Online July 22, 2023
Journal of Neuroendovascular Therapy 2023; 17: 196–201 DOI: 10.5797/jnet.oa.2023-0032

Original Article

Intracranial Non-Sinus-Type Dural Arteriovenous Fistulas Could Be Curable by Transarterial Embolization or Transvenous Embolization with Liquid Embolic Material

Yoshikazu Matsuda,[1] Tomoaki Terada,[2] Yu Sakamoto,[2] Minako Kubo,[1] Arisa Umesaki,[3] Yuko Tanaka,[4] Hiroaki Matsumoto,[5] Hiroo Yamaga,[2] Tomoyuki Tsumoto,[3] and Tohru Mizutani[1]

Objective: Recently, the occlusion rate of transarterial embolization (TAE) for intracranial non-sinus-type dural arteriovenous fistulas (NSDAVFs) has improved after ONYX was introduced. Additionally, when TAE for NSDAVF is unsuccessful, transvenous embolization (TVE) has become available as an alternative treatment. We investigated the factor for the favorable occlusion rate of endovascular treatment for NSDAVF at our institutions.

Methods: Two hundred and twenty-seven patients with intracranial dural arteriovenous fistulas (DAVFs) were treated at our institutions between September 2014 and October 2022. The patients diagnosed with NSDAVF in all DAVFs who underwent endovascular treatment were included. The clinical characteristics, angiographical outcomes, and clinical outcomes of patients who underwent endovascular treatment were evaluated.

Results: Thirty-eight patients had intracranial NSDAVF (tentorial: 23 cases, parasagittal-convexity: 7, anterior cranial fossa: 6, middle cranial fossa: 2). Our participants' mean age was 64.8 ± 11.3 years, and 31 (81.6%) of them were males. Patients' symptoms were as follows: asymptomatic (24), hemorrhage (10), tinnitus (3), and trigeminal neuralgia (1). TAE and TVE were performed on 35 and 3 patients, respectively. The rate of immediate angiographical occlusion was 84.2% (32/38). The follow-up angiographical occlusion rate in 6 months was 88.5% (31/35). Complications occurred in three cases. There was no morbidity or mortality after 30 days.

Conclusion: TAE using the combination of the new microcatheter and microguidewire and TVE in the case of difficult or failed TAE for NSDAVF could achieve high success rates and safety.

Keywords ▶ non-sinus-type DAVF, TAE, TVE

[1]*Department of Neurosurgery, Showa University Hospital, Tokyo, Japan*
[2]*Department of Neurosurgery, Showa University Northern Yokohama Hospital, Yokohama, Kanagawa, Japan*
[3]*Department of Neurosurgery, Showa University Fujigaoka Hospital, Yokohama, Kanagawa, Japan*
[4]*Department of Stroke Medicine and Neuroendovascular Therapy, University of Occupational and Environmental Health, Kitakyushu, Fukuoka, Japan*
[5]*Department of Neurosurgery, Tokyo Metropolitan Ebara Hospital, Tokyo, Japan*

Received: May 2, 2023; Accepted: June 29, 2023
Corresponding author: Yoshikazu Matsuda. Department of Neurosurgery, Showa University Hospital, 5-8, Hatanodai 1 Chome, Shinagawa-ku, Tokyo 142-8666, Japan.
Email: ymatsuda0517@yahoo.co.jp

Introduction

Intracranial non-sinus-type dural arteriovenous fistulas (NSDAVFs) can be a risk factor for intracranial hemorrhage.[1–4] Surgical treatment, including endovascular treatment, is recommended for NSDAVF because of its natural history. Generally, transarterial embolization (TAE) is selected because there is no venous sinus access route for transvenous embolization (TVE) in NSDAVF.

Previously, TAE for NSDAVF in Japan demonstrated low success and high complication rates.[3] However, TAE could achieve higher success rates after ethylene vinyl alcohol copolymer (ONYX; Medtronic, Minneapolis, MN, USA) was introduced. Furthermore, TVE has been feasible as an alternative treatment when TAE is difficult due to the tortuous nature of the target artery or when TAE fails.[5] We evaluated the factor for favorable outcomes of endovascular treatment for NSDAVF.

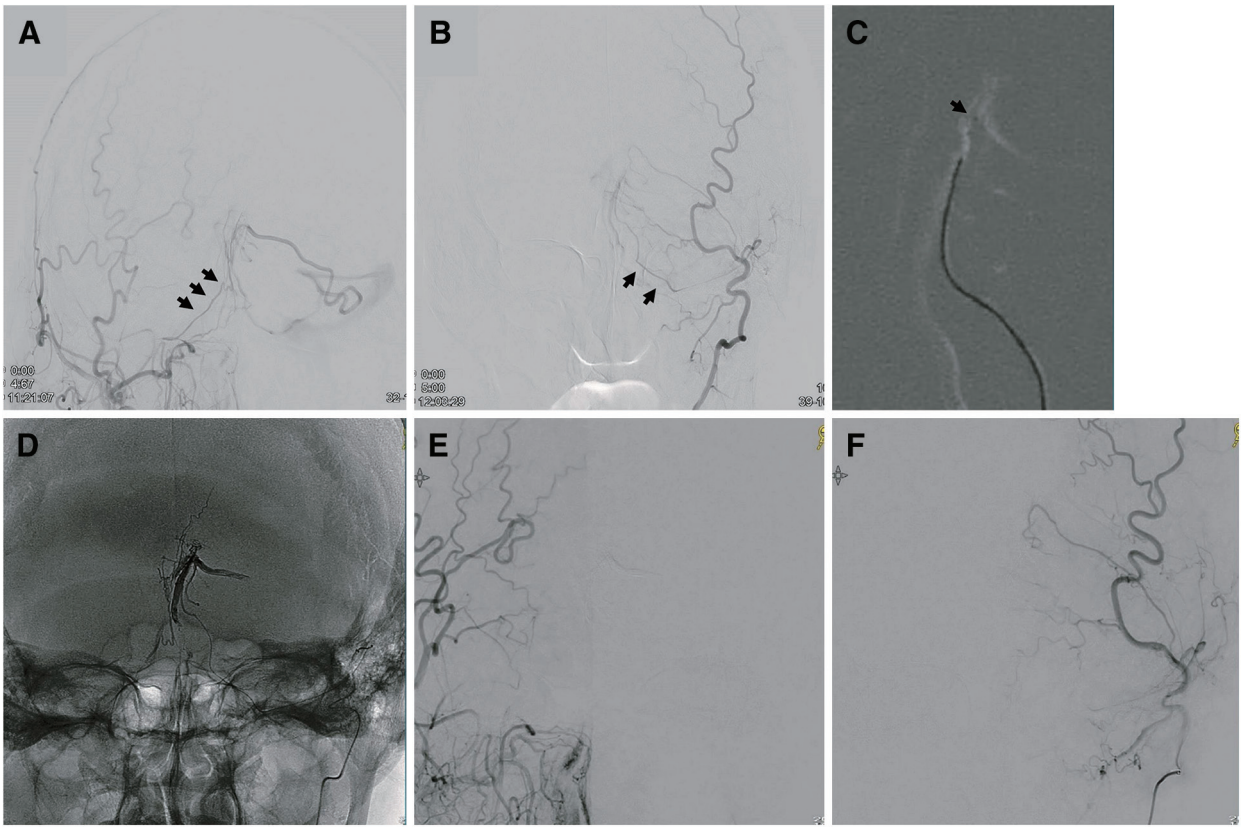

Fig. 1 Images of asymptomatic tentorial DAVFs. (**A** and **B**) Anterior–posterior views of the right ECA showing the hypoglossal branch of the AphA (arrow) and the OA (arrows) connecting to the shunt point. (**C**) An image of the roadmap showing the marker of the MC (arrow). (**D**) Fluoroscopic image after the injection of ONYX. (**E** and **F**) Anterior–posterior views of the right ECA and the left OA demonstrating the disappearance of the shunt. AphA: ascending pharyngeal artery; DAVFs: dural arteriovenous fistulas; ECA: external carotid artery; MC: microcatheter; OA: occipital artery

Materials and Methods

Patient selection and data collection

In this retrospective study, we included 227 patients who underwent endovascular treatment for intracranial dural arteriovenous fistulas (DAVFs) at our institutions between September 2014 and October 2022. All DAVFs were diagnosed via DSA. Among them, 41 patients had NSDAVF. Three patients were excluded because they underwent surgery. The clinical characteristics, angiographic findings, and clinical outcomes were obtained from patients' medical records.

The research within our submission has been approved by the ethics institutional review board of Showa University.

Interventional procedure

All procedures were performed under general anesthesia. A representative case of a patient with tentorial DAVF who underwent TAE is shown in **Fig. 1**.

During the TAE procedure, a 7F sheath was inserted into the right common femoral artery. A 7F guiding catheter was placed into an external carotid artery (ECA). A distal access catheter was inserted into the ECA distal through the guiding catheter. Marathon (Medtronic), Scepter (MicroVention, Aliso Viejo, CA, USA), or DeFrictor (Medico's Hirata, Osaka, Japan) was chosen to embolize the feeder of the NSDAVF. Onyx, N-butyl-2 cyanoacrylate (NBCA), or a precipitating hydrophobic injectable liquid (Phil; Terumo, CA, USA) was chosen as the liquid material. In case TAE failed, or judged risky or difficult, TVE was considered. The procedure for TVE is shown in **Fig. 2** as a representative case. The 6F sheath was inserted into the cervical jugular vein. The 6F guiding catheter was navigated into the sinus. The microcatheter (MC) for coil placement to perform the pressure cooker technique[6] was placed proximal to the shunt point. DeFrictor was advanced more distally than MC for coiling near the shunt point. After some coils were inserted to protect ONYX reflux into the venous drainage route, ONYX was injected from the DeFrictor.

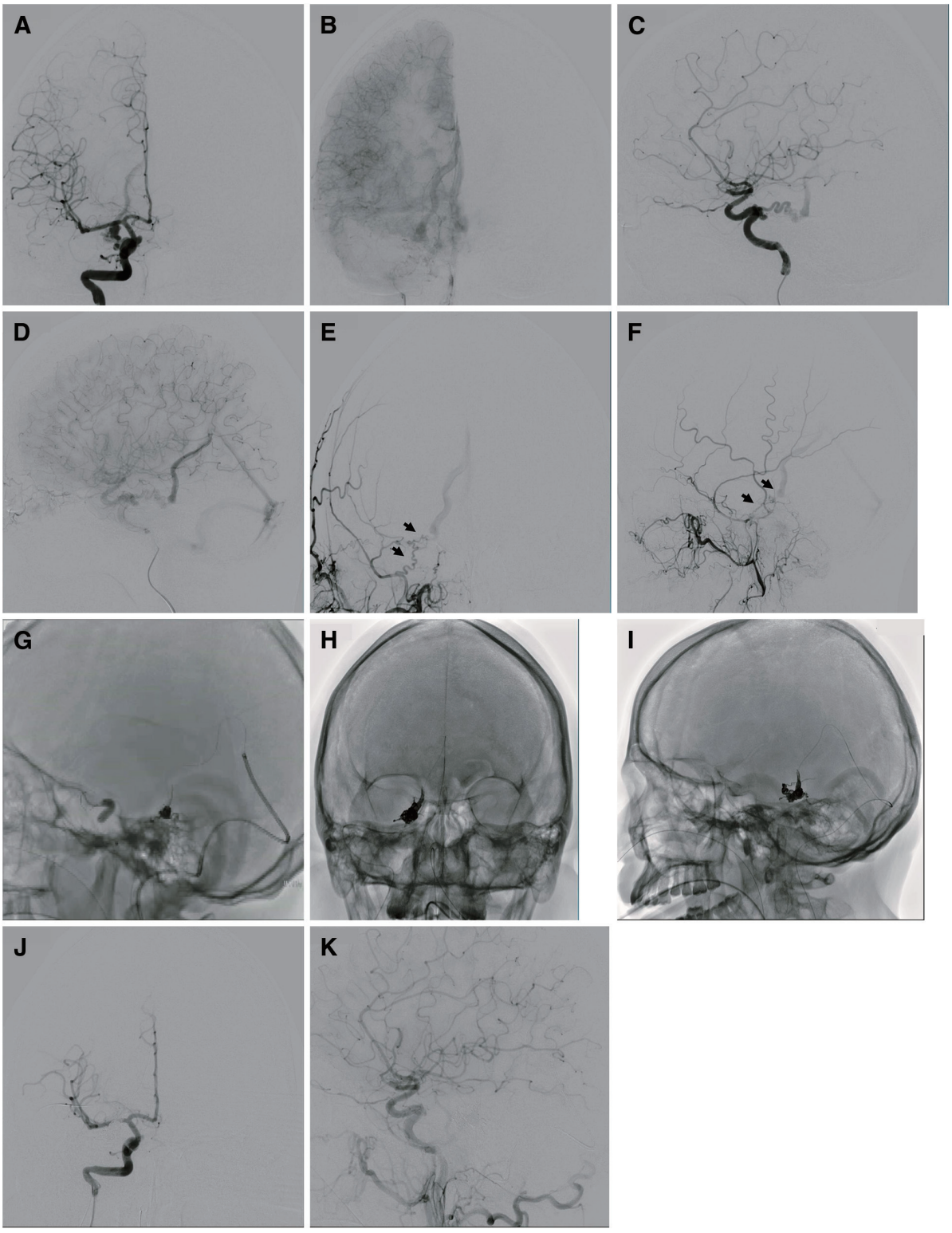

Fig. 2 Images of asymptomatic tentorial DAVF. (**A** and **B**) Anterior–posterior early and delayed phase views of the right ICA showing DAVF supplied from MHT drains into the basal vein. (**C** and **D**) Lateral early-phase and delayed phase views of the right ICA. (**E**) Anterior–posterior view of the right ECA showing the DAVF supplied from the petrosal branch of the MMA (arrows) that drains into the basal vein. (**F**) Lateral view of the right ECA. The petrosal branch of the MMA and the basal vein are shown. (**G**) Image before the injection of ONYX. Coils are inserted to prevent the reflux of ONYX into the drainer. The right ICA is occluded by a balloon catheter to prevent its migration into the ICA of ONYX. (**H** and **I**) Fluoroscopic anterior–posterior and lateral images after ONYX embolization. (**J** and **K**) Anterior–posterior and lateral images of the right ICA showing the disappearance of the DAVF. DAVF: dural arteriovenous fistula; ECA: external carotid artery; ICA: internal carotid artery; MHT: meningohypophysial trunk; MMA: middle meningeal artery

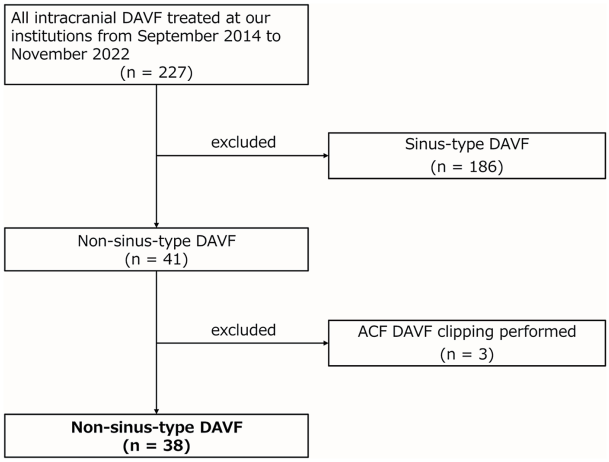

Fig. 3 Flowchart of the patient recruitment process of this study. ACF: anterior cranial fossa; DAVF: dural arteriovenous fistula

Afterward, the proximal side of the DeFrictor was cut near the puncture site by pulling and embedded subcutaneously, if the MC retrieval failed.

Results

We evaluated 38 patients with NSDAVF who underwent an endovascular treatment (**Fig. 3**). The mean age of these patients was 64.8 ± 11.3 years (range: 40–84 years), and 31 (81.6%) of them were males. There were 24 asymptomatic patients and 10 patients who experienced an intracranial hemorrhage. Out of four of the symptomatic patients, three had tinnitus while one had trigeminal neuralgia (**Table 1**).

The tentorium (23) was the most common location for NSDAVFs, followed by the parasagittal-convexity (7), anterior cranial fossa (ACF, 6), and the middle cranial fossa (2).

A summary of the procedures is shown in **Table 2**. TAE alone was performed in 35 patients, while TVE alone was performed in three patients. The middle meningeal artery (MMA) was most commonly selected as the target pedicle. Two pedicles were required to occlude the DAVF completely in one patient. DeFrictor was mainly selected to embolize the feeder after it was introduced. As liquid materials, ONYX was used in 35 patients, NBCA was used in two patients, and Phil was used in one patient.

Immediate angiographic occlusion was achieved in 32 (84.2%) patients. Follow-up angiography in 6 months was performed in 35 patients, and angiographical complete occlusion was demonstrated in 31 (88.5%) patients (**Table 3**). Two patients achieved more progressive occlusion of the DAVF on follow-up angiography. One patient who underwent TVE suffered from transient hemianopsia due to an occipital hemorrhage and fully recovered within 1 month. Although one patient suffered from trochlear nerve palsy after TAE, the patient recovered in 1 month. One other patient demonstrated an asymptomatic acute epidural hematoma due to the extravasation of the MC. There was no deterioration of the morbidity and mortality after 30 days.

Table 1 Patient characteristics of non-sinus-dAVF, N = 38

Characteristic	No.
Age (mean)	64.8 ± 11.3
Male (%)	31 (81.6)
Presentation	
Asymptomatic	24
Hemorrhage	10
Tinnitus	3
V neuralgia	1
Locations	
Tentorium	23
ACF	7
Convexity	6
MCF	2

ACF: anterior cranial fossa; dAVF: dural arteriovenous fistula; MCF: middle cranial fossa

Table 2 Procedural characteristics

Characteristic	No.
TAE	35
TVE	3
Target arterial pedicles	
MMA	20
OpA	6
OA	3
AMA	2
AphA	2
PMA	2
PCA	1
MC	
Defrictor	20
Marathon	9
Scepter (Scepter mini)	9 (1)
Embolic material	
ONYX	35
NBCA	2
Phil	1

AMA: accessory meningeal artery; AphA: ascending pharyngeal artery; MC: microcatheter; MMA: middle meningeal artery; NBCA: N-butyl-2 cyanoacrylate OA: occipital artery; OpA: ophthalmic artery; PCA: posterior cerebral artery; PMA: posterior meningeal artery; TAE: transarterial embolization; TVE: transvenous embolization

Discussion

The success rate of TAE for all DAVF was low (26%) before the introduction of ONYX.[3] However, after ONYX was introduced, the occlusion rate of TAE improved to

Table 3 Outcome of patients

Angiographic outcome	No.
Immediate occlusion (total n = 38, %)	32 (84.2%)
Follow-up occlusion (total n = 35, %)	31 (88.5%)
Complications	
Hemorrhage (transient hemianopsia)	1
Transient trochlear nerve palsy	1
AEDH (asymptomatic)	1
Morbidity at 30 days	0
Mortality at 30 days	0

AEDH: acute epidural hematoma

62%–92% in the short term.[7–10] In our study, ONYX was mainly selected except for two cases of NBCA, and one case of Phil. Generally, TAE for NSDAVF was selected because of the no venous approach. Regarding ACF DAVF, favorable occlusion rates have been reported in some recent articles. Trivelato et al. reported that the occlusion of TAE and/or TVE for ACF DAVF was achieved in 88.2% of cases within 6 months.[5] Other studies including a small number of cases showed total occlusion rates of TAE ranging from 63% to 100%.[4,11–13] On the other hand, the occlusion rate of tentorial DAVF ranged from 56.0% to 83.0%.[14] Our series showed that the overall follow-up occlusion rate was 88.5%, which is comparable to the rates reported in these reports. However, to our knowledge, there is currently no published study that mentions the occlusion rate for patients with all NSDAVFs.

The main reason for the favorable occlusion rate is the development of the MC (DeFrictor; Hirata) and microguidewire (Chikai X010; Asahi Intecc, Aichi, Japan). This combination use enabled closer access to the shunt point and resulted in the penetration of ONYX into the drainer, including facilitation of shunt. According to Trivelato et al., TAE failure could be explained by the fact that the Onyx did not penetrate the proximal portion of the draining vein.[5] Hiramatsu et al. reported that the most common complication was an arterial ischemia in the NSDAVF.[3] Actually, our series included six patients who underwent TAE via the ophthalmic artery. In all of them, the MC was navigated close to the shunt point, beyond the central retinal artery.

Furthermore, as for the complication rate, the rates of perioperative morbidity and long-term neurologic morbidity in tentorial DAVF were 3.0%–13.0% and 2.0%–11.0%, respectively, in previous reports.[14] Some articles reported that the complication rate in ACF DAVF ranged from 0% to 16%.[4,11–13] Although our perioperative morbidity rate was 5.3%, the deterioration of morbidity and mortality at 30 days was 0%, which was an excellent outcome even for a short-term result.

We suppose that the main reason for the favorable outcomes in our series is the development of the MC and guidewire-facilitated navigation close to shunt points beyond a critical artery. This positioning of the MC creates a security zone for the reflux of liquid materials.

The main limitation of our study is that it is a retrospective study. Since patients who underwent open surgery were excluded, our results might have diminished the occlusion rate and exaggerated the complication rate. In the near future, prospective studies including consecutive cases are needed.

Conclusion

TAE using the combination of the new MC and microguidewire, and additional TVE if TAE for NSDAVF was difficult, risky, or failed, could achieve the high success rate by accessing to the closer point to the shunt.

Disclosure Statement

None.

References

1) Hiramatsu M, Sugiu K, Hishikawa T, et al. Epidemiology of dural arteriovenous fistula in Japan: analysis of Japanese Registry of Neuroendovascular Therapy (JR-NET2). *Neurol Med Chir (Tokyo)* 2014; 54: 63–71.
2) Hiramatsu M, Sugiu K, Ishiguro T, et al. Angioarchitecture of arteriovenous fistulas at the craniocervical junction: a multicenter cohort study of 54 patients. *J Neurosurg* 2018; 128: 1839–1849.
3) Hiramatsu M, Sugiu K, Hishikawa T, et al. Results of 1940 embolizations for dural arteriovenous fistulas: Japanese Registry of Neuroendovascular Therapy (JR-NET3). *J Neurosurg* 2019; 133: 166–173.
4) Agid R, TerBrugge K, Rodesch G, et al. Management strategies for anterior cranial fossa (ethmoidal) dural arteriovenous fistulas with an emphasis on endovascular treatment. *J Neurosurg* 2009; 110: 79–84.
5) Trivelato FP, Smajda S, Saleme S, et al. Endovascular treatment of anterior cranial base dural arteriovenous fistulas as a first-line approach: a multicenter study. *J Neurosurg* 2022; 137: 1758–1765.
6) Chapot R, Stracke P, Velasco A, et al. The pressure cooker technique for the treatment of brain AVMs. *J Neuroradiol* 2014; 41: 87–91.

7) Abud TG, Nguyen A, Saint-Maurice JP, et al. The use of Onyx in different types of intracranial dural arteriovenous fistula. *AJNR Am J Neuroradiol* 2011; 32: 2185–2191.
8) Cognard C, Januel AC, Silva NA Jr., et al. Endovascular treatment of intracranial dural arteriovenous fistulas with cortical venous drainage: new management using Onyx. *AJNR Am J Neuroradiol* 2008; 29: 235–241.
9) Hu YC, Newman CB, Dashti SR, et al. Cranial dural arteriovenous fistula: transarterial Onyx embolization experience and technical nuances. *J Neurointerv Surg* 2011; 3: 5–13.
10) Lv X, Jiang C, Zhang J, et al. Complications related to percutaneous transarterial embolization of intracranial dural arteriovenous fistulas in 40 patients. *AJNR Am J Neuroradiol* 2009; 30: 462–468.
11) Cannizzaro D, Peschillo S, Cenzato M, et al. Endovascular and surgical approaches of ethmoidal dural fistulas: a multicenter experience and a literature review. *Neurosurg Rev* 2018; 41: 391–398.
12) Robert T, Blanc R, Smajda S, et al. Endovascular treatment of cribriform plate dural arteriovenous fistulas: technical difficulties and complications avoidance. *J Neurointerv Surg* 2016; 8: 954–958.
13) Kulanthaivelu K, Pendharkar H, Prasad C, et al. Anterior cranial fossa dural arteriovenous fistulae - angioarchitecture and intervention. *Clin Neuroradiol* 2021; 31: 661–669.
14) Cannizzaro D, Brinjikji W, Rammos S, et al. Changing clinical and therapeutic trends in tentorial dural arteriovenous fistulas: a systematic review. *AJNR Am J Neuroradiol* 2015; 36: 1905–1911.