

ON-LINE APPENDIX

Study Population

A total of 119 DAVFs in 107 patients were treated with various treatment modalities, including transarterial embolization, TVE, open surgery, and radiosurgery in a single tertiary center between January 2009 and March 2020. Among these patients, we considered only those who were treated with TVE. DAVFs treated with transarterial embolization ($n = 39$), open surgery ($n = 13$), and radiosurgery ($n = 9$) were excluded. Finally, a total of 58 patients were included in this study. The medical records and radiologic findings were retrospectively reviewed from our prospectively collected DAVF data base, which included baseline clinical and radiologic characteristics, treatment outcomes, and periprocedural complications.

Outcome Assessment

Clinical symptoms were assessed at 3 months after the procedure in an outpatient clinic by dividing the patients into 3 categories: 1) symptom-free, 2) symptom-improved, or 3) symptom-persistent. Immediate postoperative radiologic outcome was evaluated by DSA and was classified as complete or near-complete occlusion and incomplete or partial occlusion. The follow-up radiologic examination was performed using MRA with a TOF image at 3–12 months after the procedure. We performed follow-up DSA only in cases with recurrence on MRA or symptom relapse. The clinical outcome and angiographic results were retrospectively assessed by the 2 observers (J.H.C. and B.-S.K.), who were blinded to the information regarding the patient baseline characteristics.

Illustrative Cases

Case 1. Transverse Sigmoid DAVF with Isolated Sinus and Cortical Venous Reflux Presenting with Intracranial Hemorrhage. A 61-year-old woman presented with headache and nausea. Initial brain CTA showed an intracranial hemorrhage located in

the left temporal area. DSA showed an isolated transverse-sigmoid DAVF with cortical venous reflux fed mainly by the ipsilateral external carotid artery (Fig 1A). We performed intraprocedural FPCTRA (DSA24) as a control image (Fig 1B). During the microcatheter navigation through the occluded sigmoid sinus, low-dose FPCTRA with reduced FOV (DRcare) was performed to identify whether the microcatheter was going in the right direction (Fig 1C, -D). After placing the microcatheter into the target shunt pouch, we could achieve complete occlusion by TVE (Fig 1E, -F).

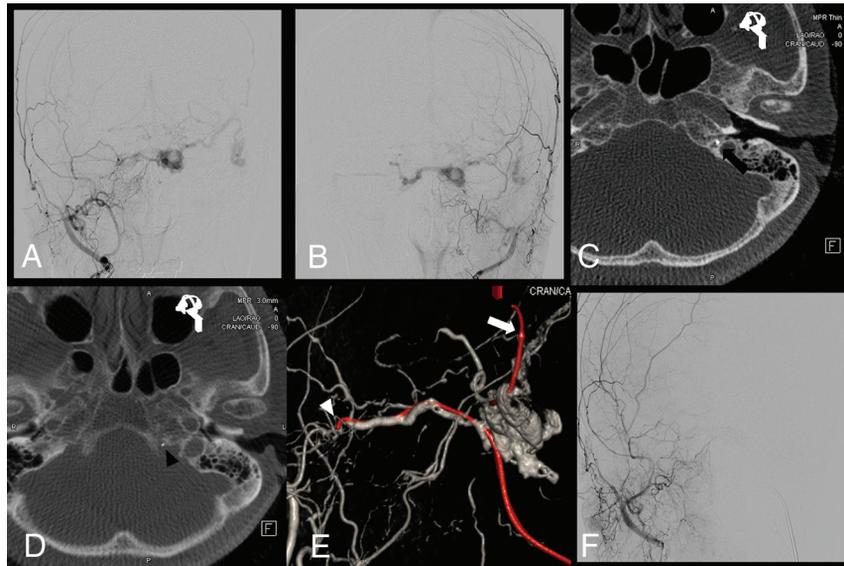
Case 17. Cavernous sinus (CS) DAVF with Ipsilateral inferior petrosal sinus (IPS) Occlusion and Cortical Venous Reflux Presenting with Eye Symptoms. A 72-year-old woman presented with diplopia, chemosis, and exophthalmos. DSA showed a cavernous sinus DAVF fed by both external carotid arteries and mainly draining in to multiple cortical veins with an occluded inferior petrosal sinus (On-line Fig 1A, -B). After performing initial DSA24, we checked DRcare 2 times during the microcatheter navigation through the occluded inferior petrosal sinus (On-line Fig 1C, -D). After we confirmed microcatheter placement by fusion of the subtraction image of DSA24 and the third DRcare image (On-line Fig 1D), successful coil embolization was achieved (On-line Fig 1E).

Case 18. ACC DAVF without Sinus Occlusion Presenting with Eye Symptoms. An 81-year-old woman presented with chemosis and exophthalmos. The initial DSA showed a Borden type I DAVF involving the ACC fed by both external carotid arteries and mainly draining to the left internal jugular vein and inferior petrosal sinus (On-line Fig 2A, -B). We checked DRcare and fused DRcare with initial DSA24 with initial DSA24 during microcatheter navigation (On-line Fig 2C) and after microcatheter placement in the shunt pouch (On-line Fig 2D). Thereafter, we achieved complete occlusion of the DAVF (On-line Fig 2E, -F).

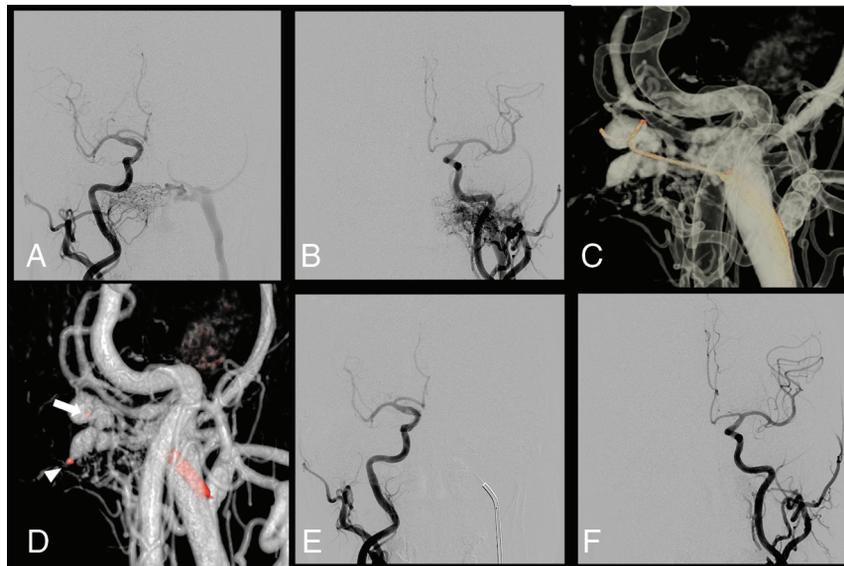
On-line Table. Details of patients treated using the FPCTRA and IF technique

No.	Sex/Age (yr)	Initial Symptom	Location	Borden Type	Sinus Occlusion	Access Route	Angiographic Outcome	Improvement of Symptoms	Periprocedural Complications
1	F/61	ICH	Transverse sigmoid	III	Isolated sinus	Ipsilateral IJV by blinded navigation	Complete	Yes (free)	No
2	M/56	Eye symptoms	CS	I	Ipsilateral IPS	Ipsilateral IPS by blinded navigation	Complete	Yes (free)	No
3	M/62	Eye symptoms	ACC	I	None	Ipsilateral IJV	Complete	Yes (free)	No
4	F/58	Eye symptoms	ACC	I	Ipsilateral IJV	Ipsilateral FV	Complete	Yes (free)	No
5	M/39	Eye symptoms	ACC	I	Ipsilateral IJV	Ipsilateral FV	Complete	Yes (free)	No
6	F/55	Tinnitus	ACC	I	None	Ipsilateral IJV	Complete	Yes (free)	No
7	M/67	Tinnitus	ACC	I	None	Ipsilateral IJV	Near-complete	Yes (free)	No
8	F/71	Eye symptoms	CS	I	Ipsilateral IPS	Ipsilateral IPS by blinded navigation	Complete	Yes (free)	No
9	F/67	Tinnitus	ACC	I	None	Ipsilateral IJV	Partial	Yes (free)	No
10	F/67	Eye symptoms	CS	I	Ipsilateral IPS	Ipsilateral STV	Complete	Yes (free)	No
11	F/63	Headache	Transverse sigmoid	I	None	Ipsilateral IJV	Complete	Yes (free)	No
12	F/57	Eye symptoms	CS	II	Ipsilateral IPS	Ipsilateral IPS by blinded navigation	Complete	Yes	No
13	F/68	Eye symptoms	CS	II	Ipsilateral IPS	Ipsilateral STV	Complete	Yes	Sixth-nerve palsy (full recovery after 5 mo)
14	F/70	Eye symptoms	CS	I	Ipsilateral IPS	Ipsilateral STV	Complete	Yes (free)	No
15	F/77	Eye symptoms	CS	I	Ipsilateral IPS	Ipsilateral IPS by blinded navigation	Complete	Yes (free)	No
16	F/62	Eye symptoms	CS	I	None	Ipsilateral IPS	Complete	Yes (free)	No
17	F/72	Eye symptoms	CS	II	Ipsilateral IPS	Ipsilateral IPS by blinded navigation	Near-complete	Yes (free)	Sixth-nerve palsy (full recovery after 3 mo)
18	F/81	Eye symptoms	ACC	I	None	Ipsilateral IJV	Complete	Yes (free)	No

Note:—IPS, indicates inferior petrosal sinus; IJV, internal jugular vein; I, intracranial hemorrhage; CS, cavernous sinus; STV, superficial temporal vein; FV, facial vein; ICH, intracranial hemorrhage.



ON-LINE FIG 1. Case 17. A 72-year-old woman presenting with eye symptoms. *A* and *B*, Initial DSA shows a dural AVF involving the intercavernous and left cavernous sinuses with the left inferior petrosal sinus occlusion fed by both external carotid arteries. During the microguidewire and microcatheter navigation, we checked low-dose FPCTRA with reduced FOV (DRcare) 2 times. *C*, First, the DRcare image shows that the microguidewire tip is directed the wrong way and placed in the groove for the emissary vein (*black arrow*). *D*, Second, the DRcare image shows that the microguidewire is placed in the groove for the inferior petrosal sinus (*black arrowhead*). *E*, We successfully advanced 2 microcatheters through the occluded inferior petrosal sinus. Thereafter, we placed 1 microcatheter in the intercavernous sinus (*white arrowhead*) and another in the left superior ophthalmic vein (*white arrow*), and this placement is confirmed by fusion. *F*, Successful coil embolization is performed.



ON-LINE FIG 2. Case 18. An 81-year-old woman presenting with eye symptoms. *A* and *B*, Both common carotid angiographies show a dural AVF involving the left anterior condylar confluence draining into the left internal jugular vein. *C*, We obtained a fusion image during microguidewire navigation and can confirm the right placement of the microguidewire in the shunt pouch. *D*, Fusion image after placement of 2 microcatheters shows a different microcatheter tip location (*white arrow* and *white arrowhead*) in the target shunt pouch. *E* and *F*, Complete occlusion can be achieved by coil embolization.