Single-stage Coil Embolization for Kissing Aneurysms of the Internal Carotid Artery Using Enterprise Stent: Three Cases Reports

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Purpose: Kissing aneurysms (KAs) are caused by the rare incidence of two aneurysms with different cervixes mutually contacting each other, with craniotomy surgical clipping having been reported as difficult. The objective was to investigate the treatment outcome of single-stage coil embolization using an Enterprise stent for internal carotid artery KA.

Materials and Methods: The subjects consisted of three cases and six aneurysms (women: two cases, age: 42–70 years old, average: 55.7 years old) that underwent single-stage coil embolization using an Enterprise stent. Localization of the aneurysms was as follows: internal carotid artery-ophthalmic arterial bifurcation and internal carotid artery (C3): one case; internal carotid artery-posterior communicating arterial bifurcation and anterior choroidal arterial bifurcation: two cases; wherein, the maximum aneurysm diameter was 2.8–7.6 mm (average: 5.1 mm). The technical success rate, the presence of perioperative complications, the degree of embolus follow-up cerebral angiography after treatment (4–6 months, average: after 4.7 months), and more than 3 years follow-up contrast-enhanced magnetic resonance angiography (after 3.4–4.1 years, average: after 3.7 years) were assessed.

Results: Coil embolization was successful in all cases, with no observation of perioperative complications. Upon follow-up angiography, complete occlusion (CO) was observed in all three cases and six aneurysms.

Conclusion: The initial treatment outcome of single-stage coil embolization for carotid KA using an Enterprise stent was good.

Keywords ► kissing aneurysms, coil embolization, Enterprise stent

Introduction

Kissing aneurysms (KAs) are caused when two aneurysms with different cervixes mutually contact each other, having first been reported by Jefferson et al. in 1978.1) In 1984, Yasargil2) named such aneurysms as KAs. They are relatively rare, observed in 0.2%–0.9% of all cerebral aneurysms, and it is believed that posterior communicating aneurysms and anterior choroidal aneurysms are the most commonly observed.2)

It is regarded that surgical clipping, which is a surgical treatment for KA, is challenging due to difficulties in surgical procedures such as exfoliation, etc., which are required due to adhesion between aneurysms.

Meanwhile, as far as we know, there are few reported cases of KA occurring in the same artery due to endovascular
therapy among recent surgical treatments which are gradually shifting from surgical clipping.\textsuperscript{3–6)}

**Objective**

The objective was to investigate the treatment outcome of single-stage coil embolization using an Enterprise stent for three cases and six aneurysms of KAs generated by mutually contacting the same internal carotid artery.

### Subjects and Methods

The subjects consisted of three cases and six unruptured aneurysms (a man and two women; mean age, 55.7 years [range, 42–70 years] that underwent single-stage coil embolization using Enterprise stent from January 2012 to July 2013 (Table 1). Informed consent was obtained from all individual participants included in the study. Localization of the aneurysms was as follows: one case had an internal carotid artery-ophthalmic arterial bifurcation aneurysm and an internal carotid artery (C3) aneurysm, and the other two cases had an internal carotid artery-posterior communicating arterial bifurcation aneurysm and an anterior choroidal arterial bifurcation aneurysm. Three aneurysms of two cases were recurrence following coil embolization, and two aneurysms of one case were re-enlargement following coating. Wherein, the maximum aneurysm diameter was 2.8–7.6 mm (average: 5.1 mm) (Table 2).

**Interventional procedure**

The administration of two antiplatelet drugs (aspirin: 100 mg, clopidogrel: 75 mg) was commenced from 14 days prior to treatment. Aspirin Reaction Units (ARU; determined as effective when 550 or less) and P2Y12 Reaction Units (PRU; determined as effective when 250 or less) were measured by the VerifyNow system (Accumetrics, CA, USA) 7 days prior to treatment and confirmed effective in both. The therapeutic procedure was carried out under general anesthesia in all cases, with an Enterprise stent used as the stent in all three cases. Regarding two cases, the jailing or semi-jailing method was carried out for distal aneurysms, whereas the trans-cell method was carried out for proximal aneurysms, and the semi-jailing method by combined stenting and coil embolization was carried out on one case (Table 2). Antiplatelet drug administration of two drugs was continued for at least 3 months following surgery, before being subsequently reduced to one drug. Follow-up angiography was carried out 4–6 months following endovascular treatment.

**Investigation items**

An investigation was carried out into the technical success rate, the presence of perioperative complications, the embolization ratio evaluated by Raymond-Roy Occlusion Classification upon immediately following treatment and upon 3 months after endovascular treatment.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Clinical characteristics</th>
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<tbody>
<tr>
<td>Location</td>
<td>Size (mm)</td>
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<tr>
<td>Case 1</td>
<td>3.3 × 3.7 × 2.4</td>
</tr>
<tr>
<td>IC (C3)</td>
<td>7.1 × 7.6 × 6.9</td>
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<tr>
<td>Case 2</td>
<td>2.8 × 2.3 × 2.3</td>
</tr>
<tr>
<td>IC-AChA</td>
<td>3.5 × 2.9 × 2.3</td>
</tr>
<tr>
<td>Case 3</td>
<td>2.4 × 4.0 × 3.7</td>
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<tr>
<td>IC-AChA</td>
<td>3.3 × 6.3 × 3.9</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Interventional procedures and immediate results</th>
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<tbody>
<tr>
<td>Location</td>
<td>Technique</td>
</tr>
<tr>
<td>Case 1</td>
<td>IC-OphA</td>
</tr>
<tr>
<td>IC (C3)</td>
<td>Trans-cell</td>
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<tr>
<td>Case 2</td>
<td>IC-AChA</td>
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<tr>
<td>IC-PCoA</td>
<td>Semi-jailing</td>
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<tr>
<td>Case 3</td>
<td>IC-AChA</td>
</tr>
<tr>
<td>IC-PCoA</td>
<td>Trans-cell</td>
</tr>
</tbody>
</table>

AChA: anterior choroidal artery; IC: internal carotid artery; OphA: ophthalmic artery; PCoA: posterior communicating artery
Coil embolization was successful in all cases (Figs. 1–3), with no observation of perioperative complications. Upon the angiography immediately following treatment, two cases and four aneurysms resulted in complete occlusion (CO; 66.7%), while one case and two aneurysms resulted in residual neck (33.3%); however, upon follow-up angiography (after 4–6 months, average: after 4.7 months), CO was observed in all three cases and six aneurysms with good patency of parent artery (Table 3). More than 3 years of follow-up, contrast-enhanced magnetic resonance angiography (after 3.4–4.1 years, average: after 3.7 years) revealed CO of the aneurysms and good patency of the stents.

Case 1 (Fig. 1)  
A 42-year-old woman had KA of the right internal carotid artery-ophthalmic arterial bifurcation (OphA) and recurrence after coiling of C3. Stent-assisted coil embolization for the KAs was performed in one session. Under general anesthesia and systemic heparinization, an 8 Fr Brite Tip guiding catheter (Codman, Raynham, MA, USA) was inserted into the right internal carotid artery from the right common femoral artery. A Prowler Select Plus (Codman) as a microcatheter for the stent delivery was navigated to the distal M1 segment of the middle cerebral artery over microguidewire (Transcend platinum tip; Stryker, Kalamazoo, MI, USA). Then, an Excelsior SL-10 (Stryker) was turned over a Transcend platinum tip and introduced into the distal aneurysm of the KA. An Enterprise measuring 4.5 × 28 mm was placed to cover the neck of KA. Coiling of the distal aneurysm was accomplished using the Jailing method with a total four coils (one Trufill DCS Orbit Galaxy Complex Fill 3.5 mm × 9 cm; Codman, one Target 360 Ultra 3 mm × 4 cm; Stryker, and two Target 360 Ultra 3 mm × 4 cm; Stryker), and then coiling of the proximal aneurysm was successfully
accomplished using the Trans-cell method with a total two coils (one Trufill DCS Orbit Galaxy Complex Fill 4 mm × 10 cm; Codman, and one Target 360 Ultra 3 mm × 6 cm; Stryker). The KAs were completely occluded. There were no thromboembolic events, rupture, or procedure-related mortality. The 4-month follow-up angiogram revealed CO of the aneurysms and a good patent parent artery.

Case 2 (Fig. 2)
A 70-year-old man had KA of the left internal carotid artery-posterior communicating arterial bifurcation (PCoA) and anterior choroidal arterial bifurcation (AChA). Head CT angiogram showed re-enlargement of the aneurysms following coating. Diagnostic cerebral angiogram was performed and showed left AChA aneurysm (2.8 mm) and left PCoA aneurysm (3.5 mm). Stent-assisted coil embolization for the KAs was performed in one session. Under general anesthesia and systemic heparinization, a 7 Fr FUBUKI guiding catheter (Asahi Intecc, Aichi, Japan) was inserted into the left internal carotid artery from the right common femoral artery. A Prowler Select Plus (Codman) as a microcatheter for the stent delivery was navigated to the distal M1 segment of the middle cerebral artery over microguide-wire (ASAHI CHIKAI 14; Asahi Intecc). Then, an Excelsior SL-10 (Stryker) was turned over an ASAHI CHIKAI 14 and introduced into the distal aneurysm of the KA. An Enterprise measuring 4.5 × 22 mm was placed to cover the neck of KA. Coiling of the distal aneurysm was accomplished using the Semi-jailing method with a total three coils (one Trufill DCS Orbit Galaxy Complex Xtrasoft 2.5 mm × 3.5 cm; Codman, one Trufill DCS Orbit Galaxy Complex Xtrasoft 2 mm × 2 cm; Codman, and one Target 360 Ultra 1.5 mm × 2 cm; Stryker), and then coiling of the proximal aneurysm was successfully accomplished using the Semi-jailing method too with a total two coils (one Trufill DCS Orbit Galaxy Complex Xtrasoft 2.5 mm × 3.5 cm; Codman, and one Trufill DCS Orbit Galaxy Complex Xtrasoft 2 mm × 2 cm; Codman, and one Target 360 Ultra 1.5 mm × 2 cm; Stryker).
Single-stage Coil Embolization for Kissing Aneurysms

Case 3 (Fig. 3)
A 55-year-old woman had KA recurrence after coiling of the right PCoA and AChA. Stent-assisted coil embolization for the KAs was performed in one session. Under general anesthesia and systemic heparinization, a 7 Fr FUBUKI Complex Xtrasoft 2 mm × 2 cm (Codman). The KAs were completely occluded. There were no thromboembolic events, rupture, or procedure-related mortality. The 6-month follow-up angiogram revealed CO of the aneurysms and a good patent parent artery.

Fig. 3 A 55-year-old woman had KA recurrence after coiling of the right PCoA and AChA. (A) A working-projection image of digital subtraction angiography reveals recurrence of the KA (arrow). (B) A lateral view shows the branches (PCoA; arrow, AChA; arrowhead). (C) Live image shows a microcatheter for coil delivery navigated to the distal aneurysm (arrow) and partial deployment of an Enterprise stent (arrowhead). (D and E) Live images of a working-angle (D) and a lateral view (E) show coil embolization of the distal aneurysm (arrow). The Enterprise stent is placed to cover the neck of KA (arrow) and a microcatheter is inserted into the proximal aneurysm of the KA using the Trans-cell method (small arrow). (F) Digital subtraction angiography immediately after stent-assisted coil embolization shows slightly neck remnant of the KA (arrow). (G) The branches are saved during the procedure (PCoA; arrow, AChA; arrowhead). (H and I) The 4-month follow-up angiogram reveals CO of the KA (arrow) and a good patent parent artery and branches (PCoA; small arrow, AChA; arrowhead). AChA: anterior choroidal arterial bifurcation; CO: complete occlusion; KA: kissing aneurysm; PCoA: posterior communicating arterial bifurcation.
guiding catheter (Asahi Intecc) was inserted into the right internal carotid artery from the right common femoral artery. A Prowler Select Plus (Codman) as a microcatheter for the stent delivery was navigated to the distal M1 segment of the middle cerebral artery over microguidewire (SAHI CHIKAI 14; Asahi). Then, an Excelsior SL-10 (Stryker) was turned over an ASHI CHIKAI 14 and introduced into the distal aneurysm of the KA. An Enterprise measuring $4.5 \times 22$ mm was placed to cover the neck of KA. Coiling of the distal aneurysm was accomplished using the Semi-jailing method with a total four coils (one Trufill DCS Orbit Galaxy Complex Xtrasoft 2.5 mm $\times$ 3.5 cm; Codman, one Trufill DCS Orbit Galaxy Complex Xtrasoft 2 mm $\times$ 2 cm; Codman, one Target 360 Ultra 2 mm $\times$ 2 cm; Stryker and one Target 360 Ultra 1.5 mm $\times$ 2 cm; Stryker). Then, the custody into the proximal aneurysm was tried, but was hard to operate the SL-10 because the Prowler was inserted. Therefore, coiling of the proximal aneurysm was accomplished using the Trans-cell method with a total five coils (three Trufill DCS Orbit Galaxy Complex Xtrasoft 4 mm $\times$ 6 cm; Codman, one Trufill DCS Orbit Galaxy Complex Xtrasoft 3 mm $\times$ 4 cm; Codman, and one Trufill DCS Orbit Galaxy Complex Xtrasoft 2 mm $\times$ 2 cm; Codman). The KAs were occluded with slightly neck remnant. There were no thromboembolic events, rupture, or procedure-related mortality. The 4-month follow-up angiogram revealed CO of the aneurysms and a good patent parent artery.

### Discussion

Jefferson et al. first reported five cases of KA mutually contacting the same internal carotid artery in 1978, and in 1984, Yasargil named two aneurysms occurring upon mutually contacting the same internal carotid artery KA.

Meanwhile, without being limited to the internal carotid artery, anatomically experienced aneurysms are also reported as KA even if the mother blood vessel is different, such as KA occurring in the anterior communicating artery. 

Table 3  Follow-up angiographic results

<table>
<thead>
<tr>
<th>Location</th>
<th>Follow-up (month)</th>
<th>Follow-up occlusion rate</th>
<th>Parent artery stenosis</th>
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<tbody>
<tr>
<td>Case 1</td>
<td>IC-OphA</td>
<td>4</td>
<td>CO</td>
</tr>
<tr>
<td>Case 2</td>
<td>IC-AChA</td>
<td>6</td>
<td>CO</td>
</tr>
<tr>
<td>Case 3</td>
<td>IC-AChA</td>
<td>4</td>
<td>CO</td>
</tr>
<tr>
<td></td>
<td>IC-PCoA</td>
<td></td>
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</tbody>
</table>

AChA: anterior choroidal artery; CO: complete occlusion; IC: internal carotid artery; OphA: ophthalmic artery; PCoA: posterior communicating artery

Yasargil reported that KAs were observed in 2 (0.2%) of 1012 cases with cerebral aneurysms, while in the report by Komiyama et al., it was mentioned that KAs were observed in 5 (0.9%) of 531 aneurysm patients, indicating the incidence thereof is rare.

Regarding the cause of KA, Jefferson et al. reported that a family history of subarachnoid hemorrhage (SAH) was observed in two of five cases; however, Komiyama et al. reported that no family history of SAH was observed in any of the five KA cases and the genetic predisposition of KAs is unknown. In a review of 14 KA cases, it was reported that the onset of SAH was common, among which posterior communicating aneurysms along with anterior choroidal aneurysms were the most common, observed in nine cases.

Concerning treatment method and prognosis, as mentioned by Yasargil, the surgical treatment of KA is difficult due to difficulty in procedures such as exfoliation and clipping operations during surgery, thereby making surgery treatment challenging, and in the review of 15 KA cases, it was reported that a complication in which the anterior choroidal artery became blocked was observed in 3 of the 15 cases (20%) that underwent surgery.

As far as we were able to research, there were few reports on coil embolization for KAs generated in the internal carotid artery of the same blood vessel. It was reported that coil embolization using a simple technique was carried out on a SAH-onset anterior choroidal artery and duplicated middle cerebral aneurysm, with the course thereof good although neck remnant was observed immediately following treatment. The authors mentioned that
Single-stage Coil Embolization for Kissing Aneurysms

coil embolization of KAs is difficult compared to conventional coil embolization in that taking the working angle and identifying the branch is difficult, rendering of the branch must be constantly confirmed during embolization and careful attention is required.

In our cases, single-stage coil embolization was carried out on three cases and six aneurysms that were internal carotid artery KAs using an Enterprise stent and as a result, all three cases and six aneurysms were found to be relatively small wide-neck aneurysms with branches branching from between the aneurysm in two cases; however, treatment was successful in all cases, with no observation of perioperative complications. Moreover, all cases were found to be completely occluded upon follow-up angiography without recurrence. The following were considered as the reasons therefore: 1) Treatment was possible without having to temporarily block the parent artery and blood vessel. In coil embolization using balloon assistance, there is a danger of ischemia and embolisms of the branch occurring due to temporal hemostasis, with Sluzewsk et al.\textsuperscript{(13)} reporting that intraoperative thrombogenesis was observed in 11.3% (5/44) of cases due to the balloon assisting method, among which stroke occurred in two cases (4.5%); however, the prognosis was good. 2) It was a relatively small aneurysm; therefore, using a stent, embolization was possible using the stent of the first coil. Accordingly, the risk of intraoperative rupture was potentially reduced by applying stress to the aneurysm wall. It has been reported that the risk of intraoperative rupture is 2.2% and prognosis is in the event of embolizing a small aneurysm by balloon assistance. 3) Branches were branching from between the two aneurysms in all three of our cases. However, they branched from the proximal side of the neck upon preoperative 3D-DSA in both cases, leading us to believe that placing a stent resulted in saving the branch and successful coil embolization. In both cases of this study, relative close embolization of all four aneurysms was possible without occluding the branch.

Regarding the order of aneurysms to be embolized, for combined stent-assisted coil embolization of KA, the distal aneurysm should be given priority due to the fact that there is less risk of the stent shifting to the distal side when a microcatheter is moved from the distal aneurysm to the proximal aneurysm in addition to being less prone to influence the inserted coil. In the investigation into six single-stage coil embolization for multiple aneurysms, Xavier et al. also carried out treatment while changing the working angle because the first placed coil was in the way when embolizing the second aneurysm following embolization of the first aneurysm, making it difficult to confirm the branch as well as making identification of the neck and parent blood vessel of the second aneurysm difficult.\textsuperscript{(11)} The aneurysms are proximal each other in the coil embolization of KA; therefore, the branch branches from between the other aneurysm and the neck of the aneurysm following embolization of the first aneurysm, suggesting that, taking into consideration the fact that the branch cannot be confirmed, a comprehensive decision must be made prior to endovascular therapy regarding which aneurysm should be embolized first. In order to do so, it was believed that preoperative evaluation using 3D-CTA and 3D-DSA was particularly very important.

It is also important how to place the microcatheter tip into the aneurysm sac for stent-assisted coiling of KA. Jail- ing or semi-jailing technique may have advantages over trans-cell technique because of the ease of the microcatheter control.\textsuperscript{(12)} And semi-jailing technique seems to be the best choice for KA when a microcatheter is moved from the first embolized aneurysm to another aneurysm. In this study, three cases of the stent-assisted coil embolization for the KA in the same session. All performed embolization of distal aneurysm of the KA first. We performed embolization of the distal aneurysm using the Jailing method and embolization of the proximal aneurysms using the Trans-cell method in Case 1, but suffered from the microcatheter insertion into the proximal aneurysm a little. Therefore, in Case 2, embolization for the both aneurysms of the KA was performed using the Semi-jailing method which was high in the operability of the microcatheter. In Case 3, embolization of the distal aneurysm using the Semi-jailing method, but the operation to insert the microcatheter into the proximal aneurysm was difficult because the microcatheter for the stent delivery entered. Therefore, the microcatheter for the stent delivery was removed and coiling of the proximal aneurysm was accomplished using the Trans-cell method. It is necessary to examine the embolization method every case on the stent-assisted coil embolization for KA.

Combination of stent-assisted technique and multi- microcatheter technique may be useful for such cases. It is necessary to examine the use of LVIS stent or flow diverter stent which were not available at the point in our cases.

Although long-term follow-up is required in the future, it is believed that the fact that recurrence was not observed in all six aneurysms upon initial follow-up angiography indicated that successful close embolus was made possible by placing a stent.
Conclusion

Although the initial treatment outcome of single-stage coil embolization for carotid KA using an Enterprise stent was good, long-term follow-up employing multiple cases is required in the future.

Disclosure Statement

There are no conflicts of interests to be disclosed regarding this paper.

References


