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Case Report

# Onyx transarterial embolization of dural arteriovenous fistula for failed N-butyl cyanoacrylate treatment: case report

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●Abstract●

**Objective**: To report efficacy of transarterial Onyx embolization of dural arteriovenous fistulas (DAVFs) previously treated with N-butyl cyanoacrylate (NBCA). Two cases are presented with special considerations given to the technical and anatomical aspects based on operative findings.

**Case Presentation**: Superior petrosal and tentorial DAVFs presented with tinnitus and cortical venous reflux, headache with decreased cognitive function respectively. The DAVFs were initially treated with multiple injections of NBCA ending in persistently remaining fistula, subsequently leading to recurrence. Transarterial Onyx embolization was performed, resulting in penetration of Onyx into the complex vascular network and draining veins, with retrograde filling of multiple feeding arteries. The affected sinus was preserved.

**Conclusion**: With the potential of better penetration of Onyx, transarterial Onyx embolization may be capable of treating recurrent NBCA-treated DAVFs. Larger number of cases and longer follow-up are required to determine the efficacy and safety of transarterial Onyx embolization of DAVFs.

●Key Words●

DAVF, dural arteriovenous fistula, NBCA, Onyx, transarterial embolization

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## Introduction

Total occlusion of dural arteriovenous fistulas (DAVFs) via transarterial embolization is difficult due to the rich anastomotic network of the dural/falcine plethora of feeding arteries, blood supply to cranial nerves, and extracranial to intracranial anastomoses. Incomplete occlusion of the fistulas will result in recanalization of the DAVF from the multiple collateral arteries constituting the dural blood supply. Transvenous occlusion or surgical skeletonization of true sinus or resection of the affected venous sinus has been reported effective in selected cases[5,12,13]. However, these treatments can be hazardous when the venous sinus drains cortical or deep veins. When total occlusion of a DAVF is difficult, surgical or endovascular selective disconnection of cortical venous reflux to control the disease is reported effective in DAVFs with combined sinus drainage and cortical venous reflux[15].

Onyx (ev3, Irvine, CA, USA) is a new liquid embolic agent with longer precipitation time enabling prolonged injection time, with potential of better penetration into a fistulous network. Previous reports have described initial successful transarterial Onyx embolization of DAVF as a primary treatment[1,3,6,9,11,14]. In our report, we present successful Onyx DAVF embolization in recurrent DAVFs previously treated with N-butyl cyanoacrylate (NBCA). Focus is given on the technique and anatomical considerations of transarterial DAVF Onyx embolization based on intraprocedural findings.

## Case Presentation

### 1. Case 1

A 41 year-old woman presented in May 2004 with an incidental right petrous DAVF discovered during workup for a head trauma. Neurological examination was normal except for pulsatile tinnitus, which she had been aware for several years. The patient initially underwent transarterial NBCA embolization from the right middle meningeal and occipital artery branches. Three embolizations were performed from the middle meningeal branches and one from the occipital artery branch, resulting in significant decrease of the shunt to

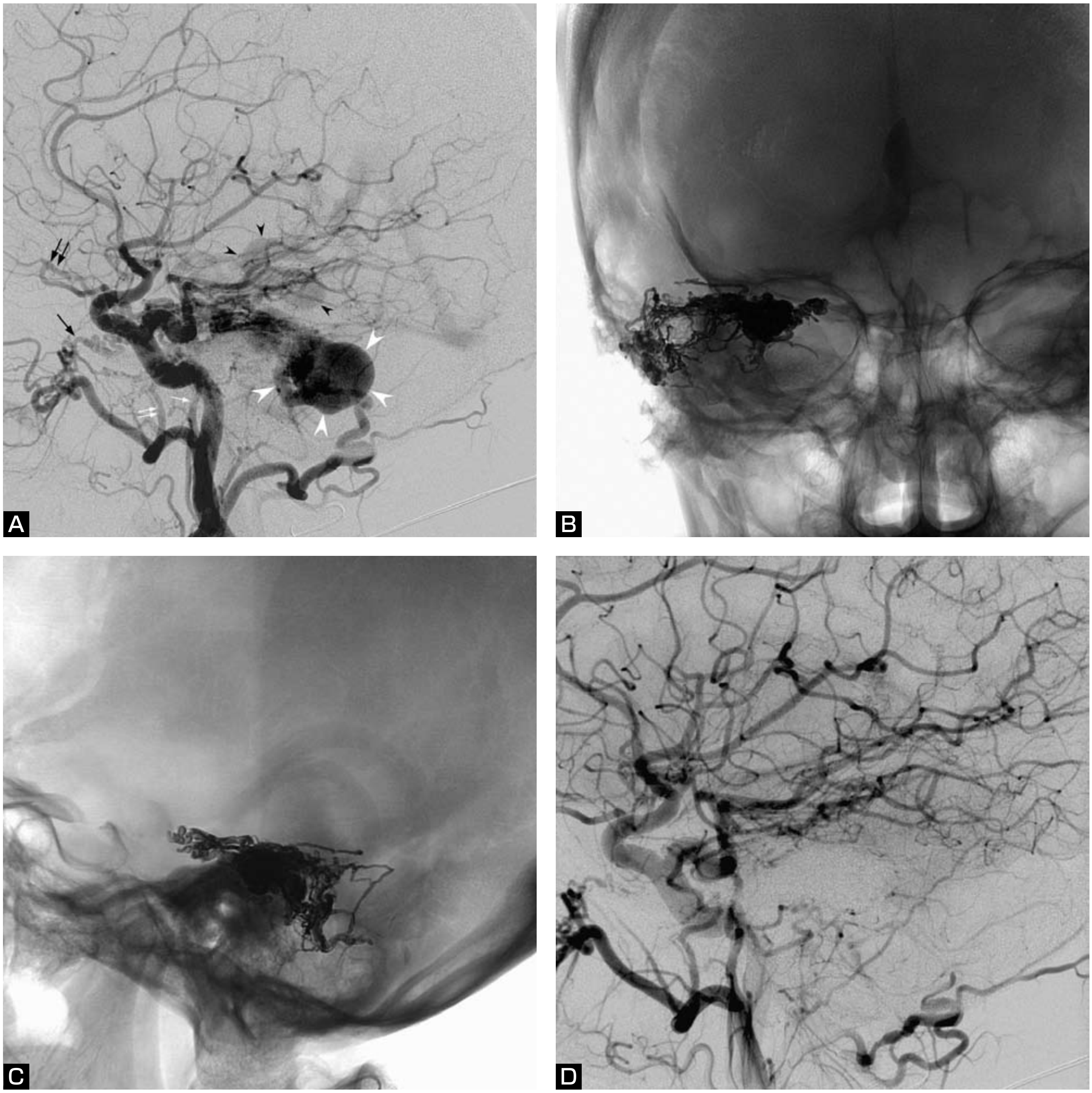
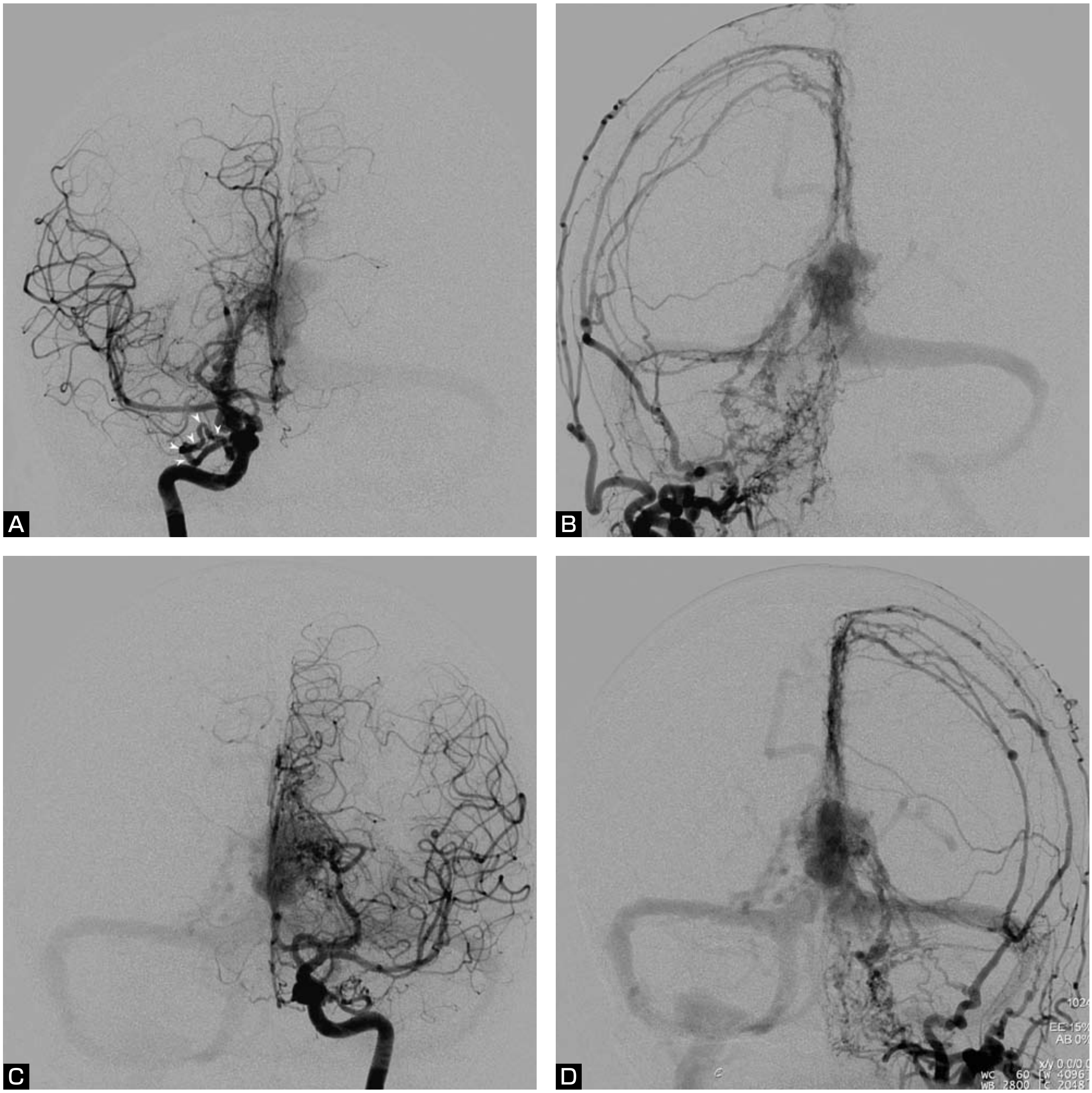
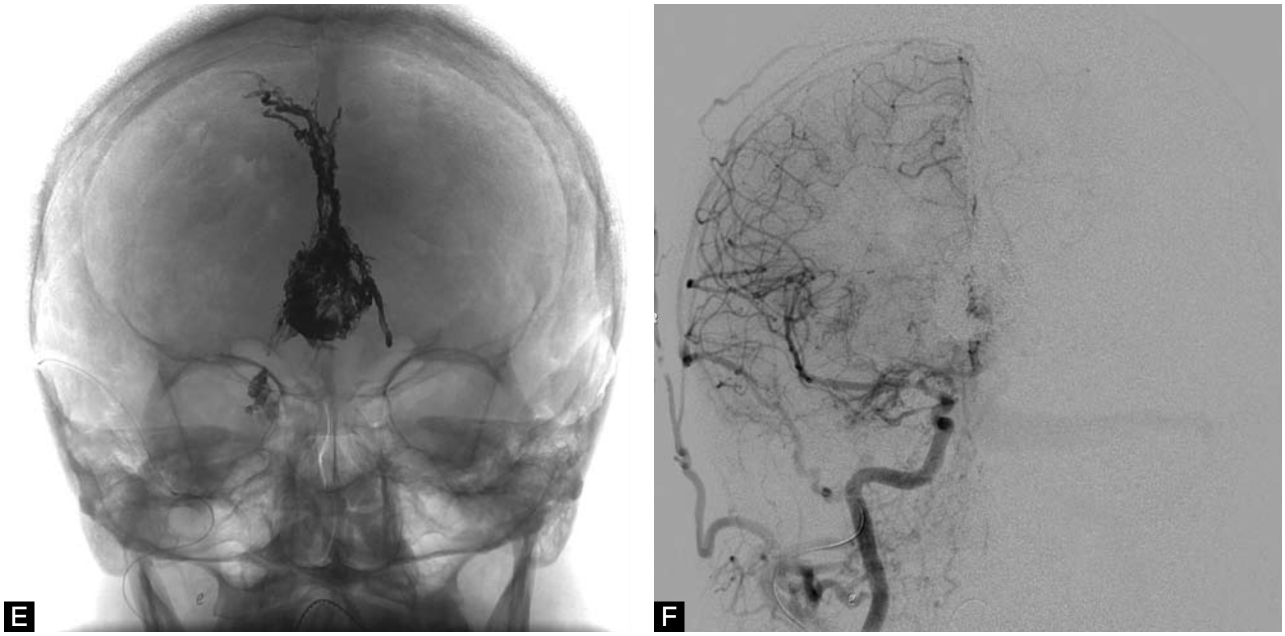



**Fig. 1** Right common carotid artery angiogram in lateral view (**A**) show persistent right petrosal DAVF, supplied from C5 branch of the internal carotid artery, recurrent meningeal branch of the ophthalmic artery (black double arrow), artery of foramen rotundum (black arrow), middle meningeal artery (white double arrow), accessory meningeal artery (white arrow), and occipital artery. Venous drainage is to a superficial cortical vein with a venous ectasia in the right cerebellar hemisphere (white arrowheads), then to the lateral mesencephlic vein (black arrowheads), draining to the basal vein of Rosenthal. Note persistent trigeminal artery. Post Onyx embolization unsubtracted image in anteroposterior (**B**) and lateral (**C**) views demonstrate Onyx cast filling the vascular network of the fistula and the affected sinus. Mid-arterial phase of post-embolization right common carotid artery angiogram in lateral view (**D**) shows complete occlusion of DAVF.

the fistula. However, persistent filling of the DAVF remained (**Fig. 1A**) 18 months after the first embolization with feeders from right middle meningeal artery (white arrow), accessory meningeal artery (white double arrow), artery of foramen rotundum (black arrow), recurrent meningeal artery from the ophthalmic artery (black double arrow), occipital artery, anterior inferior cereberellar artery, and bilateral C5 branches of the internal carotid arteries. Venous drainage




was to a superficial cortical vein with a venous ectasia in the right cerebellar hemisphere (white arrowheads), then to the lateral mesencephlic vein (black arrowheads), which drained to the basal vein of Rosenthal. The patient underwent a second procedure in November 2005 using Onyx. Under general anesthesia, the right occipital artery transmastoid branch was catheterized with a 5Fr Envoy (Cordis, Miami Lakes, FL, USA) guiding catheter. A Marathon (ev3, Irvine, CA, USA) microcatheter was advanced close to the fistula site with the aid of Silverspeed 10 (ev3 Irvine, CA, USA) and Mizzen Soft (Boston Scientific, Fremont, CA, USA) microguidewires. The microcatheter was flushed first with 40 mg of lidocaine to prevent vasospasm, then 3 ml of normal saline, and then with 0.23 ml of dimethyl sulfoxide (DMSO) over 2 minutes, followed by 2.4 ml of Onyx 18 injection over 45 minutes. The Onyx was slowly and continuously injected with intermittent pauses from 20 to 45 seconds whenever reflux of Onyx was observed to the catheterized access vessel or when the Onyx started to penetrate into an unfavorable vessel (normal vessel, functional venous sinus, etc). Frequent interim angiograms of all potential circulations using a second diagnostic catheter were performed to monitor safe and



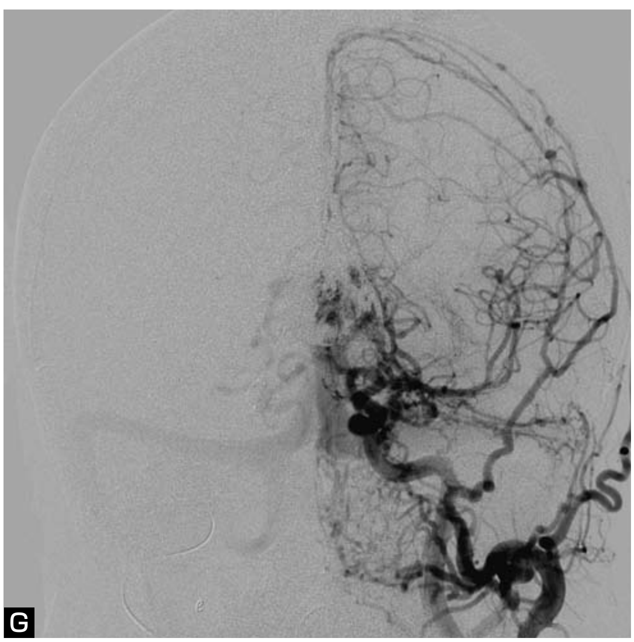




**Fig. 2** Right internal (**A**), external (**B**), and left internal (**C**), external (**D**) carotid artery angiograms in anteroposterior view show multiple feeders to the tentorial DAVF. Note prominent feeder from recurrent meningeal branch of the right ophthalmic artery (A arrowheads). Venous drainage is to the vein of Galen. Post embolization non-subtracted anteroposterior view demonstrates Onyx cast filling multiple feeders (**E**). Note that Onyx injection from 3 pedicles of right middle meningeal artery penetrated to the left side feeders as well. The cast almost represents the configuration of the vein of Galen. Post-embolization right (**F**) and left (**G**) common carotid artery angiograms in anteroposterior view show significant decrease in the arteriovenous shunt. Note preservation of the vein of Galen.

progressive Onyx deposition. Special attention was paid to avoid the Onyx refluxing or penetrating into vital vessels such as an internal carotid artery or a venous sinus through feeders and anastomoses. The Onyx penetrated the fistula to the venous sinus and could be controlled to permit reflux into the multiple feeding arteries, to assure total occlusion without sacrificing the sinus. The microcatheter was retrieved with gentle traction. Post-embolization unsubtracted skull image in anteroposterior and lateral views demonstrated the cast of Onyx obliterating multiple feeders and the affected sinus (**Fig. 1B, C**). Angiogram showed complete occlusion of the DAVF (**Fig. 1D**). No transient or permanent neurological or procedure related complications were encountered. Six-month follow up angiogram demonstrated stable occlusion of the DAVF.

## 2. Case 2

A 57 year-old woman presented with left pulsatile tinnitus, bilateral exophthalmos, and decreased cognitive function in 1998. Workup revealed a tentorial vein of Galen DAVF with venous congestion to the deep venous system; she underwent 5 sessions of transarterial NBCA embolizations in July 1998, October 1998, February 1999, March 1999, and June 2001, with decrease of the shunt to the DAVF, and improvement of the exophthalmos and cognitive function each time. Workup MRI for increasing headaches and cognitive decline in August 2005 showed evidence of increased cortical venous reflux and venous hypertension that warranted another treatment. The DAVF was supplied from bilateral middle meningeal, occipital, posterior meningeal arteries, recurrent meningeal artery from bilateral ophthalmic arteries, and left anterior falcine artery (**Fig. 2A-D**). There was supply from meningeal branches of bilateral posterior cerebral arteries as well (**Fig. 2A, C**). Venous drainage was to the vein of Galen with reflux of contrast to the posterior portion of the superior sagittal sinus and the cortical veins. The most prominent recurrent meningeal artery off the right ophthalmic artery (**Fig. 2A** arrowheads) was embolized with NBCA, followed by transarterial Onyx 18 embolization from two right middle meningeal artery branches. A 5Fr Envoy guiding catheter was selectively placed into the right internal maxillary artery and another 5Fr Envoy guiding catheter was placed into the right common carotid artery for control angiogram. A Marathon microcatheter and Silverspeed 10 microguidewire was employed in the two Onyx embolizations. A total of 4.6 ml Onyx was injected from 2 middle meningeal artery branches, each injection taking 30 minutes. Both microcatheters were retrieved with gentle traction without incident. In November 2006, a second-stage procedure was performed. Two 5Fr Envoy catheters were placed in bilateral common carotid arteries. The right side was used for catheterization of the fistula, and the other was used for interim control angiogram. A right middle meningeal artery feeder was catheterized close to the fistula at the vein of Galen with a Marathon microcatheter and 0.008 Mirage (BALT, Montmorency, France) microguidewire. Total of 3.0 ml Onyx was injected in 41 minutes. The Onyx was able to penetrate the vascular network in the wall of the dilated vein of Galen and refluxed to multiple feeding arteries. Notably, the Onyx also penetrated to the contralateral nidal network in the dural wall of the vein of Galen from the right middle meningeal artery injections. The cast of Onyx almost represents the configuration of the vein of Galen (**Fig. 2E**). The embolization resulted in significant decrease in the arteriovenous shunt, preserving the vein of Galen (**Fig. 2F, G**). The microcatheter was retrieved in 3 seconds with gentle traction. The patient experienced transient severe headache after the first procedure, which was well-controlled with dexamethasone. The patient recovered from the headache and cognitive dysfunction and remains stable. She is currently under observation for signs for neurological decline, at which further intervention will be considered.

## Discussion

Until present, transarterial embolization of DAVF with embolic materials such as NBCA, ethanol, coils, and particles was largely unsatisfactory for extensive lesions due to proximal feeding artery occlusion and subsequent reestablishment of arterial blood supply through numerous collateral vessels[4,10]. Cure may be achieved in selected cases if permanent embolic agents such as NBCA or ethanol can be used effectively and safely. If NBCA can be injected under flow control, transarterial embolization of DVF can be more effective[2,8]. However, Onyx, with its enhanced ability to penetrate, may overcome this shortcoming.

Onyx liquid embolic system is an ethylene-vinyl alcohol copolymer (EVOH) dissolved in DMSO, mixed with tantalum[7]. EVOH precipitates in aqueous condition with dissolution of DMSO providing mechanical occlusion of the vessel. The characteristic feature of Onyx is that it is a non-adhesive material that allows prolonged injection time. In the brain arteriovenous malformation (AVM), this feature enabled the Onyx to penetrate better into an AVM nidus and retrogradely occlude multiple arterial feeders[16].

There have been several reports of transarterial embolization of DAVF using Onyx[1,3,6,9,11,14] as the primary treatment. All reported excellent occlusion of the fistula due to improved penetration of the embolic material as well as lesser arterial catheterizations. In this report, we present successfully treated recurrent DAVFs previously embolized by NBCA using transarterial Onyx injection. Two conclusions may be deduced from our experience. First, repeat treatment of DAVFs previously treated by NBCA is feasible. Incomplete occlusion of the fistulas almost always resulted in recruitment of multiple collateral arteries constituting the dural blood supply, leading to recurrence. In our cases, recurrence resulted in enlargement of another arterial feeder enabling access for retreatment. Second, Onyx may be a more potent agent in transarterial DAVF embolization than NBCA. Although NBCA embolization was effective in reducing the arteriovenous shunts, it was to a lesser extent than that achieved by Onyx. Our cases may be examples of showing the efficiency of Onyx over NBCA. However, further studies are necessary to conclude what the most effective treatment is for DAVFs.

For better penetration of the Onyx into the nidal network and retrograde filling of the multiple feeding arteries, the tip

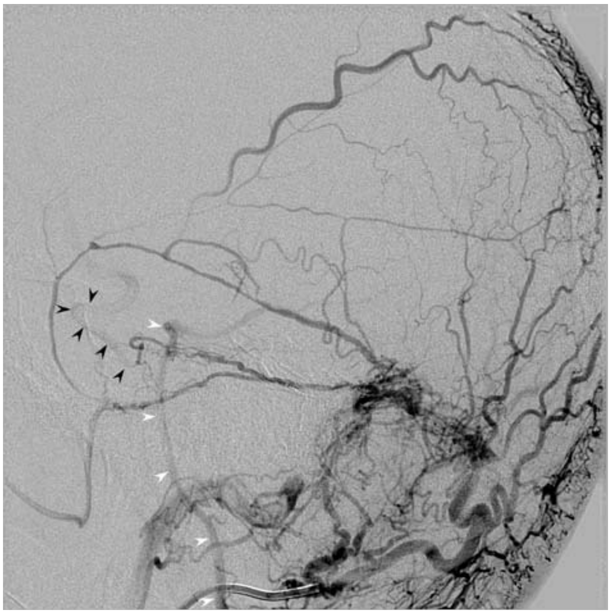


**Fig. 3** Control left occipital artery angiogram in lateral view during left transverse-sigmoid sinus DAVF embolization demonstrates the entire extent of the disease. The nidal network interconnecting multiple arterial feeders is shown from this single arterial injection. Note that the left internal carotid (black arrow heads) and the left vertebro-basilar (white arrow heads) arteries are opacified through the nidal network. This image gives an insight to the potential of transarterial DAVF embolization.

of the microcatheter should be covered with Onyx with a small amount of reflux. This enables to put pressure on the syringe to "push" the Onyx forward and "backfill" the feeding arteries. Nogueira et al. stressed the importance of early plug formation for this purpose[9]. On the other hand, because of the superb penetration of the Onyx, special attention has to be paid not to over-penetrate the Onyx into normal arteries or venous sinus. In Onyx treatment of brain AVM cases, we use two catheters to monitor the whole extent of the AVM during Onyx injection. One catheter is used for guiding a microcatheter and control angiogram, while the other is catheterized to another cerebral circulation system that supplies the AVM for interim control angiograms. The same technique was applied in case 2, which aided us in detecting unfavorable Onyx filling toward normal vessels through anastomosis. In case 1, it was unnecessary to use 2 catheters because the right common carotid artery angiogram documented the entire DAVF.

During Onyx injection of DAVF, the Onyx sequentially filled a complex interconnecting network, analogous to an AVM nidus, before draining into the venous sinus. Arteriovenous shunting of a DAVF may not be a collection of multiple single fistulas opening into a venous sinus. In case 2, the Onyx penetrated the nidal network of the dural covering of the vein of Galen, reaching to the contralateral surface before entering the vein of Galen. The configuration of the Onyx cast almost shows the outline of the vein of Galen. An illustrative example of this is shown in **Fig. 3**. After the majority of the fistula was occluded in a left transverse-sigmoid sinus DAVF with Onyx, a left occipital artery injection opacified the nidal network of the DAVF and retrogradely visualized the entire arterial feeder of the fistula. The injection shows occipital artery branches supplying the dural fistula, retrograde visualization of the nidal network and multiple feeders of middle and posterior meningeal arteries, and internal carotid artery C5 branches. Reflux of contrast through the nidal network reaches as far as the internal carotid and vertebro-basilar arteries. This nidal network was not seen in conventional angiogram and was only observed after closure of the majority of the fistula, thus opening up potential anastomosis. Carlson et al., in their report have indicated to the presence of such network, and we have angiographically demonstrated the existence of the network[3]. These observations that some DAVFs possess a nidal network interconnecting multiple feeders may have important impacts on DAVF treatment. First, with better penetration ability of the Onyx, this type of DAVF may benefit most from transarterial Onyx embolization. Second, this shows the possibility that certain DAVFs can be treated transarterially without venous sinus sacrifice, as experienced in our cases. Third, this may expand the indication for endovascular DAVF treatment in such cases as curative venous sacrifice may not be an option due to absence of venous outflow restrictions, or cortical venous drainage. Forth, this nidal network may be a potential source of recanalization after incomplete transarterial or transvenous embolization.

To determine the exact indication for transarterial Onyx DAVF embolization, and its long-term effectiveness, further experience and study are necessary. For safe injection, anatomical analysis and assessment of the potential anastomosis and the supply to transcranial nerves is mandatory. The present technique of reflux and "plug" formation on the delivery catheter is still not optimal. Advances in delivery catheters with detachable tips, proximal control, or other forms to obtain control in forward delivery of Onyx are forthcoming, which will further add to its safety and reliability.

## Conclusion

Transarterial Onyx embolization was effective in treating recurrent DAVFs previously treated by transarterial NBCA injection. Plug formation at the tip of the microcatheter and double catheter technique was applied in the embolization. With the potential of better penetration of the Onyx and from our observations that in certain DAVFs a nidal network is interconnecting with other feeding arteries, transarterial Onyx embolization may be a more effective treatment for DAVF than transarterial embolization with previously used embolic agents or certain transvenous embolizations. Larger number of cases and longer follow up are required to determine the efficacy and safety of transarterial Onyx embolization of DAVFs.

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