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Technical Note

Retrograde T-Stent Technique for Large, Wide-Necked Internal Carotid-Posterior Communicating Artery Aneurysm

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Objective: We report a case of a wide-necked internal carotid-posterior communicating (IC-Pcom) artery aneurysm treated by the retrograde T-stent technique in which a stent was also placed in the Pcom artery via the posterior circulation.
Case Presentation: A 35-year-old woman was diagnosed with an unruptured right IC-Pcom artery aneurysm (maximum diameter: 11 mm, neck diameter: 8.5 mm) during a detailed examination for vertigo. The Pcom artery (2.1 mm) branched from the aneurysmal dome. A microcatheter was guided in retrograde via the Pcom artery from the posterior circulation. A low-profile visualized intraluminal support (LVIS) Jr. 2.5 mm × 17 mm was deployed from the internal carotid artery (ICA) to the Pcom artery, and then, an LVIS 4.5 mm × 23 mm was deployed while pressing the flare of the LVIS Jr. protruding into the ICA. T configuration stenting was completed, and the coil was inserted as tightly as possible.
Conclusion: The retrograde T-stent technique, which has the advantage of optimal stent positioning, is useful for preserving a Pcom artery branching from the aneurysmal dome.

Keywords ▶ retrograde T-stent technique, stent-assisted coil embolization, internal carotid-posterior communicating aneurysm, wide neck large aneurysm

Introduction

Recently, many assist techniques using a balloon or stent have been devised for the treatment of cerebral aneurysms, facilitating effective coil embolization with the preservation of a parent blood vessel or branches. In particular, methods, such as the stent and balloon technique,[1] Y-configuration technique,[2,3] and kissing Y-configuration technique,[4] have been developed to treat wide-necked cerebral aneurysms that are difficult to treat using the simple technique.[5] According to several case reports, the T-stent technique led to favorable embolization of internal carotid-posterior communicating (IC-Pcom) artery aneurysms.[6,7] However, in previous studies regarding T- or Y-stent techniques for IC-Pcom artery aneurysms, an antegrade method involving IC-mediated access to the Pcom artery was adopted. We report a patient in whom the T-stent technique employing a retrograde method involving Pcom artery access through the posterior cerebral artery was selected, facilitating accurate stent positioning and favorable embolization. The details of the procedure, comparison with the antegrade method, and its advantages are also presented.

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Case Presentation

Patient: The patient was a 35-year-old woman.
Medical history: The patient's medical history was not contributory.
Family history: The patient's family history was not contributory.
Present illness: MRI and CTA for detailed examination of vertigo and nausea at a local clinic revealed a large right IC aneurysm. She was referred to our department.
Physical examination: The patient was alert, and there was no neurological deficit.
Imaging findings: Cerebral angiography revealed an unruptured right IC-Pcom artery aneurysm measuring 11 mm in maximum diameter (**Fig. 1A** and **1B**). The aneurysmal neck measured 8.5 mm, indicating a wide-necked aneurysm.

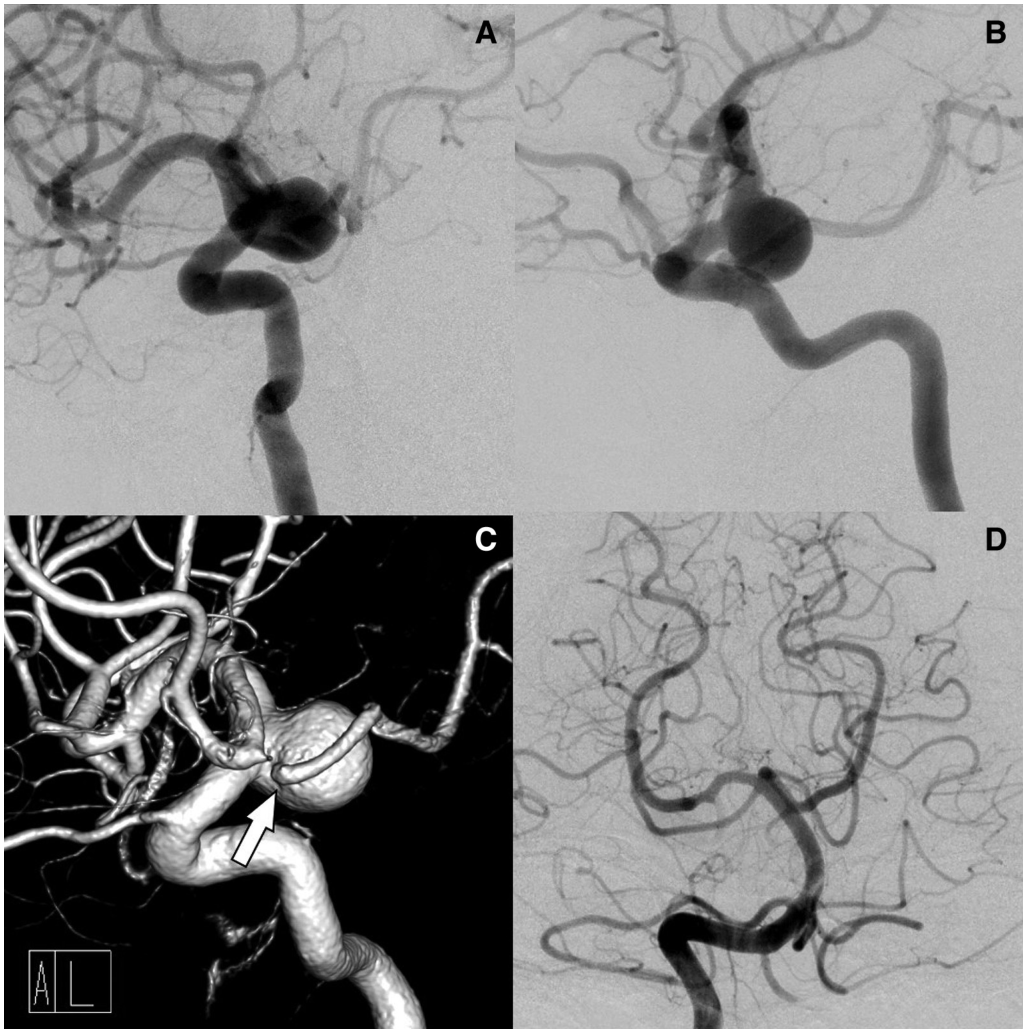

Fig. 1 Preoperative right internal carotid angiography (**A**, AP view; **B**, lateral view) showed a wide-necked large aneurysm at the origin of the Pcom artery artery. 3D RA (**C**) demonstrated that the Pcom artery branched from the aneurysmal dome (white arrow). Right vertebral angiography (**D**, AP view) showed a developed right P1. AP: antero-posterior; RA: rotational angiography

Furthermore, the Pcom artery directly branched from the aneurysmal dome (**Fig. 1C**), with a diameter of 2.1 mm. Vertebral arteriography demonstrated development of the ipsilateral posterior cerebral artery (**Fig. 1D**).

Therapeutic strategies: Several neurosurgeons discussed whether direct surgery or endovascular treatment was appropriate, and considered that the latter was advantageous for safe aneurysm treatment involving Pcom artery preservation. Based on the Pcom artery bifurcation morphology, balloon-assisted or simple stent-assisted techniques were considered to make preservation of this blood vessel difficult; therefore, we selected the T-stent technique in which stents are inserted into the IC and Pcom artery. For this technique, a retrograde method involving access to the Pcom artery via the posterior circulation was adopted for the following reasons: non-aneurysm-mediated approaching is possible and positioning of a stent to be placed in the Pcom artery is relatively easy. The oral administration of two antiplatelet drugs (aspirin at 100 mg/day, clopidogrel at 75 mg/day) was started 1 week before treatment.

Prior to treatment, the treatment plan was approved by the ethics review board of our hospital (Approval No. 2019-0182). Written informed consent was received from the patient.

Endovascular treatment

Under general anesthesia, an 8 Fr long sheath was inserted into the right femoral artery and a 6 Fr long sheath was inserted into the left femoral artery. Heparin at 5000 units was intravenously injected for systemic heparinization. Subsequently, it was intravenously injected at 1-hour intervals in order to prolong the activated clotting time by 2- to 3-fold of the pretreatment value. After inserting 6 Fr Roadmaster (Goodman, Aichi, Japan) into the right vertebral artery, 4.2 Fr Fubuki (Asahi Intecc, Aichi, Japan) was inserted into the right vertebral artery as an intermediate catheter. Furthermore, 8 Fr Launcher (Medtronic, Minneapolis, MN, USA) was inserted into the right IC. As an intermediate catheter, Cerulean DD6 (Medikit, Tokyo, Japan) was inserted to the petrous portion of IC. Under compression of the right IC, 3D rotational angiography (RA) of the right vertebral artery was performed and a working angle to retrogradely guide a microcatheter into the IC through the Pcom artery via the posterior circulation was established (**Fig. 2A**). Using CHIKAI 14 (Asahi Intecc), Excelsior SL-10 (Stryker, Kalamazoo, MI, USA) was retrogradely inserted into the Pcom artery and guided into the distal right IC through the aneurysm. Subsequently, 3D RA of the right IC was performed, and a working angle for stenting and intra-aneurysmal embolization was re-established (**Fig. 2B**). Using CHIKAI 14, Headway 21 Plus (Terumo Corporation, Tokyo, Japan) was guided to the horizontal area of the right middle cerebral artery. In addition, a steam-pigtail-shaped SL10 was guided into the aneurysm under CHIKAI 14 guidance. An LVIS Jr. 2.5 mm × 17 mm (Terumo Corporation) was half-deployed in the IC to the Pcom artery through the SL-10 inserted into the distal right IC. At this point, the starting point of the stent was adjusted such that its distal flare slightly protruded into the IC. Subsequently, an LVIS 4.5 mm × 23 mm was half-deployed from the right middle cerebral artery through the Headway 21 Plus in order to push the distal flare of the LVIS Jr. that was slightly protruding into the IC to the aneurysmal side. At this point, cone-beam CT was performed. The distal flare of the LVIS Jr. protruded from the Pcom artery orifice into the aneurysm. There was no gap between the LVIS deployed in the IC and the distal flare of the LVIS Jr. (T-configuration stenting). After confirming this (**Fig. 2C** and **2D**), the LVIS Jr. and LVIS were completely deployed. Imaging demonstrated an eclipse sign and the intra-aneurysmal retention of contrast medium (**Fig. 2E** and **2F**). During coil embolization, the origin of the Pcom artery was secured using the LVIS Jr.; the coil loop did not reach this site (**Fig. 2G**). A total of 16 bare platinum/hydrogel coils measuring 205 cm in length were inserted and the procedure was completed, with a volume embolization ratio of 24% and neck remnant (**Fig. 3A** and **3B**). There was no problem regarding Pcom artery blood flow during coil embolization (**Fig. 3C**).

Postoperative course

The postoperative course was favorable. There were no new neurological symptoms. The oral administration of two antiplatelet drugs was continued, and the patient was discharged with a modified Rankin Scale score of 0. Cerebral angiography 6 months after the surgery demonstrated recurrence and aneurysmal enlargement (**Fig. 4A**). Slight stenosis of the IC proximal to the aneurysm was observed, which was possibly related to stenting. There was no occlusion of the Pcom artery, but its blood flow had changed to retrograde from the posterior circulation. To prevent rupture, additional surgery was selected. A microcatheter was guided into the aneurysm through the mesh of the LVIS using the trans-cell method; almost complete embolization was obtained, and the procedure was concluded (**Fig. 4B**). During additional treatment, the origin of the Pcom artery was also secured using the LVIS Jr. deployed during the initial treatment; the coil loop did not reach this site. A Pcom artery-mediated collateral pathway from the posterior circulation was favorable (**Fig. 4C**). The patient was discharged with no neurological symptoms. No recurrent aneurysm was found on cerebral angiography 3 months after re-embolization. Furthermore, there was no change in the slight stenosis at the site of IC stenting.

Discussion

Many assist techniques using a balloon or a stent for wide-necked aneurysms have been devised, facilitating treatment that was previously difficult. The insertion of several stents is necessary and effective for aneurysms that make branch-vessel preservation difficult.[8,9] The Y-stent technique is advantageous in that coil embolization can be performed while preserving multiple parent blood vessels. However, stent deformity or deviation in a stent-overlapped part may increase the risk of thrombotic complications.[10] On the other hand, the T-stent technique may have the following advantages: stents do not overlap and there is no stent deformity, and thrombotic complications may be less likely to develop compared to the Y-stent technique. However, when deploying another stent on the side of a stent without a gap, stent shortening or accurate positioning must be considered; the T-stent technique is technically more difficult than the Y-stent technique.

Several studies reported treatment using the T-stent technique for IC-Pcom artery aneurysms,[6,7] but an antegrade method involving access to the Pcom artery through the IC was adopted. This method makes stent-end positioning on

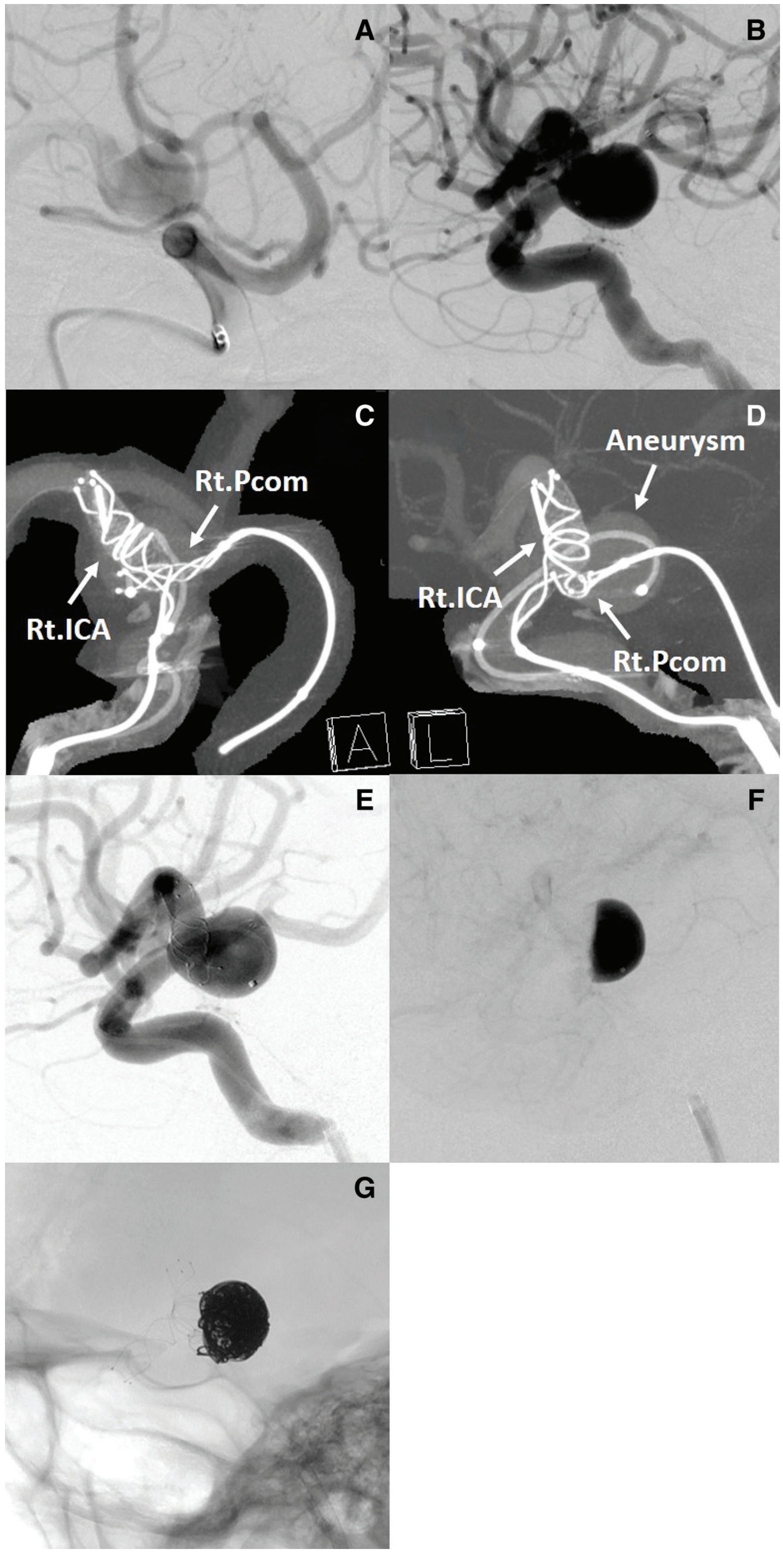

Fig. 2 (**A**) Working angle to guide a microcatheter from the posterior circulation to the posterior communicating artery and internal carotid artery in a retrograde fashion. (**B**) Working angle for stent placement and coil embolization. T-configuration stenting was confirmed by cone-beam CT (**C** and **D**), and both stents were fully deployed. (**E** and **F**). Right internal carotid angiography after stent deployment showed the eclipse sign. (**G**) The coil mass did not reach the orifice of the Pcom artery.

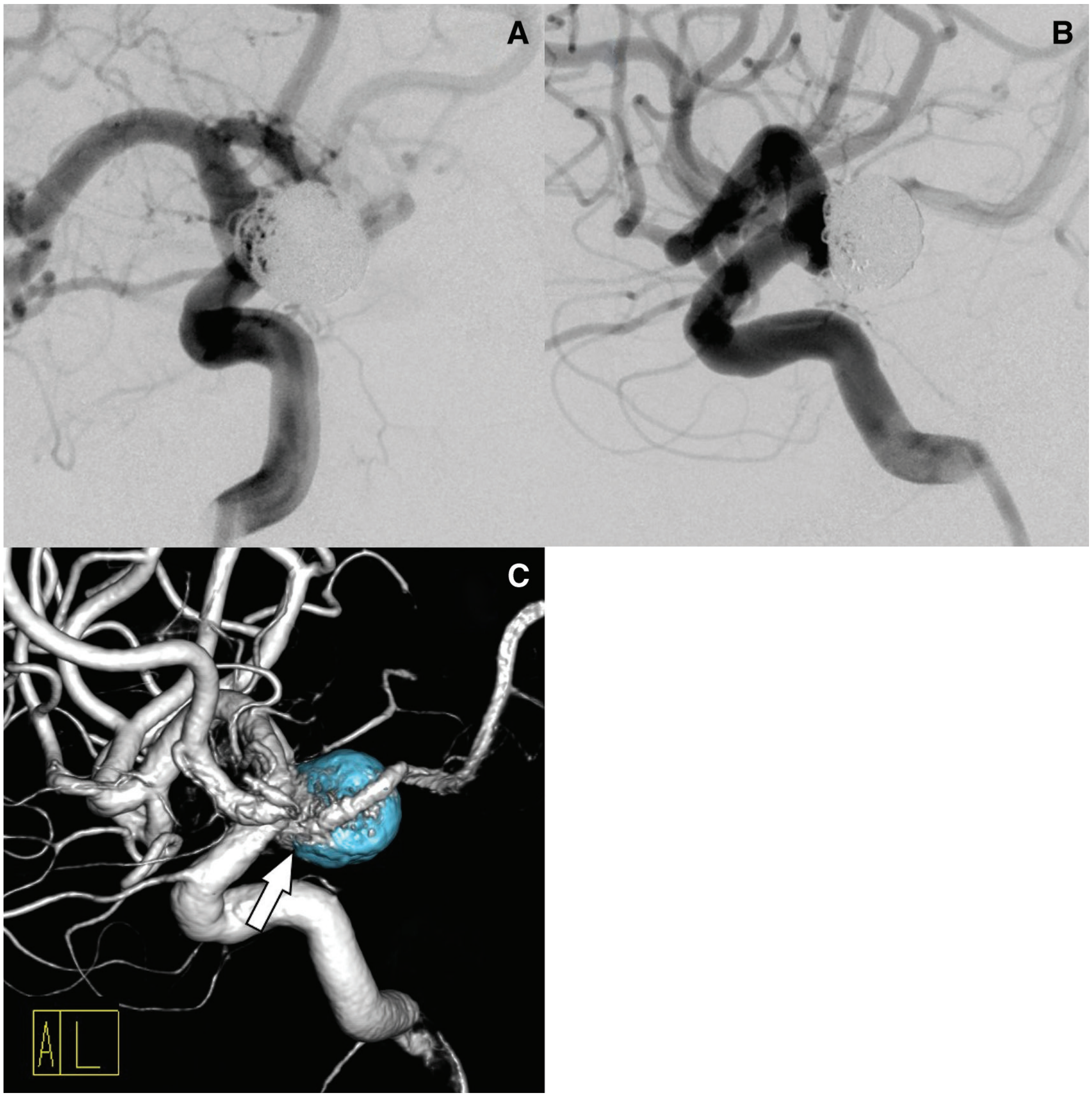

Fig. 3 Postoperative right internal carotid angiography (**A**, AP view; **B**, lateral view; **C**, 3D rotational angiogram) showed the neck remnant of the aneurysm, preserving the patency of the Pcom artery (the white arrow shows the distal flare of the LVIS Jr.). AP: anteroposterior

the IC side on Pcom artery stent deployment difficult, as described above. Furthermore, when accessing the Pcom artery, it is necessary to guide a microcatheter along the aneurysmal wall in many cases (intra-aneurysmal microcatheter looping technique).[11] Procedure-related risks, including intraoperative rupture, may increase, which is a limitation. On the other hand, a retrograde method involving access to the Pcom artery from the posterior circulation, which we adopted in the present case, facilitates Pcom artery access in the absence of the intra-aneurysmal microcatheter looping technique. Positioning on the IC side for stent deployment may be easier than when the antegrade method is used. However, there are requirements to adopt the retrograde method: the P1 ipsilateral posterior cerebral artery and Pcom artery must be developed. Cho et al. reported the necessity of a Pcom artery diameter sufficient for a microcatheter for stent insertion to pass for retrograde stenting.[12] Ahmed et al. reported that the mean vascular diameter was 1.17 mm in patients in whom a microcatheter was retrogradely guided into the anterior communicating artery or Pcom artery for stenting.[13] These studies suggest that P1/Pcom artery diameters of at least approximately 1 mm are necessary. In the present case, the Pcom artery was developed, measuring 2.1 mm in diameter; therefore, we considered catheterization and stenting possible.

Endo et al. suggested that the Pcom artery can be obliterated in ruptured IC-Pcom artery aneurysm patients with a positive reaction on the Allcock test and P1 visualization on vertebral arteriography.[14] However, the risk of thrombosis/occlusion of perforators, such as the tuberothalamic

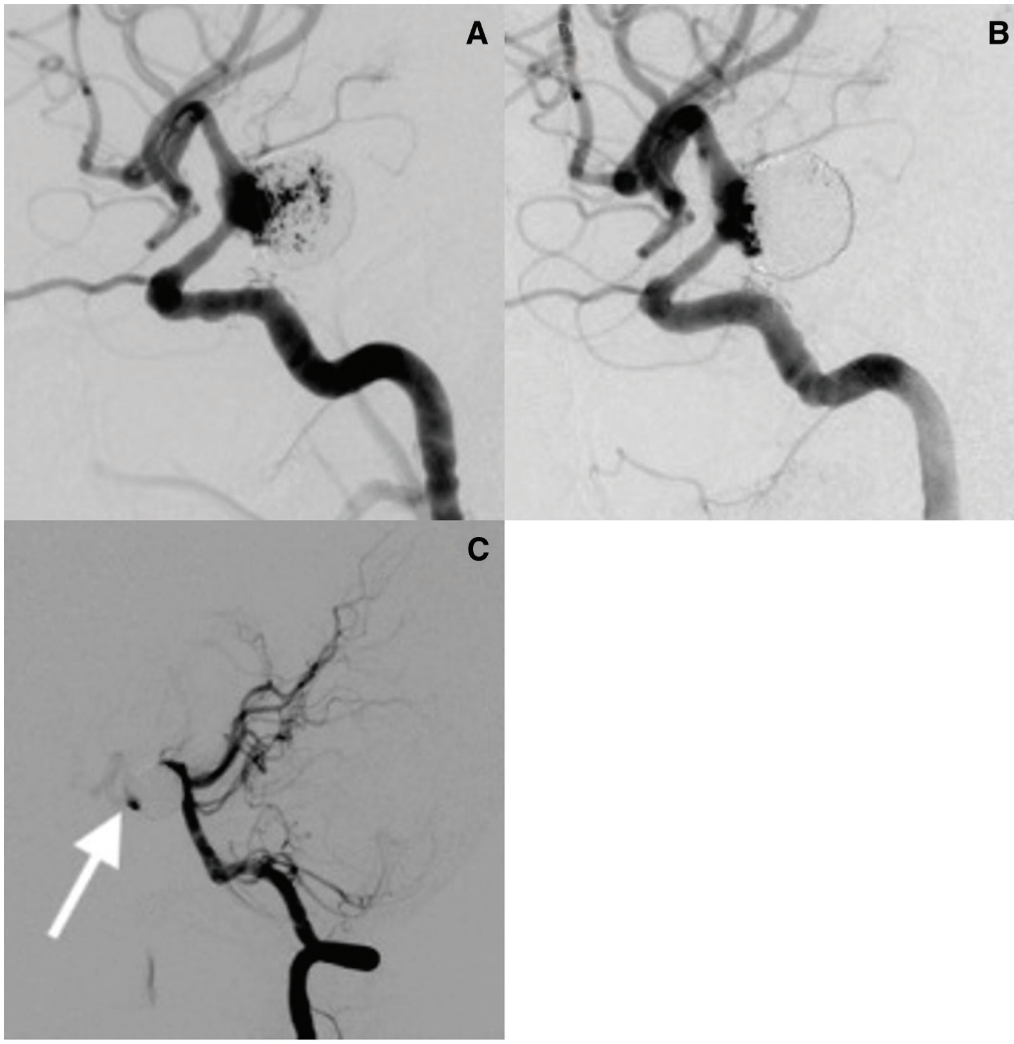

Fig. 4 (**A**) Right internal carotid angiography 6 months after the first treatment showed recanalization and regrowth of the aneurysm. (**B**) After the second treatment, right internal carotid angiography showed the neck remnant of the aneurysm, and (**C**) right vertebral angiography showed retrograde flow from the Pcom artery to the anterior circulation (white arrow).

artery, related to Pcom artery blinding cannot be ignored. Whether this risk is permissible for unruptured aneurysms remains controversial. According to Cho et al., there were no ischemic symptoms after complete obliteration of the Pcom artery, whereas ischemic events developed in two of 21 patients in whom obliteration was incomplete.[15] In the present case, we selected a strategy to preserve the Pcom artery using a stent considering the risk of ischemic symptoms after Pcom artery obliteration.

Regarding the stent selection for the T-stent technique, low-profile stents are appropriate for the Pcom artery. In the present case, we used an LVIS Jr. An open cell stent, Neuroform Atlas (Stryker), facilitates stent deployment and can be useful. However, re-sheathing is difficult after deployment; an additional attempt is impossible. Therefore, the Neuroform Atlas is unfavorable for the T-stent technique in which positioning is the most important point. On the other hand, an LVIS Jr. facilitates re-sheathing or an additional attempt, but may shorten more frequently than other stents; for positioning, the stent must be deployed considering this characteristic. Morinaga et al. reported three patients in whom an LVIS Jr. was deployed in a branch vessel for the T-stent technique, leading to favorable results,[7] similar to the present case. They suggested the usefulness of the Neuroform Atlas with a high-level adhesiveness to a parent blood vessel as a stent to be inserted into the IC.[7] However, in the present case, the use of a braided stent with a high metal covering rate, such as LVIS, may have led to thrombosis of the aneurysm through flow diversion effects.[16] Furthermore, in the present case, cone-beam CT before the complete deployment of two stents was useful for confirming the positional relationship between the two stents.

A previous study reported the T-stent technique for bifurcation-type aneurysms,[17] but few studies have examined the usefulness of this technique for side-wall-type aneurysms, IC-Pcom artery aneurysms, possibly because of the difficulty of accessing the Pcom artery. According to previous studies, the intra-aneurysmal microcatheter looping technique was required for accessing the Pcom artery.[6,18] If access via a retrograde method is possible, as demonstrated in the present case, the Pcom artery can be secured relatively readily and safely. The T-stent technique is safe and useful for the treatment of IC-Pcom artery aneurysms.

In the present case, recurrence was detected early after surgery. The LVIS inserted into the IC slightly projected into the aneurysm, and the distal flare of the LVIS Jr. placed in the Pcom artery protruded from the Pcom artery orifice into the aneurysm, securing the lumen; therefore, the aneurysmal volume to be embolized may have been smaller than the actual volume, and this may have played a role in the recurrence. As a large IC aneurysm recurred in a short period, careful follow-up must be continued in the future.

As a precaution, the retrograde T-stent technique is not routinely adopted. The procedure is complex, and patients must be carefully selected. This method may be considered for patients in whom Pcom artery preservation is necessary and retrograde access to the Pcom artery is possible. In the present case, recurrence was detected after initial treatment. The embolic state after additional treatment has been stable, but careful follow-up should be continued in the future.

Conclusion

The use of the retrograde T-stent technique for a large, wide-necked IC-Pcom artery aneurysm led to favorable embolization. The Pcom artery-preserving effects of the T-stent technique were confirmed. The retrograde method may be safer and more accurate for catheter guiding and stent positioning than the antegrade method.

Disclosure Statement

The authors completed self-reporting of conflicts of interest to the Japanese Society for Neuroendovascular Therapy. Hasegawa received rewards, such as lecture fees, from Medtronic Japan Co., Ltd. from January to December 2019. The other authors have no conflict of interest.

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