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Original Article

Preservation of Branching Vessel Using Super Compliant Double-Lumen Balloon Microcatheter: Bulging Neck Plasty Technique and Other Options

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Objective: There are several methods to treat wide-neck aneurysms. We survey the cases that were treated using a super-compliant double-lumen balloon microcatheter (Super-Masamune) for preservation of the branching vessel originating proximal to the aneurysm, especially in the bulging neck plasty (BNP) technique.
Methods: We assessed 10 cases in which branching vessel preservation was performed using Super-Masamune. The cases were categorized into three groups: (1) ordinary neck plasty (ONP): balloon microcatheter was navigated to the branch that should be preserved; (2) BNP: another branch was preserved by inflating balloon bulging without cannulation; (3) protection during parent artery occlusion (PPO): the balloon microcatheter was navigated to the vessel to be occluded. The balloon preserves a branch originating near the aneurysm without cannulating to the branch.
Results: The aneurysm locations were as follows: internal carotid artery (ICA), three cases; anterior communicating artery (AcomA), one case; basilar artery (BA), three cases; and vertebral artery (VA), three cases. Four cases were ruptured aneurysms, while six cases were unruptured or ruptured in chronic stage. The ONP, BNP, and PPO groups contained two, five, and three cases, respectively. Embolization resulted in complete obliteration in six cases, neck remnant in two cases and body filling in two cases. No rupture/rerupture was noted in this series. One case showed an intraoperative rupture.
Conclusion: Super-Masamune is useful for neck plasty, especially BNP, in wide-neck aneurysms. Super-Masamune is also useful for parent artery occlusion when an important branch originates proximal to the aneurysm.

Keywords▶ neck plasty, balloon assist, embolization, parent artery occlusion

Introduction

With the introduction of the Gugulielmi Detachable Coil in 1991, embolization became the standard treatment for cerebral aneurysms.[1)] While this technique initially only involved the insertion of a microcatheter, the subsequent introduction of the neck plasty technique allowed the use of a balloon microcatheter to protect the coils from protruding the parent artery. Several kinds of balloons have been developed to perform this technique. We want to have more compliant balloon than any balloon commercially available in that time, so we began to develop a super-compliant double-lumen balloon microcatheter (Super-Masamune; Fuji Systems Corporation, Tokyo, Japan) in 2011,[2)] started its clinical application in 2012,[3,4)] and achieved market launch by 2014. The purpose of this article is to show the usefulness of Super-Masamune by summarizing the cases after the marketing launch of Super-Masamune wherein this microcatheter was used to preserve the branches near the aneurysm.

Materials and Methods

During the period from 2014 to June 2020, a total of 670 cerebral aneurysm embolization procedures were performed.

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Table 1 Patient profiles

	Age	Sex	Site	Type	Hunt & Kosnik Grade	Maximum diameter (mm)	NP type	Result	Preservation of target vessel	Last follow-up[$]		Remarks
1	73	F	ICA	Saccular	0	8	ONP	CO	Complete	CO	24	
2	63	F	BA	Saccular	0	5.8	ONP	CO	Complete	CO	24	Intraoperative rupture
3	68	F	BA	Saccular	0	7	BNP	CO	Complete	CO	24	
4	59	F	BA	Saccular	0	6.3	BNP	NR	Complete	NR	24	
5	55	F	ICA	Saccular	0	4.3	BNP	NR	Complete	NR	24	
6	67	F	ICA	Saccular	2	9.3	BNP	BF	Complete		10	Retreatment (10M)
7	59	M	AcomA	Saccular	5	13	BNP	BF	Complete		1	Retreatment (1M)
8	47	M	VA	Dissection	5	9	PPO	CO	Complete		ND	
9	54	M	VA	Dissection	5	6.3	PPO	CO	Complete	CO	6	
10	45	M	VA	Partially thrombosed	0	16	PPO	CO	Complete	CO	6	

AcomA: anterior communicating artery; BA: basilar artery; BF: body filling; BNP: bulging neck plasty; CO: complete obliteration; ICA: internal carotid artery; ND: not done; NP: neck plasty; NR: neck remnant; ONP, ordinary neck plasty; PPO: protection during parent artery occlusion; VA: vertebral artery

Of these, the Super-Masamune device was used in 42 cases, and in 10 of these cases, the device was used to preserve branch vessels (**Table 1**). The Super-Masamune balloon microcatheter has a length of 150 cm, distal outer diameter of 2.8 F, and proximal outer diameter of 3.4 F. Its compatible guidewire is 0.014 inch in length, and the balloon length is 4.0 mm. A total of three radiopaque markers are provided at the tip and proximal end of the balloon, as well as at 3 cm proximal from the tip. The balloon expands to a diameter of 7.0 mm with the recommended injection volume of 0.2 mL and to 8.0 mm with the maximum injection volume of 0.36 mL. Since Super-Masamune is a "super-compliant" device, we utilized it in intra-aneurysmal neck plasty, in which it was inflated within the aneurysm. However, in the present study, we excluded cases in which this method was utilized. The subjects were four males and six females ranging in age from 45 to 73 years (mean age: 59 years).

The method of embolization with the Super-Masamune device does not differ substantially from that used for other balloon devices. The antiplatelet therapy method differed in cases of rupture and non-rupture, but the device used was the same. In the present study, introduction of the Super-Masamune device into the blood vessel affected by the aneurysm was performed for one of the following three objectives: (1) preservation of the target vessel (ordinary neck plasty: ONP), (2) inflation of a balloon to the origin of another vessel in addition to preservation of the target vessel (bulging neck plasty: BNP), and (3) preservation of other branching vessels in the vicinity during occlusion of the target vessel (protection during parent artery occlusion: PPO). In cases involving ONP and BNP, the necessity of a microcatheter for coil embolization coaxilally requires the insertion of an 8F guiding catheter. In cases involving PPO, since a single Super-Masamune device can be used for both occlusion of the aneurysm and preservation of the vessel, a 6F guiding catheter was used (except in Case 8).

Results

The target artery was internal carotid artery (ICA) in three patients, anterior communicating artery (AcomA) in one patient, basilar artery (BA) in three patients, and vertebral artery (VA) in three patients. Aneurysm size ranged from 4.3 mm to 16 mm (mean: 8.5 mm). Four patients presented with ruptures (Hunt & Kosnik [H & K] grade 2: 1 patient, grade 5: 3 patients) and six patients with no rupture. There were two cases of ONP, five cases of BNP, and three cases of PPO. Embolism results immediately following the procedure were complete obliteration in six, neck remnant (NR) in two, and body filling (BF) in 2. Intraoperative rupture occurred in one patient who underwent ONP, but this did not contribute to neurological worsening. Adjunctive treatment consisted of stent-assist coiling in one patient and clipping in one patient.

Representative case 1: Case 4 (Fig. 1)

This case involved a 59-year-old female who was transported to the hospital for H & K grade 3 subarachnoid hemorrhage (SAH). She underwent coil embolism using the simple technique. At her 6-month follow-up, coil compaction was discovered, and she underwent repeat treatment 9 months after SAH. The aneurysm was saddled on the left superior cerebellar artery (SCA), so we performed BNP using the Super-Masamune device, which was resulted in NR.

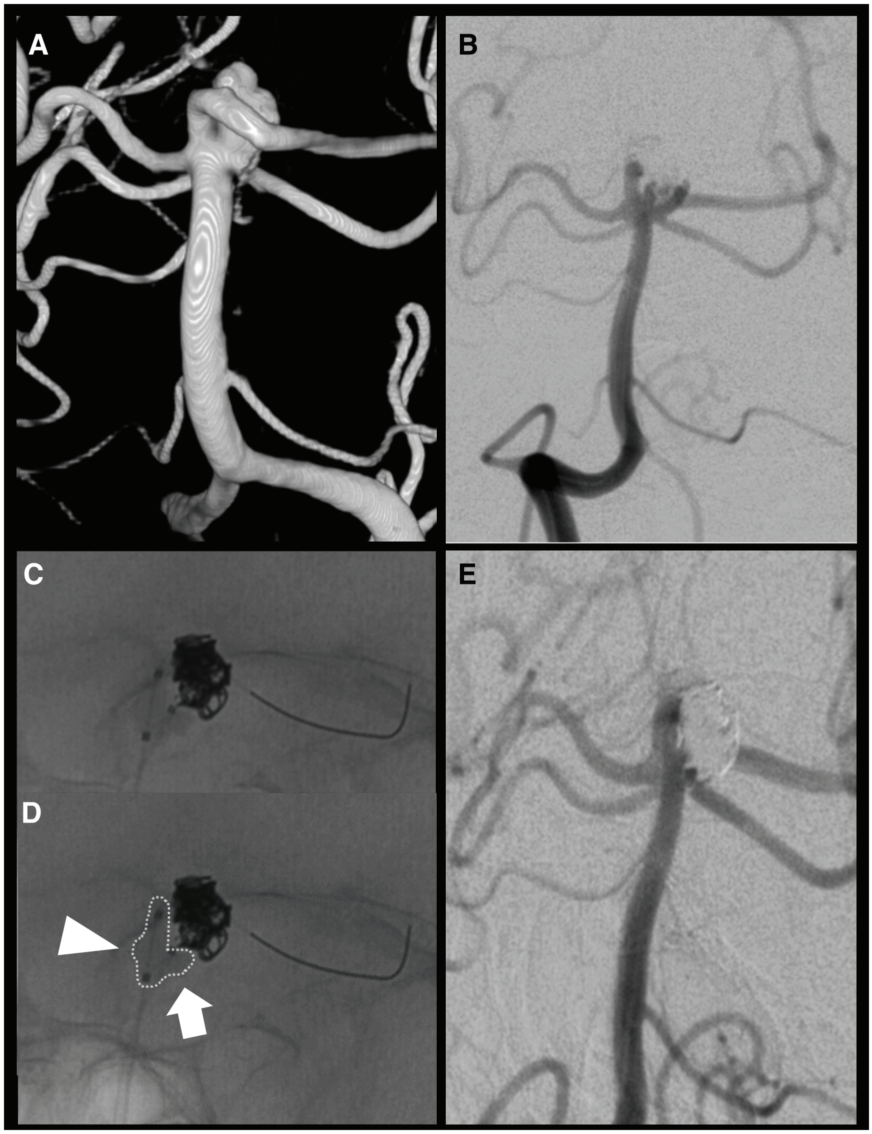

Fig. 1 VA angiograms, obtained in the antero-posterior view, of Case 4. (**A**) A 3D DSA image obtained just prior to the first embolization showing the BA—left SCA aneurysm. Note that the left SCA is originating from the aneurysm dome. (**B**) Angiogram obtained just prior to the second embolization, 9 months after the first embolization, showing recanalization of the aneurysm. (**C** and **D**) Skull X-p during coil insertion. White dots indicate shape of inflated Super-Masamune (**D**). Note that balloon bulges the left SCA (white arrow) and right PCA (white arrowhead). (**E**) An angiogram obtained just after embolization showing the neck remnant. Note that the left SCA is completely preserved. PCA: posterior cerebral artery; SCA: superior cerebellar artery; VA: vertebral artery

Representative case 2: Case 6 (Fig. 2)

This case involved a 67-year-old female with H & K grade 2 SAH. She suffered rupture of an aneurysm in the left ICA and underwent embolization under general anesthesia. A fetal-type posterior communicating artery branched off of the aneurysm dome; therefore, BNP was performed using the Super-Masamune device. The procedure was resulted in BF, and the patient was discharged home after one month. At 10 months postoperatively, she underwent adjunctive therapy consisting of stent-assisted coiling.

Representative case 3: Case 8 (Fig. 3)

This case involved a 47-year-old man with H & K grade 5 SAH. The patient suffered rupture of an aneurysm in the right VA and underwent embolization under general anesthesia. The posterior inferior cerebellar artery (PICA) branched off of the distal end of the aneurysm, and PPO was performed using the Super-Masamune device to preserve the PICA. The Super-Masamune was navigated such that it straddled the distal end of the aneurysm, and a microcatheter used to insert the coil was navigated proximal to this on the

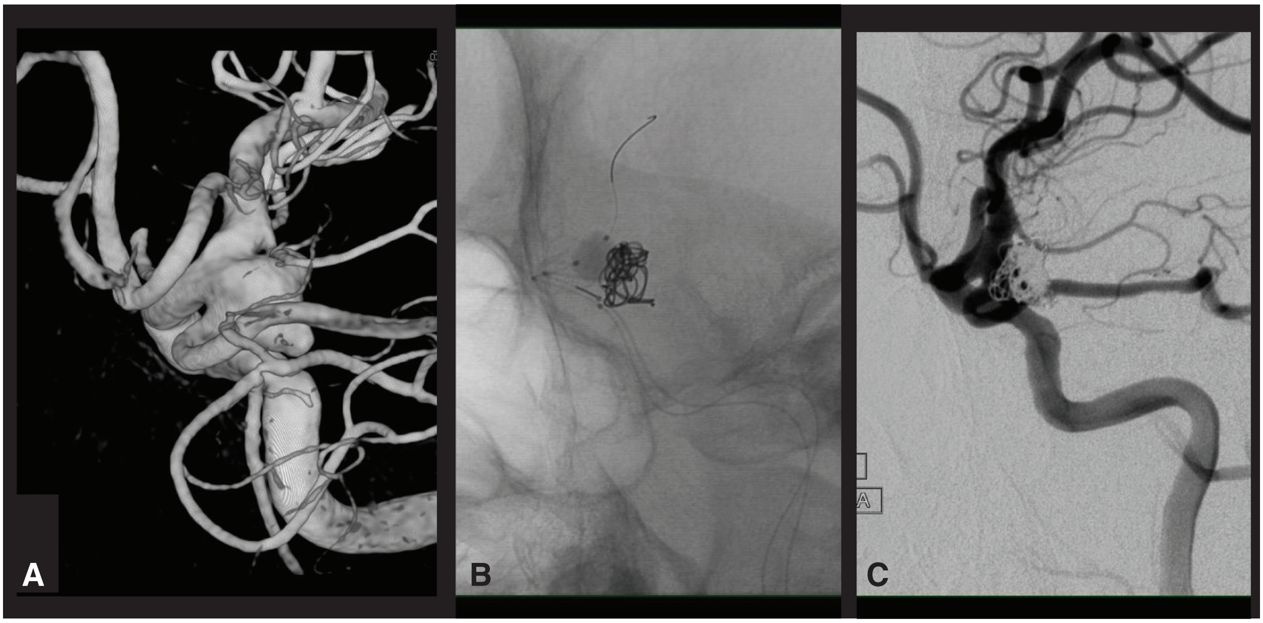

Fig. 2 Left internal carotid angiograms, obtained in the lateral oblique view, in Case 6. (**A**) A 3D DSA image just prior to embolization. The left PcomA is originating from the aneurysm dome. (**B**) Skull X-p during coil insertion. Note that the balloon is bulging in the aneurysm. (**C**) An angiogram obtained just after embolization showing body filling. Left PcomA is completely preserved. PcomA: posterior communicating artery

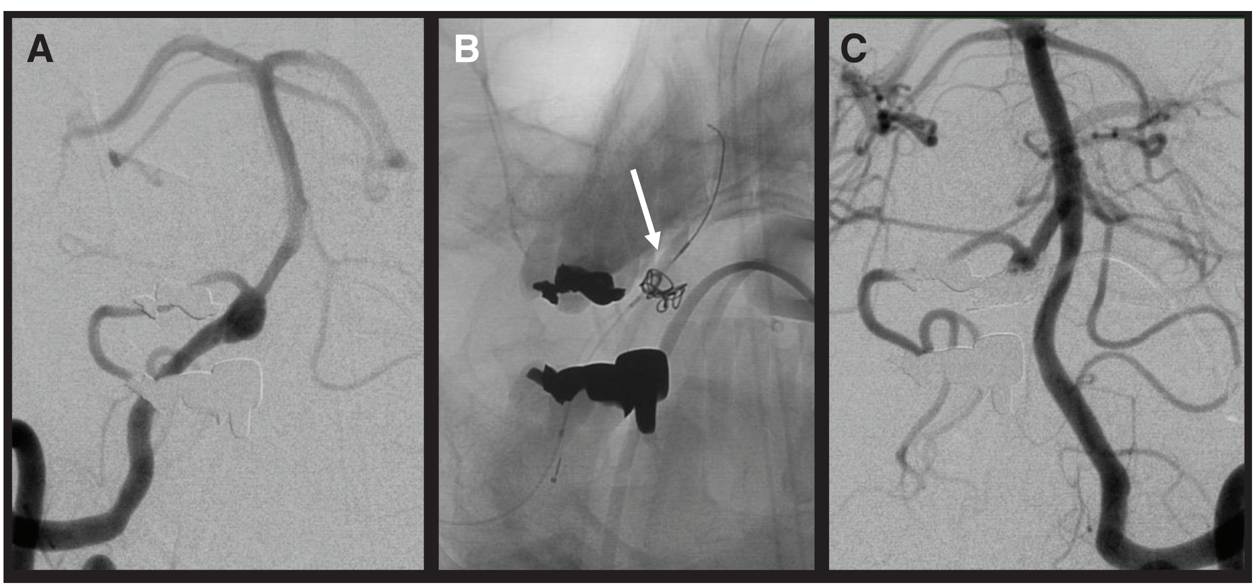

Fig. 3 VA angiograms, obtained in the antero-posterior caudal view, in Case 8. (**A**) An angiogram showing right VA dissection. Note that the right PICA is originating from the distal end of dissection. (**B**) Skull X-p during coil insertion. The white arrow indicates the inflated Super-Masamune. (**C**) Left VA angiogram just after coiling. The right PICA is filled via the left VA. PICA: posterior inferior cerebellar artery; VA: vertebral artery

same axis. The right VA was occluded with the aneurysm at a site proximal to the PICA. PICA blood flow was preserved through retrograde flow from the VA union to the right VA.

Discussion

The neck plasty technique was initially developed as an adjunctive technique for use in conjunction with arterial aneurysm embolization.[5,6] The balloon initially used was semi-compliant; thus, it could only expand the parent vessel.[7–11] Subsequent advancements[12–16] led to the development of a variety of balloon types (**Table 2**). One of these was the Hyperform occlusion balloon system (Hyperform: Medtronic, Minneapolis, MN, USA), which is a compliant balloon. One of its characteristics is that with slight overinflation, bulging can be accomplished in a

Table 2 Profiles of compliant balloons

	Super-Masamune	Hyperform (4 mm × 7 mm)	Hyperform (7 mm × 7 mm)	Scepter XC (4 mm × 11 mm)
Outer diameter (Fr) Proximal shaft/ Distal tip	3.4/2.8	2.8/2.5	3.0/2.8	2.8/2.1
Balloon length (mm)	4	7	7	11
Maximum balloon diameter (mm)	7	5	8	6
Distal tip length (mm)	2	2	2	5
Lumen	Double lumen	Single lumen	Single lumen	Double lumen
Second marker for coiling	(+)	(–)	(–)	(–)
Coil insertion	Possible	Impossible	Impossible	Possible

space that is not in the course of the balloon; therefore, the indications of this technique were expanded to include its use in neck plasty.[14,15] The Super-Masamune device utilized in the present study is even more compliant that the Hyperform[2]; thus, it can accomplish bulging in more types and locations of free spaces than any type of conventional balloon. For this reason, neck plasty could be performed such that it could achieve inflation within the aneurysm, as was done in Case 6 (**Fig. 2B**). For example, as in many cases of basilar bifurcation of an aneurysm, when it is desirable to preserve two vessels, the operator would want to navigate the balloon in the vessel that is overridden by the aneurysm. Due to the morphology and positioning of the vessel, however, the guidewire and/or microcatheter can often more easily be navigated in the vessel that is not overridden by the aneurysm. When using a super-compliant balloon, on the other hand, even if the balloon is inserted in the vessel that is more accommodating, since the balloon is inflated such that it reaches the space on its own, it is inflated at the entrance of the vessel that the surgeon wants to preserve. In Case 4, we wanted to preserve the left SCA, but it was quite difficult to directly navigate the balloon in this vessel. However, it was easy to insert the guidewire and microcatheter into the left posterior cerebral artery. Using the Super-Masamune device, we could select this vessel and inflate it there, and we were still able to preserve the left SCA (**Fig. 1C**). Of the cases described in this study, five of the seven in which neck plasty was performed to preserve the parent vessel were BNP procedures. We believe that Super-Masamune is suited for use when attempting this method. BNP always need to inflate balloon larger than diameter of the parent artery. So, there is possibility of rupture of parent artery. Super-Masamune is so compliant that balloon goes to free space rather than rupturing vessel. We do not have such complication so far, we should keep in mind the potential risk of vessel rupture.

Since the outer diameter of the Super-Masamune device is somewhat large and since a sufficiently wide contrast lumen is required, when using the device coaxially, a guiding catheter that is 1F slightly larger than that used with other balloons is required. Therefore, in cases involving ONP wherein the required inflation is not very large, it is easier to utilize other types of balloons. The Super-Masamune device, however, can be used when a BNP with a larger balloon than that used in normal ONP procedures is required.

On the other hand, when performing PPO, the merits of using the Super-Masamune device include the fact that just one balloon can accomplish the tasks that normally require the use of a microcatheter and a balloon catheter. This is the method that has been previously reported with the forerunner device, the Masamune device. Even in cases wherein a single microcatheter should be sufficient, the additional use of a balloon serves as a kind of "insurance." Furthermore, as a modified method employed in the series of cases described in this study, we preserved the PICA by passing by the site of occlusion along the same axis in cases in which the PICA branches off from the distal end of the dissection (Case 8, **Fig. 3**). This can be accomplished—albeit not on the same axis—by going around from the opposite side via the union, but after the parent vessel is successfully occluded, only the VA on the opposite side supplies the BA; thus, there is merit in completing the treatment without manipulating the VA and BA on the opposite side at all. Even under such circumstances, the Super-Masamune device adequately protects the origin of the PICA, allowing satisfactory occlusion. After completing the occlusion procedures, we were able remove the Super-Masamune device without incident.

Although one of the cases assessed in this study showed intraoperative rupture, this did not lead to any worsening in neurological findings. This complication is likely to occur when performing ONP with other types of balloons as well. Thus, we did not experience any complications that were attributable to the unique characteristics of the Super-Masamune device itself, and we observed no complications caused by the use of the balloon to achieve large impactions in the aneurysms.

The introduction of high-performance stents is gradually resulting in a shift from the use of balloons to the use of stents in adjunctive techniques performed for cases of wide-neck aneurysms.[17] In our personal experience, there are more opportunities to use a stent than a balloon. However, balloons have multiple merits, such as the fact that they can be used in the chronic stage of a rupture and that their use can reduce the period of time for which antiplatelet therapy is used. As indicated, successful outcomes are difficult to achieve in BNP procedures performed using a stent. Therefore, neck plasty using a balloon will remain an essential procedure for the foreseeable future. Thus, the Super-Masamune device remains an effective option for most BNP procedures, in which its use is possible.

Conclusion

Neck plasty using the Super-Masamune device is an extremely useful option while performing an ONP and also when performing a BNP in which strong impaction of the aneurysm is desired. It is also extremely effective when performing a PPO procedure.

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Disclosure Statement

We declare no conflicts of interest.

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