Online January 28, 2021
Journal of Neuroendovascular Therapy 2021; 15: 659–664 DOI: 10.5797/jnet.cr.2020-0123

Case Report

Case of a Stuck Coil in the Final Stage of Stent-Assisted Coil Embolization

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Objective: We report a case in which two coils became stuck in a microcatheter at the end of coil embolization for a cerebral aneurysm.

Case Presentation: Two coils became stuck in the microcatheter at the final stage of stent-assisted coil embolization for an unruptured anterior communicating artery aneurysm. The rear end of a detached coil was near the tip of the microcatheter. The coil inserted next was pushed out of the microcatheter and pulled back into the microcatheter. Then, the rear end of the detached coil and the retracted coil meshed into the microcatheter, and became immobile. The microcatheter and these two coils were removed simultaneously, and coil embolization was finished.

Conclusion: At the end of coil embolization, the filling rate is relatively high. Insertion of another coil and traction may cause the coils to become stuck in the microcatheter.

Keywords ▶ aneurysm, coil embolization, coil stuck, volume embolization ratio

Introduction

Sticking, knotting, fracture, and unraveling have been reported as issues related to coils during embolization of cerebral aneurysms.[1–7] We report a case in which two coils became meshed and stuck in the microcatheter during the final stage of coil embolization for an unruptured cerebral aneurysm. Although coil sticking is infrequent during coil embolization,[1] according to our review of the literature, there have been no detailed reports of the mechanism causing the interlocking of two coils in a microcatheter. We report a possible mechanism using intraoperative images and enlarged photographs of the meshed coils and microcatheter.

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Case Presentation

The patient was a 60-year-old man. He underwent MRA of the head for transient dizziness and an anterior communicating artery aneurysm was detected, he was referred to our hospital. He had a history of hypertension, diabetes, and dyslipidemia. He had a smoking history, but no familial history of subarachnoid hemorrhage. Cerebral angiography revealed an aneurysm (neck: 3.74 mm, dome: 5.28 × 4.24 mm, height: 4.44 mm) in the right A1-A2 segment of the anterior communicating artery (**Fig. 1A** and **1B**). As the patient requested treatment, coil embolization was performed.

Endovascular treatment

Stent-assisted coil embolization was carried out under general anesthesia. After systemic heparinization, an 8-Fr guiding catheter was inserted via the right femoral artery and placed in the cervical region of the right internal carotid artery. It was difficult to guide the Excelsior SL-10 (Stryker, Kalamazoo, MI, USA) for stent placement to the left anterior cerebral artery through the anterior communicating artery; therefore, it was guided to the right anterior cerebral artery. Using a 3.4-Fr. TACTICS (Technocrat Corporation, Aichi, Japan) as a distal access catheter, an Excelsior SL-10, steam shaped to the morphology from the end of the internal carotid artery to the right A1 and the aneurysm,

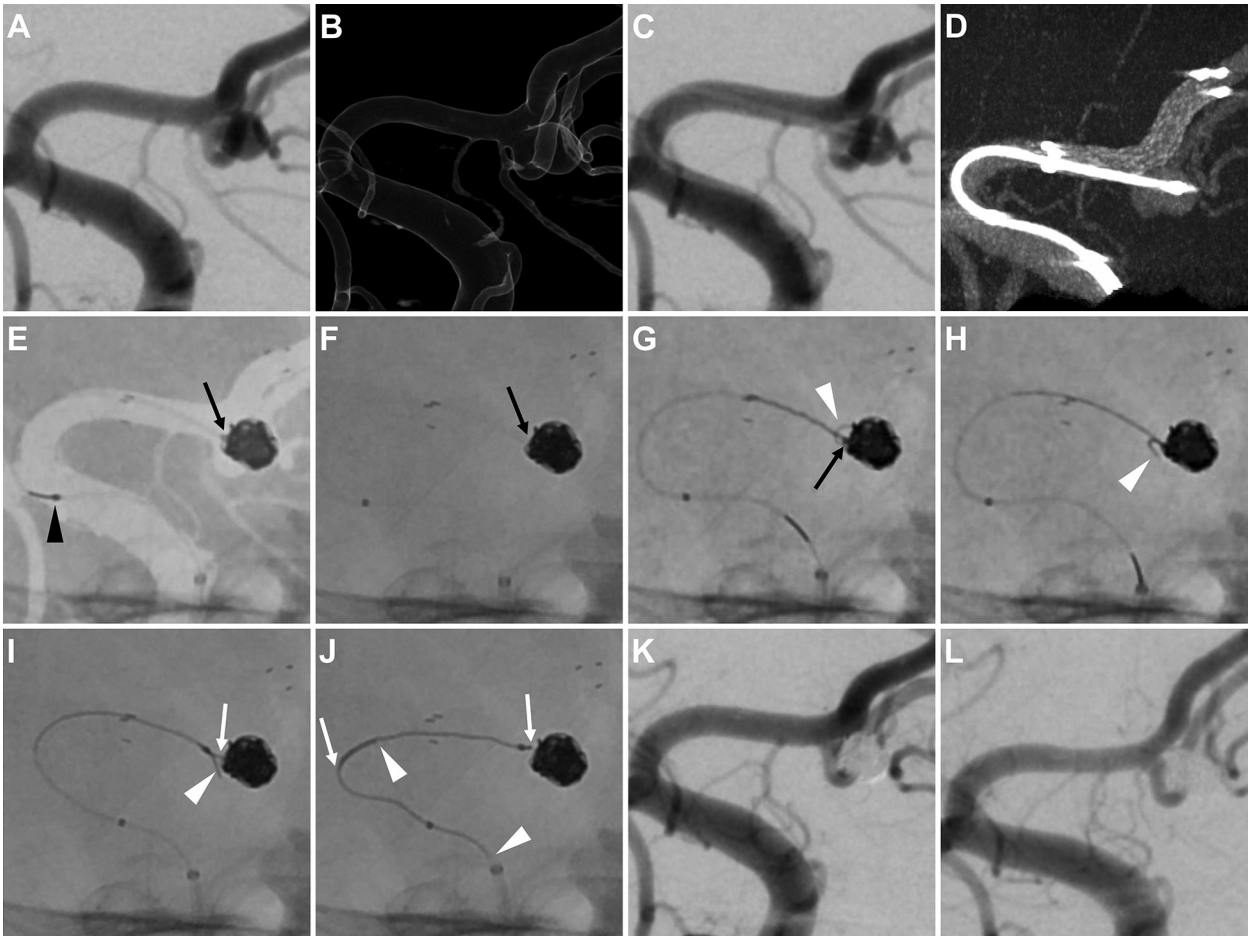

Fig. 1 Imaging findings during embolization (working angle: frontal view). (**A**) Cerebral angiography before treatment. (**B**) Translucent image of 3D cerebral angiography before treatment. (**C**) Cerebral angiography after placement of the SL-10 in the aneurysm and deployment of the Neuroform Atlas from the right A2 to A1. (**D**) Cone-beam CT using a 12-fold dilution of contrast agent. (**E**) The second marker of the SL-10 and the alignment marker of the delivery wire of the 5th coil are arranged in an inverted T shape (black arrowhead), and the tip marker of the SL-10 is located out of the coil mass (black arrow). (**F**) After detachment of the 5th coil, the tip marker of the SL-10 is back in the coil mass (black arrow). (**G**) The tip of the 6th coil escaped out of the coil mass (white arrowhead) and the tip marker of the SL-10 is located out of the coil mass (black arrow). (**H**) The 6th coil is stuck in the SL-10 with the tip of the 6th coil escaping out of the coil mass (white arrowhead). (**I**) Another coil was drawn into the tip of the SL-10 (white arrow) with 5 mm of the tip of the 6th coil escaping out of the coil mass (white arrowhead). (**J**) The 6th coil (between the two white arrowheads) and the coil drawn into the SL-10 (between the two white arrows) were the same length. (**K**) Cerebral angiography after treatment showing a mild neck remnant state. (**L**) Cerebral angiography 6 months after treatment showing complete occlusion of the aneurysm

was placed in the aneurysm. A Neuroform Atlas 3 × 21 mm (Stryker) was deployed from the right A2 to A1 (**Fig. 1C**), and the effects of neck coverage using the stent were examined by cone-beam CT using a 12-fold dilution of contrast agent (**Fig. 1D**). By the jailing technique, the anterior communicating artery was preserved with a Target 360 Soft 4 mm × 15 cm (Stryker) and the entire aneurysm was framed. Filling was performed using Target 360 Ultra 3.5 mm × 8 cm, Target 360 Ultra 3 mm × 6 cm, and Target 360 Nano 2.5 mm × 4 cm. During insertion of a Target 360 Nano 1.5 mm × 2 cm as the 5th coil, resistance was felt, but it was able to be inserted into the coil mass. The 5th coil was detached under a condition in which the second marker of the SL-10 and the alignment marker of the delivery wire of the coil were arranged in an inverted T-shape, and the tip marker of the SL-10 was located outside the coil mass (**Fig. 1E**). When the 5th coil was detached, the tip marker of the SL-10 returned into the coil mass (**Fig. 1F**). We tried to insert a Target 360 Nano 1.5 mm × 2 cm as the 6th coil, but it was unable to be inserted into the coil mass and the tip marker of the SL-10 came out of the coil mass (**Fig. 1G**). As a result, there was resistance upon traction to retrieve the 6th coil and upon pushing out the coil, and the 6th coil became stuck in the SL-10 (**Fig. 1H**). When the SL-10 was withdrawn out of the coil mass, the tip of the 6th coil protruded 5 mm from the end of the SL-10 and drew the posterior

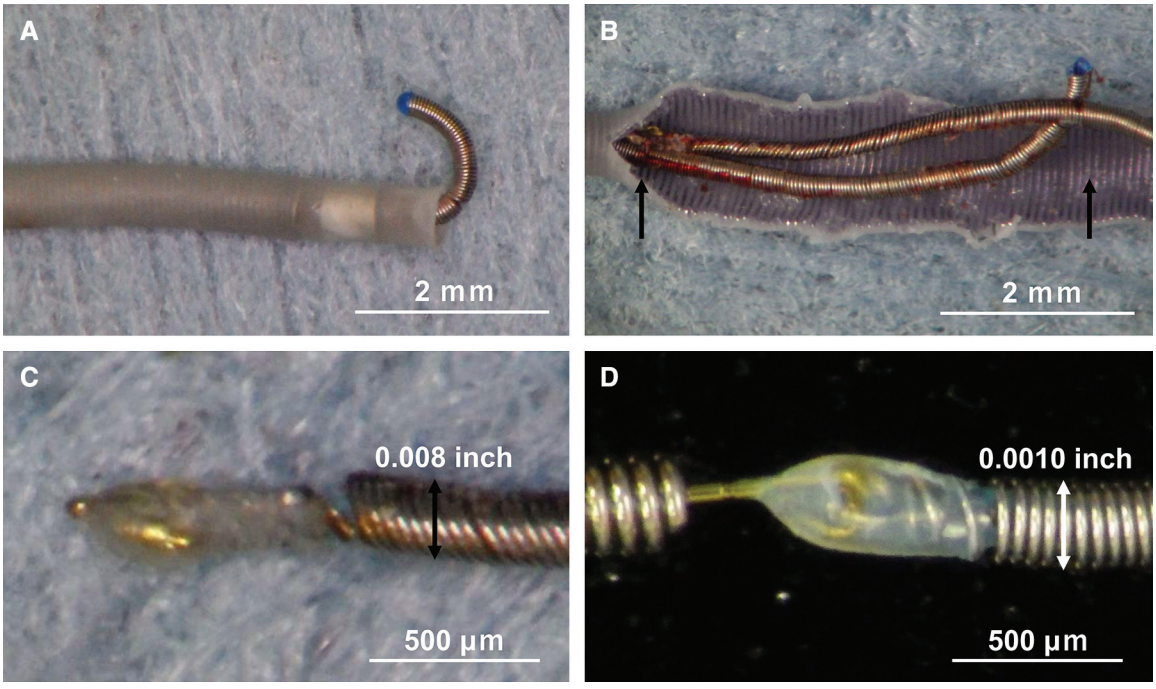

Fig. 2 Findings of the retrieved SL-10 and coils. (**A**) The tip of the distal coil drawn into the SL-10 is protruding from its end. (**B**) Two Target 360 Nano 1.5 mm × 2 cm are interlocked over a distance of 5 mm in the incised SL-10. The black arrows show the posterior end of the distal coil pulled into the SL-10 and the end of the proximal coil. (**C**) The primary coil diameter of the posterior end of the distal coil pulled into the SL-10 was shortened to approximately 0.008 inches. (**D**) The primary coil diameter of the Target 360 Nano before use is 0.010 inches. The scale bars in A and B represent 2 mm, and those in C and D represent 500 µm.

end of another coil into the end of the microcatheter (**Fig. 1I**). When traction was applied to the 6th coil, there was strong resistance, two coils meshed together were pulled into the SL-10, and the tip of the other coil that was pulled into the SL-10 came out of the coil mass (**Fig. 1J**). The other coil that was drawn into the microcatheter was the same length as the 6th coil. The SL-10 was retrieved with the two coils that were stuck. Treatment was ended in a slight neck remnant state (**Fig. 1K**). Finally, four coils were used for embolization and the volume embolization ratio (VER) was 31.7%. Postoperative consciousness was satisfactory and no neurological abnormality was noted. Cerebral angiography after 6 months confirmed complete occlusion of the anterior communicating artery aneurysm. (**Fig. 1L**).

Findings of the retrieved SL-10 and coils

The retrieved SL-10 was not damaged and the distal tip of the coil drawn into the microcatheter was confirmed (**Fig. 2A**). When the SL-10 was cut open from the tip, two Target 360 Nano 1.5 mm × 2 cm were found inside, and they were confirmed to be the 5th and 6th inserted coils. The two coils overlapped by 5 mm, but they were not fixed and were easily separated. Neither of the coils was unraveled (**Fig. 2B**). In the overlapped part of the posterior end of the 5th coil, the spiraling element wire was slanted relative to the axis of the primary coil, and the diameter of the primary coil was reduced to approximately 0.008 inches from the 0.010 inches (254 µm) before use (**Fig. 2C** and **2D**).

Discussion

This was a rare case of a coil-related complication similar to unraveling and knotting. Discussing coil-related complications in a report of case series, Abe et al. proposed that coil sticking is caused by thrombus formation in the microcatheter, narrowing of the lumen due to meandering of the microcatheter, and overlapping of two coils in the microcatheter.[1] This is the first report of a case in which coil sticking caused by overlapping of two coils in the microcatheter was confirmed by intraoperative images, and examination of the retrieved coils and microcatheter.

Although the luminal diameter of the tip of the SL-10 is 0.0165 inches, the primary coil diameter of the Target 360 Nano, which became stuck, is 0.010 inches. Therefore, theoretically, two Target 360 Nano coils do not simultaneously enter the lumen of the SL-10. However, if two coils are drawn into the SL-10 in an interlocked state, the primary coil diameter is considered to be shortened and the

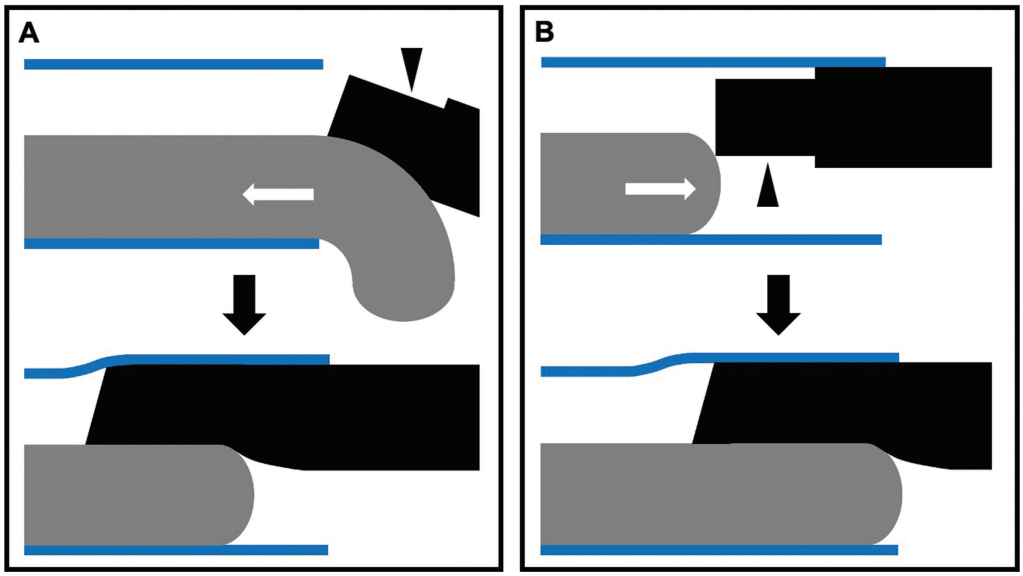

Fig. 3 Mechanism of the occurrence of coil sticking. (**A**) By Mechanism A, the posterior end of the detached coil is near the tip of the microcatheter, and when the next coil is inserted, it is temporarily pushed out of the microcatheter and withdrawn. The posterior end of the detached coil and the withdrawn coil interdigitate, and the coils become stuck in the microcatheter. The diameter of the detached zone at the posterior end of the detached coil is smaller than that of the body of the coil (black arrowhead). (**B**) By mechanism B, the posterior end of the detached coil is in the tip of the microcatheter, and when the next coil is inserted, and posterior end of the detached coil and the inserted coil are interlocked, and they become stuck in the microcatheter. The black area is the posterior end of the detached coil and the gray area is the coil to be inserted next. The white arrows indicate the direction of coil movement. The diameter of the detached zone of the posterior end of the detached coil is smaller than that of the body of the coil (black arrowhead).

lumen of the SL-10 is stretched, permitting entry of two coils in a meshed state. As two coils tightly entered the microcatheter, strong resistance to both pushing and pulling of the delivery wire was considered to have been generated, resulting in sticking.

We propose two major mechanisms for coil sticking. One is Mechanism A: The posterior end of a detached coil is near the tip of the microcatheter, and when the next coil is inserted, it is temporarily pushed out of the microcatheter and drawn back inside. The posterior end of the detached coil is interlocked with the coil that was drawn back, and the two coils become stuck in the microcatheter (**Fig. 3A**). The second is Mechanism B: The posterior end of a detached coil is in the tip of the microcatheter, and when the next coil is inserted, the posterior end of the detached coil is meshed with the inserted coil, and the two coils become stuck in the microcatheter (**Fig. 3B**). In both mechanisms, because two coils overlap in the microcatheter immediately before sticking, resistance is generated by pushing the coils in and out of the microcatheter, and is considered to be increased further by additional manipulation of coils, resulting in sticking. Furthermore, coil sticking is considered to occur in the final stage when the aneurysm has been filled with a sufficient number of coils. This is because without sufficient filling of the aneurysm with coils, by Mechanism A, the posterior end of the detached coil will drop into the coil mass, and as the tip of the microcatheter can move in the aneurysm, the posterior end of the detached coil will not stay near the tip of the microcatheter; and by Mechanism B, the posterior end of the detached coil remaining in the tip of the microcatheter will be easily pushed out of the microcatheter by the force applied to insert the next coil. In the present case, the 6th coil temporarily escaped out of the coil mass without marked resistance (**Fig. 1G**) and the tip of the coil was freely movable. In this state, the coils became stuck when the 6th coil was drawn into the microcatheter due to an increase in resistance (**Fig. 1H**) and the 6th coil was meshed with the posterior end of the 5th coil over 5 mm of its tip (**Fig. 1I**). This suggests that, in our case, sticking was due to Mechanism A. If coil sticking was due to Mechanism B, the tip of the 6th coil should have been intertwined with the posterior end of the 5th coil, which is inconsistent with **Fig. 1I**.

In this case, coil sticking occurred when we tried to insert the 6th coil, which resulted in retrieval of the 5th coil. The VER was 35.5% with six coils, 33.6% with five coils, and 31.7% with four coils. Insufficient embolization was previously suggested to be a factor that necessitates retreatment,[8] and a VER of 20–25% or higher at the end of

embolization is recomended.[9–12] On the other hand, in *in vitro* studies using cerebral aneurysm models, the maximum embolization rate was 30–36%.[10,13] Therefore, in our patient, a sufficient VER was obtained after the insertion of four coils and complete occlusion of the aneurysm was confirmed by cerebral angiography after 6 months, suggesting that the 5th and 6th coils were not only unnecessary but also caused excessive stress on the aneurysmal wall. As excessive coil insertion may induce coil sticking, as in the present case, and unnecessarily stress on the aneurysmal wall, if resistance to coil insertion is observed in the final stage of embolization, the procedure should be ended in consideration of the VER at that point.

To prevent coil sticking, the necessity of insertion of additional coils must be evaluated first if a relatively high embolization rate has been achieved. In the present case, resistance was felt while advancing and withdrawing the coil before the occurrence of sticking; therefore, it is important to notice changes in resistance to coil manipulation before the occurrence of coil sticking. In addition, concerning Mechanism B, it is important to detach the coil when the alignment marker of the delivery wire of the coil has passed the second marker of the microcatheter to prevent the posterior end of the detached coil to stay in the microcatheter.

In the event of coil sticking, if there is resistance on both advancing and withdrawing the coil, it may be possible to push out two interlocked coils through the tip of the microcatheter by pushing the delivery wire with a greater force, but this maneuver is dangerous as the tip of the microcatheter is located in the aneurysm and sudden extra stress may be exerted on the aneurysmal wall. If the distal detached coil can be disengaged from the coil mass by withdrawing the microcatheter together with the two interdigitated coils, it may be retrieved in the guiding catheter. However, at this time, as another coil in the coil mass may also be raked out of the aneurysm, the coil mass should be supported using a balloon without assistance by a stent. If the distal detached coil is trapped and anchored in the coil mass, the distal coil may be unraveled when traction is applied to the microcatheter. It is necessary to retrieve the unraveled coil using a snare wire[5–7] or cut it at the puncture site and leave the stump subcutaneously.[4] In the present case, as sticking was unable to be confirmed, we first withdrew the tip of the SL-10 from the coil mass and confirmed that the coils were stuck (**Fig. 1I**). Then, by applying strong traction to the delivery wire, the distal detached coil was retrieved from the coil mass. On traction of the delivery wire, the coil on the proximal side of the interdigitated part may have been unraveled. In expectation of such an event, we considered retrieval of the microcatheter with two coils.

Conclusion

In the final stage of coil embolization, the embolization rate becomes relatively high and insertion or withdrawal of coils may induce coil sticking. If resistance is felt during coil insertion, ending embolization at this point in consideration of the embolization rate is considered a method to avoid coil sticking.

Informed Consent

Written informed consent to publication of this case report was received from the patient.

Disclosure Statement

The authors declare no conflicts of interest.

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