior cerebral arteries peripheral to a fistula is correlated with the fistula diameter,[10] there was no change in visualization of peripheral blood vessels after balloon invagination in the present case, and invagination-related enlargement of the fistula was not clear. The peri-CCF ICA may be fragile and balloon invagination may induce fistula enlargement, making intra-CS embolization impossible; therefore, it cannot be recommended. However, if a fistula cannot be detected using conventional methods, it may be detected by carefully inflating a balloon and slightly invaginating it into the fistula in some cases.

The Super-Masamune, as an assist balloon, was useful for treatment in the present case. Its favorable compliance facilitated dense coil mass formation with a small volume of coils through adhesion to the fistula and peripheral ICA, leading to obliteration of the CCF. A previous study reported that the coil volume during intra-CS coil embolization was correlated with postoperative cranial nerve paralysis.[11] Coil reduction is useful for reducing costs and the incidence of postoperative complications.

Conclusion

We performed balloon-assisted TAE of a CCF with a DL-BMC, Super-Masamune, which has specific characteristics such as more favorable compliance in comparison with conventional BMCs, double markers, and a short tip length. A small volume of coils facilitated favorable embolization. Furthermore, the fistula position was identified based on balloon invagination into it, but the safety of this method has not been evaluated; therefore, it should be carefully conducted only when a fistula cannot be detected using standard methods.

Disclosure Statement

The authors declare no conflict of interest.

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