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Case Report

Transarterial Sinus Coiling for Dural Arteriovenous Fistula: Two Case Reports

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Objective: We report two cases of dural arteriovenous fistula (DAVF) treated by coil embolization of the affected sinus and fistula via a feeding artery instead of transvenous embolization (TVE) due to the difficulty of the transvenous approach.
Case Presentation: An 82-year-old man was diagnosed with transverse sinus (TS) DAVF. A microcatheter was inserted into the isolated TS through the fistula via the middle meningeal artery (MMA), which was the feeding artery of the DAVF. The DAVF was occluded by coil embolization of the isolated sinus and fistula. A 79-year-old man was diagnosed with cavernous sinus (CS) DAVF. A microcatheter was inserted into the CS through the fistula via an accessory meningeal artery (AMA), which was the feeding artery of the DAVF. The DAVF was occluded by coil embolization of the affected sinus and fistula.
Conclusion: These cases suggested that transarterial sinus coiling is one of the effective treatment options for DAVF.

Keywords ▶ dural arteriovenous fistula, transarterial sinus coiling, accessory meningeal artery, middle meningeal artery

Introduction

To treat dural arteriovenous fistula (DAVF), transvenous embolization (TVE) is primarily selected. However, transarterial embolization (TAE) with Onyx (Medtronic, Minneapolis, Minnesota, USA) has been increasingly performed in cases in which radical TVE is difficult. This procedure also became covered by health insurance in Japan, but Onyx could migrate into intracranial arteries or nerve-nourishing arteries; it should not be used in DAVF of the cavernous sinus (CS), anterior condylar confluence, cranio-cervical junction, or spine. In some cases, Onyx does not reach a drainer beyond the fistula, leading to feeder occlusion and not being curative. In this study, we report two cases of DAVF in which the affected sinus was reached through transarterial fistula passage and coil embolization was curative, and review the literature.

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Case Presentation

Case 1: An 82-year-old man.
Complaints: Pulsatile tinnitus, aphasia, and fluctuation.
Medical history: Hypertension and hyperlipidemia.
Present illness: He had a 1-year history of tinnitus and speech disturbance. He consulted a local hospital with recent marked fluctuation on walking. Magnetic resonance imaging (MRI) suggested DAVF, and he was referred to our department for detailed examination and treatment.
Examination findings: Magnetic resonance angiography (MRA) demonstrated abnormal blood flow signals in the left transverse sinus (TS). Digital subtraction angiography (DSA) revealed isolated left TS DAVF. Fistulae were on the parasinus medial to the left isolated TS, which were mainly fed by the bilateral occipital arteries (OAs) and bilateral middle meningeal arteries (MMAs) (**Fig. 1A–1C**). On three-dimensional rotational angiography (3D-RA) through the left external carotid artery, the medial part of parasinus ran separately the upper and lower courses and several diffuse fistulae were found all through the parasinus (**Fig. 1D**).

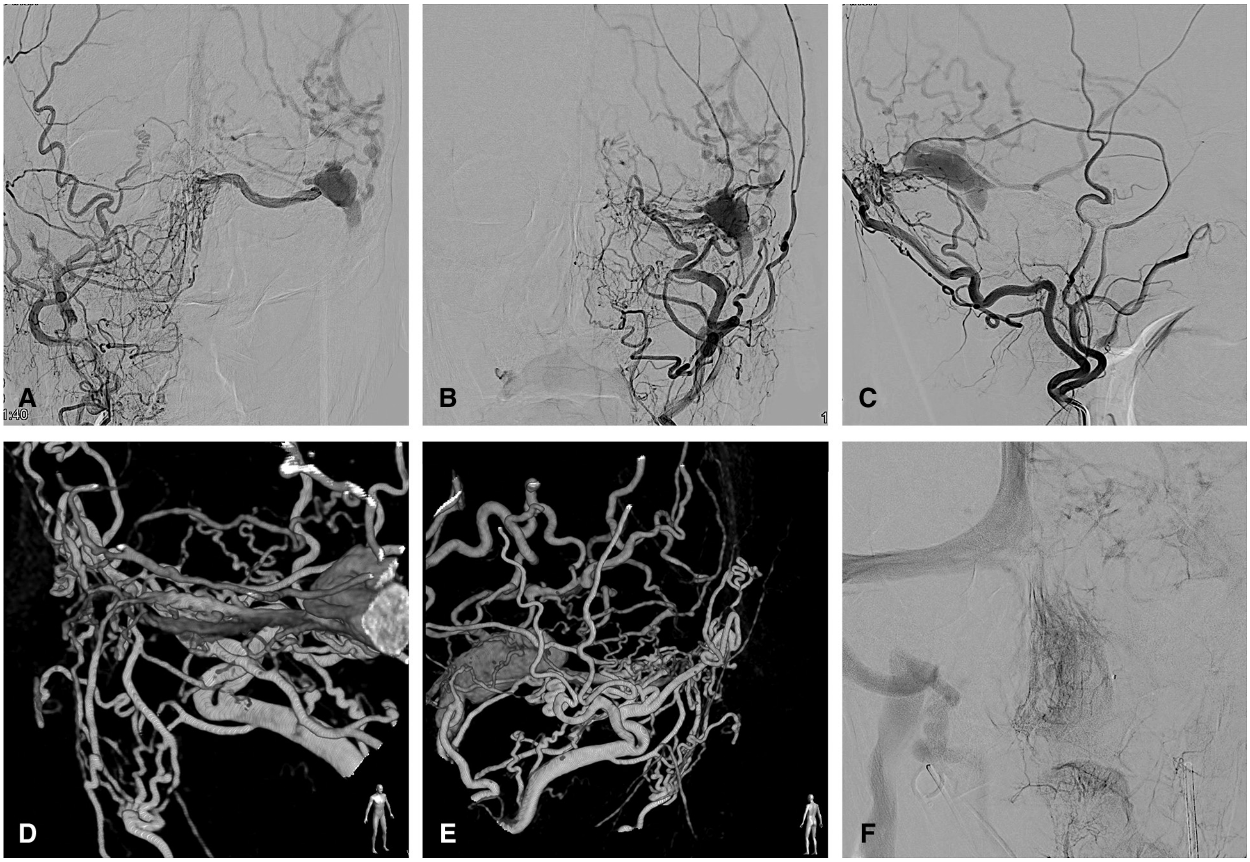

Fig. 1 (**A**) Right external carotid angiography from the A-P view shows the DAVF on the parasinus of the left TS mainly fed by the MMA and OA. Left external carotid angiography from the A-P view (**B**) and lateral view (**C**) demonstrates the left TS DAVF mainly fed by the OA and MMA with shunting flow toward parasinus, retrograde venous drainage into cortical veins, including the vein of Labbe via the isolated TS. On 3D-RA via the left external carotid artery from the right anterior oblique view, there are multiple diffuse fistulas on the parasinus (**D**) and 3D-RA via the left external carotid artery from the left posterior oblique view shows no fistulous point on the isolated TS (**E**). (**F**) Left internal carotid angiography from the A-P view in the venous phase does not reveal left transverse and SS. 3D-RA: three-dimensional rotational angiography; DAVF: dural arteriovenous fistula; MMA: middle meningeal artery; OA: occipital artery; SS: sigmoid sinus; TS: transverse sinus

There was no fistula on the isolated left TS (**Fig. 1E**). Shunting flow was drained into retrograde leptomeningeal venous drainage involving the vein of Labbe and temporal vein (**Fig. 1A–1C**). In the venous phase, neither the left TS nor sigmoid sinus (SS) was visualized (**Fig. 1F**). Under a diagnosis of symptomatic DAVF (Borden type III, Cognard type IIa+b), endovascular treatment was performed.

Endovascular treatment: Under general anesthesia, 6Fr sheaths were inserted into the right femoral artery and vein. A 6Fr Envoy (Johnson & Johnson, Miami, FL, USA) was guided into the left external carotid artery coaxially with a 4.2Fr FUBUKI (Asahi Intecc, Aichi, Japan). Subsequently, a 6Fr Envoy was guided into the left internal jugular vein and placed just before the site of occlusion. We attempted to pass it through the site of occlusion using a 0.032” or 0.035” Radifocus Guidewire (Terumo, Tokyo, Japan) and 3.2Fr TACTICS (Technocrat, Aichi, Japan) or 4.2Fr FUBUKI, but it penetrated in the direction of an emissary vein, making guiding to the SS impossible. TVE was abandoned and TAE with a liquid embolic substance was selected. A Marathon microcatheter (Medtronic) was inserted through the 4.2Fr FUBUKI, which was placed in the left external carotid artery, and the petrosquamous branch of the MMA was selected using a 0.010 CHIKAI (Asahi Intecc). The microcatheter was guided to an area adjacent to a fistula, facilitating the insertion of the microguidewire into the upper course of the medial parasinus via the fistula. The microcatheter was allowed to follow the microguidewire, and was able to be inserted into the parasinus. Therefore, coil embolization was performed instead of a liquid embolic substance. The fistulae were involved in the parasinus alone and there was no fistula in any other sinus wall; therefore, coil embolization of the parasinus alone was tried. Although coils were expected to deviate in the presence of blood flow, considering that they may be trapped by the isolated sinus or cortical vein, posing no particular risk, coils (ED10

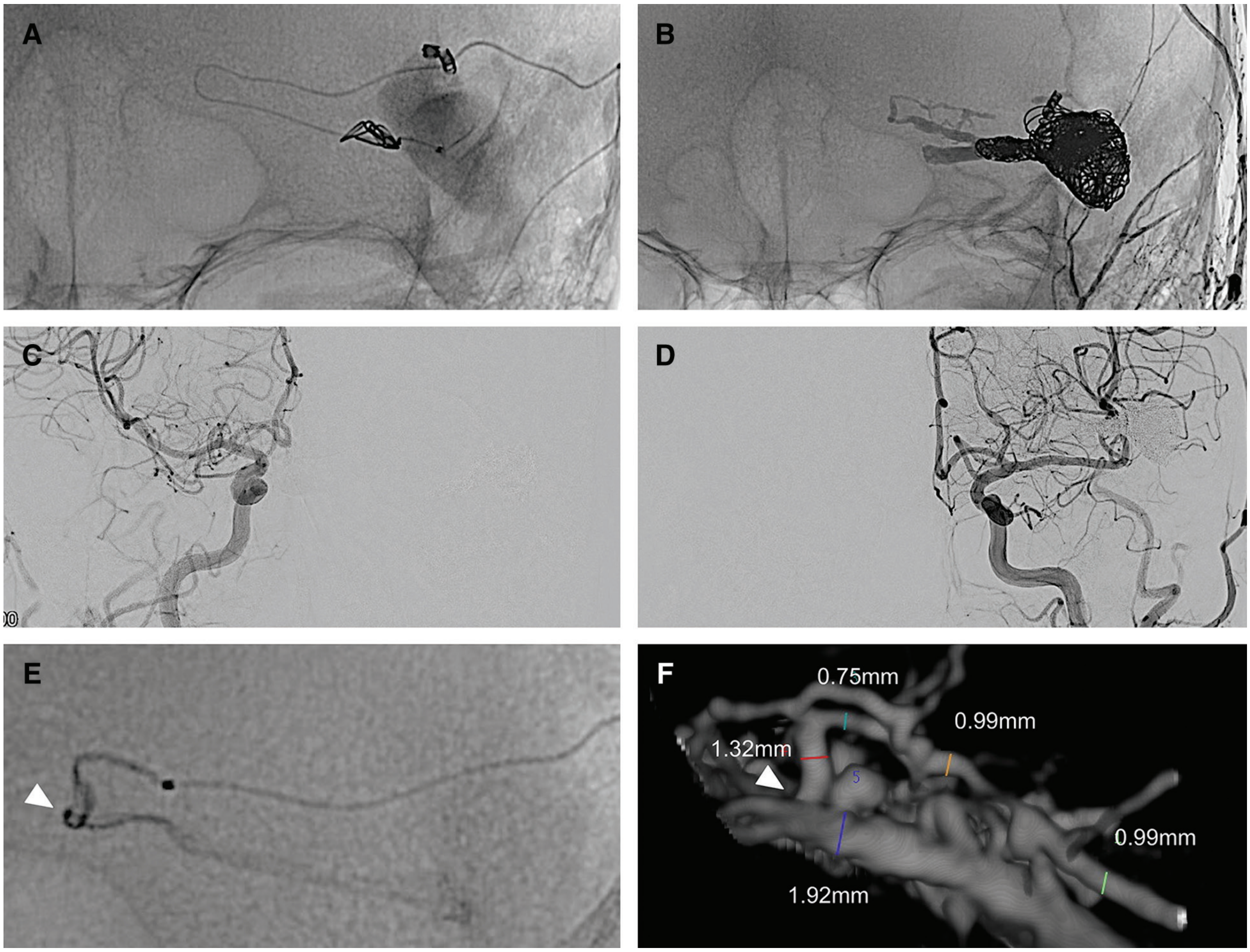

Fig. 2 (**A**) Selective angiography from the A-P view from the microcatheter confirms that it is in the left isolated TS via the left MMA, fistula, and parasinus. (**B**) Left external carotid angiography from the A-P view shows the coil mass in the isolated TS and parasinus, and NCBA cast in the other part of the parasinus, fistula, and MMA. Right (**C**) and left (**D**) common carotid angiography from the A-P view shows total occlusion of the fistula. (**E**) Selective angiography from the A-P view via the left MMA shows the fistula point (arrowhead) at the internal part of the parasinus of the left TS. (**F**) The diameter of the MMA and parasinus adjacent to the fistula point (arrowhead) according to 3D-RA (cranial 70°). 3D-RA: three-dimensional rotational angiography; MMA: middle meningeal artery; NCBA: n-butyl-cyanoacrylate; TS: transverse sinus

ExtraSoft 1.5 × 3 and 2 × 3; Kaneka Medics, Osaka, Japan) were inserted. They migrated to the isolated sinus and were trapped at the origin of the cortical vein (**Fig. 2A**). As the coils were not stabilized by coil embolization through the parasinus, the procedure was switched to a strategy to guide the microcatheter to the isolated sinus and perform coil embolization through the isolated sinus (**Fig. 2A**). The inner area of the isolated sinus was embolized with ED10 Infini ExtraSoft (n = 19, 300 cm). Subsequently, the isolated sinus to parasinus was embolized with ED10 Complex 3 × 6 while pulling the microcatheter, and the inner area of the parasinus was tightly packed with ED10 ExtraSoft 1.5- to 2.5-mm coils. Lastly, the remaining parasinus, fistula, and MMA as a feeder were embolized using 20% n-butyl-cyanoacrylate (NBCA) (B. Braun Melsungen AG, Melsungen, Germany) (**Fig. 2B**). DSA demonstrated the disappearance of DAVF (**Fig. 2C** and **2D**) and the procedure was completed. After surgery, the symptoms were ameliorated and the patient was discharged.

The fistula diameter was estimated to be approximately 1 mm based on the vascular diameters measured on selective angiography through the microcatheter inserted into the MMA as a feeder (**Fig. 2E**) or 3D-RA through the left external carotid artery (**Fig. 2F**).

Case 2: A 79-year-old man.

Complaints: Bulbar conjunctival hyperemia and diplopia.

Medical history: Renal carcinoma (right nephrectomy) and diabetes mellitus.

Present illness: Diplopia developed 3 months previously and he consulted a local ophthalmology clinic. Follow-up was continued, but bulbar conjunctival hyperemia was observed after 1 month and he again consulted the local clinic. CS

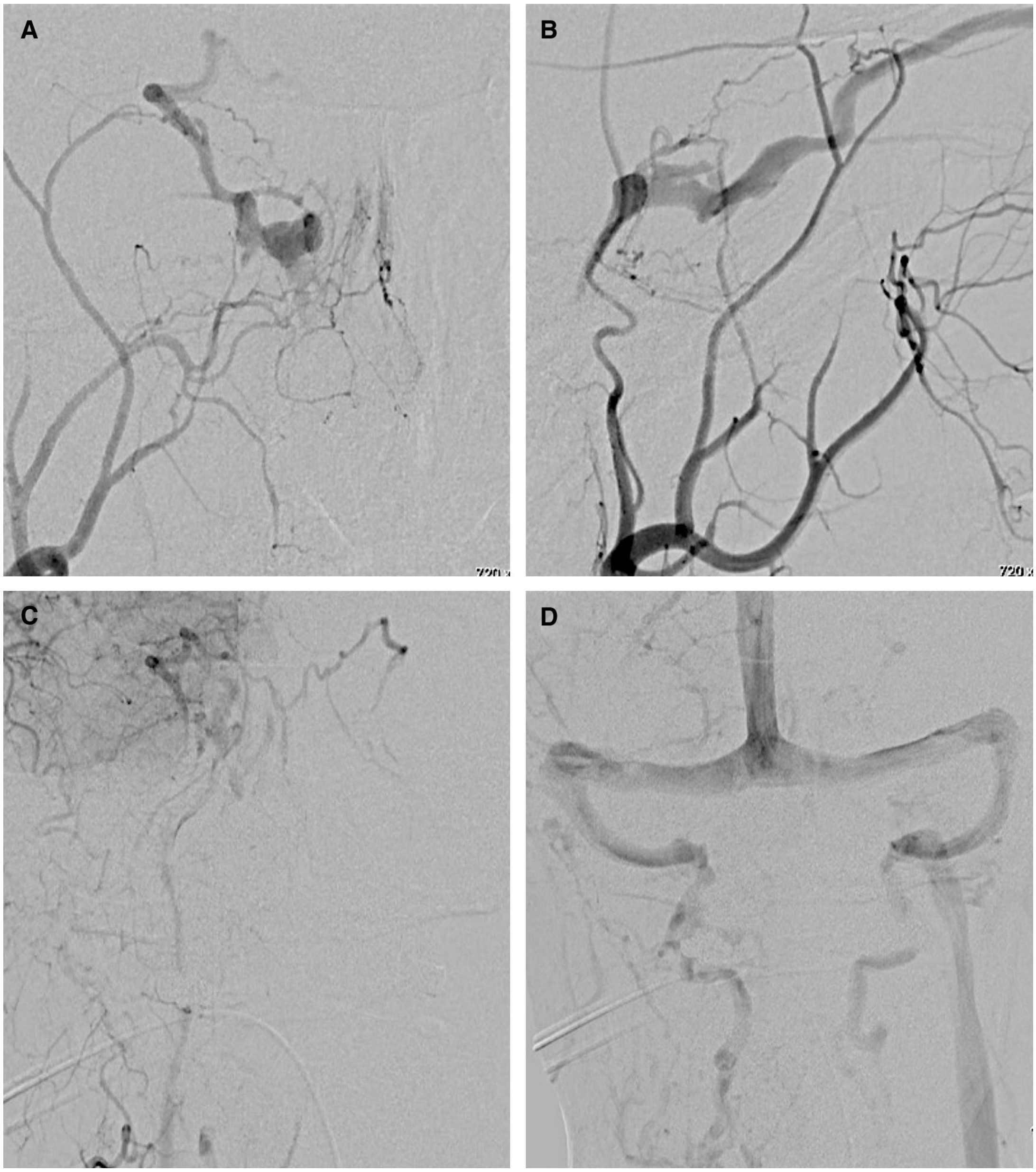

Fig. 3 Left external carotid angiography from the A-P view (**A**) and lateral view (**B**) demonstrates the right CA DAVF mainly fed by the right AMA and MMA with shunting flow toward the SOV. The IPS is occluded. (**C**) Right external carotid angiography from the A-P view in the venous phase shows the retrograde venous drainage into the bilateral SOV and right angular/facial vein. (**D**) Right internal carotid angiography from the A-P view in the venous phase reveals that the right internal jugular vein is occluded. AMA: accessory meningeal artery; CS: cavernous sinus; DAVF: dural arteriovenous fistula; IPS: inferior petrosal sinus; MMA: middle meningeal artery; SOV: superior ophthalmic vein

DAVF was suspected and he was referred to our department. As his medical history suggested renal dysfunction, a strategy to perform one-stage examination and endovascular treatment under general anesthesia was adopted.

Examination findings/endovascular treatment: Under general anesthesia, 6Fr sheaths were inserted into the right femoral artery and vein. DSA demonstrated a right CS DAVF. A feeder reversing from the frontal branch of the right MMA joined with a feeder from the right accessory meningeal artery (AMA) and then with a feeder from the petrous branch of the right MMA, leading to fistula formation in the posterior lateral upper area of the right CS (**Fig. 3A** and **3B**). Outflow tracts to the right angular/facial veins and left superior ophthalmic vein (SOV) via the right SOV were observed, and the right inferior petrosal sinus (IPS) and right internal jugular vein were occluded (**Fig. 3A–3D**). As an approach route to the right CS, a method to utilize the right angular/facial veins as outflow tracts was considered.

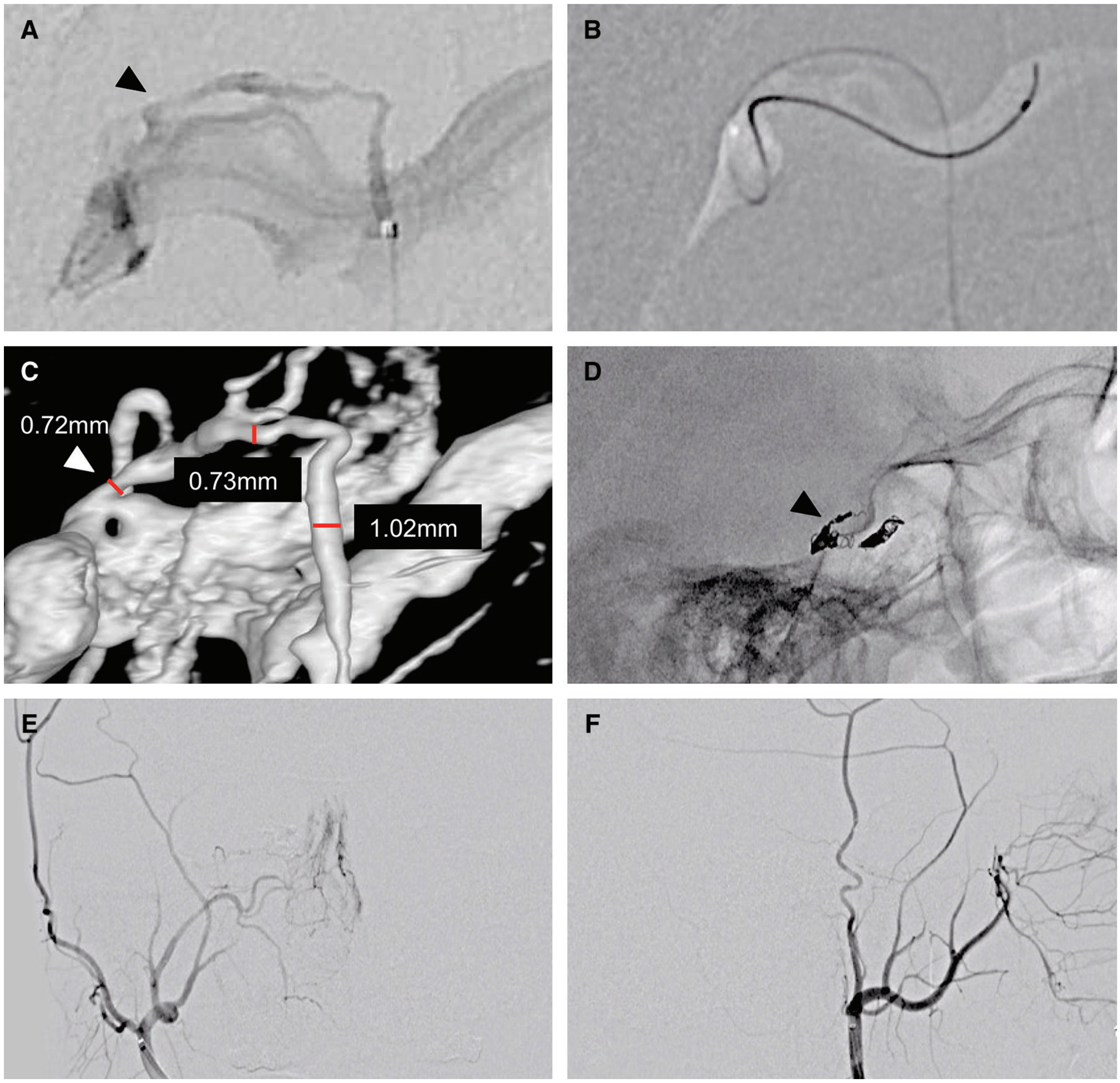

Fig. 4 (**A**) Selective angiography from the lateral view via the right AMA shows the fistula (arrowhead) at the superior part of the CA and drainage into the SOV. (**B**) Angiography from the lateral view demonstrates the successful advancement of the microcatheter into the SOV via the CA. (**C**) The diameter of the AMA adjacent to the fistulous point (arrowhead) according to 3D-RA from the right posterior oblique view. Fluoroscopy from the lateral view (**D**) after selective shunt embolization shows the coil mass in the SOV and the CA adjacent to the fistulous point (arrowhead) and the feeder. Right external carotid artery angiography from the A-P view (**E**) and lateral view (**F**) reveals complete obliteration of the CA DAVF. 3D-RA: three-dimensional rotational angiography; AMA: accessory meningeal artery; CS: cavernous sinus; DAVF: dural arteriovenous fistula; SOV: superior ophthalmic vein

However, the confluences of these veins with the jugular vein were unable to be confirmed on DSA, and the above method was considered difficult. An approach route to the right CS via the IPS through the right internal jugular vein was selected. We attempted to guide a 6Fr Envoy to the right venous angle and then to the occluded right internal jugular vein using a 0.035-inch Radifocus Guidewire, but it was impossible. An approach through the contralateral side was considered. However, the diameter of the AMA as a feeder was relatively large and torsion was slight; therefore, a transarterial approach to the right CS was adopted. A 7Fr Roadmaster (Goodman, Aichi, Japan) was guided into the right external carotid artery coaxially with a 4Fr Cerulean (Medikit, Tokyo, Japan), and the right AMA was selected using a 0.010-inch CHIKAI and Marathon. DSA through the microcatheter showed the shunting flow to the CS/SOV via the fistula (**Fig. 4A**). The microcatheter was guided into the right SOV beyond the fistula (**Fig. 4B**). The fistula diameter was estimated to be approximately 0.7 mm from the vascular diameter measured on 3D-RA through the right external carotid artery (**Fig. 4C**). Initially, the SOV was partially embolized with ED10 Extra-Soft 1.5- to 3.5-mm coils. Subsequently, a coil was inserted to an intra-CS area adjacent to the shunted pouch, and the

Table 1 Summary of 16 cases of transarterial sinus embolization using coils previously reported in the literature

First author and year	Location	Access route	Classification		Catheter	Catheter tip (mm)
			Satomi	Borden/ Cognard		
Fukai (2001)	SSS	MMA		III/II a+b	Prowler-14	0.63
Tokunaga (2003)	TSS	MMA		I/II a	Excel-14	0.63
Kiyosue (2004)	SSS	MMA		III/II a+b	(18 size)	0.83
Layton (2006)	Tentorium	MMA		III/III	Echelon-10	0.56
	Tentorium	MMA		III/IV	Echelon-10	0.56
Shiraga (2010)	TSS	MMA		III/II a+b	Renegade-18	0.83
Ohara (2012)	SSS	MMA		III/II a+b	Marathon	0.5
Takegami (2012)	CS	AMA	II		Excelsior-1018	0.67
Baik (2014)	SSS	MMA		III/II a+b	NA	0.56–0.63
	CS	AMA	II		NA	0.56–0.63
	TSS	MMA		III/II a+b	NA	0.56–0.63
	TSS	MHT		III/II a+b	NA	0.56–0.63
Ymauchi (2015)	CS	AMA	II		Headway-17	0.56
Murakami (2016)	SLSW	AFR		III/II a+b	SL-10	0.56
Our case 1	TSS	MMA		III/II a+b	Marathon	0.5
Our case 2	CS	AMA	II		Marathon	0.5

AFR: artery of the foramen rotundum; AMA: accessory meningeal artery; CS: cavernous sinus; MHT: meningohypophyseal trunk; MMA: middle meningeal artery; SLSW: sinus of the lesser sphenoid wing; SSS: superior sagittal sinus; TSS transverse-sigmoid sinus

fistula and feeder in this order were embolized with ED10 ExtraSoft 1.5- to 4-mm coils (**Fig. 4D**). DSA demonstrated the disappearance of the DAVF (**Fig. 4E** and **4F**) and the procedure was completed. After surgery, the symptoms were ameliorated and the patient was discharged.

Discussion

For DAVF treatment, transvenous superselective shunt occlusion (SSSO) is ideal, especially for lesions of the CS.[1] However, it is difficult to guide a microcatheter to a fistulous point in some cases and structural problems regarding a shunted pouch make superselective embolization through the venous side difficult in other cases. Although sinus packing is selected in such cases, it is impossible when the affected sinus functions in normal perfusion. Furthermore, occlusion of the sinus makes transvenous approaching difficult in some cases. Recently, radical TAE with liquid embolic substances, such as NBCA and Onyx, has been attempted in cases in which radical TVE is difficult. However, anastomosis-mediated reflux to intracranial or cranial-nerve-nourishing arteries could occur. In particular, the use of Onyx should be avoided in cases of CS DAVF, as observed in Case 2. In addition, a liquid embolic substance may not reach a drainer beyond a fistula, inducing feeder occlusion and not being curative. In our cases, it was possible to transarterially guide a microcatheter to a fistula through a feeder, pass it through the fistula, and insert it into the affected sinus. In Case 1, the isolated sinus and parasinus in which a fistulous point was present were obliterated. In Case 2, both the sinus and feeder sides of a fistulous point were selectively embolized with coils, being curative. Transarterial sinus coiling, as adopted in the present cases, is useful from the viewpoints of the simplicity of an approach not mediated by the occluded sinus and accuracy of fistulous point obliteration; it should be considered as an option for DAVF treatment.

Regarding treatment by transarterial sinus coiling, 16 patients including our 2 cases, have been reported. The most frequent affected site was the TSS in five patients, followed by the CS and superior sagittal sinus in four each (**Table 1**).[2–10] Although only one patient was reported to be treated using a flow-directed catheter, treatment using a flow-directed catheter was possible in our two cases, indicating the efficacy of flow-directed catheters for this treatment. The MMA as a feeder was most frequently used as an access route. It is not tortuous and is often selected as an access route for TAE. Therefore, MMA could be the most appropriate as an access route for transarterial sinus coiling. Furthermore, in all except one report, the stage was evaluated as Borden type III/Cognard type IIa+b or higher, which means the affected sinus was isolated or non-sinusal type. Regarding CS DAVF, all cases were evaluated as Satomi stage II.[11] This procedure may have been applied for cases in which approaching was difficult. In contrast, feeders presumed to develop according to stage progression, increasing the possibility that feeders appropriate for transarterial sinus coiling appear. In cases with advanced DAVF, it is important to evaluate the course and diameter of a feeder considering transarterial sinus coiling as a treatment method. In particular, the AMA, a direct dural branch of CS, was reported to utilized as an approach route in all CS DAVF cases.[2–10] Therefore, it is also important to evaluate angioarchitecture of the AMA. The stage was evaluated as Borden type I/Cognard type IIa and the affected sinus was involved in normal perfusion in only one case of TSS DAVF. Superselective embolization of the shunted pouch was unable to be performed and transarterial sinus coiling was curative in this case. This procedure could be also useful in such cases.

Histologically, the fistula diameter reportedly ranges from 30 to 200 mm in DAVF,[12,13] but 0.56- to 0.83-mm microcatheters were passed through the fistula site in previous reports.[2–10] In our study, the fistula diameter was estimated to be approximately 1 mm in Case 1 and approximately 0.7 mm in Case 2 on 3D-RA (**Figs. 2F** and **4C**). It might be possible to guide a 10-size microcatheter in our two cases, and in such cases, the variations of coils available will increase. Thus, initially, a thin-diameter braided catheter, which facilitates coil usage, should be selected. If it is difficult, selection of a flow-directed catheter with a thinner diameter improves operability during treatment. However, coils cannot be available for flow-directed catheters other than the Marathon.

As the limitation of transarterial sinus coiling, catheter movement is restricted when inserting a microcatheter whose outer diameter is similar to the fistula diameter, making catheter guiding to other shunting points or subtle catheter control during coil embolization difficult.

Conclusion

We reported two cases of DAVF in which TVE was difficult and treatment by transarterial sinus coiling was useful. This treatment may be effective in cases in which a transvenous approach to the affected sinus or shunted venous pouch is difficult. Flow-directed catheters are available for this treatment. Cases in which this treatment is possible may be rare, but it is important to evaluate the diameter and course of a feeder while considering it as a treatment option.

Disclosure Statement

The authors declare no conflict of interest.

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