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Over-the-catheter retrieval of a retained microcatheter following Onyx embolization: a technical report

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ABSTRACT

Background Brain arteriovenous malformations are vascular lesions that are increasingly being treated with endovascular embolization. A potential complication with endovascular embolization is microcatheter entrapment within the embolic material. In the present report, a novel technique for the retrieval of microcatheters retained during Onyx embolization of intracranial lesions is described.
Clinical presentation Two patients (one boy and one girl, aged 13 and 15 years, respectively) with arteriovenous malformations (one unruptured, one ruptured; Spetzler—Martin grades 4 and 3) presented for embolization.
Intervention During Onyx 18 embolization of the arteriovenous malformations, Echelon-10 microcatheters became entrapped into the arterial feeders by casts of the Onyx. Initial attempts to remove the microcatheters by traction were unsuccessful. The hubs of the microcatheters were transected and Concentric Medical Outreach distal access catheters were then advanced over the microcatheters and positioned at the proximal aspects of the microcatheter-Onyx plugs. Using the Outreach catheters for countertraction, the Echelon-10 microcatheters were then successfully released from the Onyx plugs under fluoroscopic visualization without significant distortion of the arteries. There were no complications related to the microcatheter extractions.
Conclusions A novel technique, which may be useful in the removal of retained microcatheters during Onyx embolization of Brain arteriovenous malformations, is presented.

INTRODUCTION

Brain intracranial arteriovenous malformations (bAVMs) are vascular malformations may be treated with a variety of different modalities, including microsurgical resection, endovascular embolization, fractionated radiosurgery, or some combination thereof. Complex lesions frequently require the use of combined modalities to improve outcome. The use of Onyx ethylene—vinyl copolymer (eV3 Neurovascular; Irvine, California, USA) as an embolic device for the treatment of AVMs, dural arteriovenous fistulae, and tumors, has expanded rapidly since its introduction.[1–5] Likely due to the 'plug-and-push' technique required for its use, the risk of retained microcatheters during embolization presents a significant challenge for the neurointerventional surgeon.[2 3 6] We describe a novel technique for retrieval of microcatheters retained within Onyx plugs during the embolization of bAVMs.

CLINICAL PRESENTATION

Case 1

A 13-year-old boy presented to our pediatric neurosurgery clinic for evaluation of a large Spetzler—Martin grade IV[7] bilateral thalamic AVM identified on MRI performed to evaluate for visual disturbances and episodes of loss of consciousness when rising rapidly from a recumbent position. A neurological examination revealed no deficits. Diagnostic angiography confirmed a 5.3×4.0×3.7 cm bilateral thalamic AVM with arterial supply from bilateral anterior choroidal and posterior cerebral arteries. There was no evidence of proximal or intranidal aneurysms. Venous drainage was predominantly through innumerable superficial veins. The deep venous system was presumed to be involved but visualization was obscured by the nidus itself.

The patient was scheduled for staged embolization of the AVM with stereotactic radiosurgery of any residual AVM. The first embolization procedure was performed under general anesthesia. Approximately 0.76 ml of Onyx 18 was used to embolize the AVM via the left medial posterior choroidal artery. Approximately 30% of the AVM nidus was embolized. At the completion of the injection, the microcatheter was entrapped within the Onyx plug. Although initial attempts to remove the microcatheter by traction alone failed, use of the coaxial Outback catheter technique allowed successful extraction of the microcatheter. Post-extraction angiography and CT scan revealed no evidence of vascular injury or hemorrhage. The patient was neurologically unchanged following the procedure and remained so at 2-week follow-up. Interestingly, the patient reported no further episodes of visual disturbances or loss of consciousness at follow-up of 6 months.

Case 2

A 15-year-old girl presented to an outside hospital with the acute onset of hemiparesis and aphasia. Imaging revealed acute intraparenchymal and intraventricular hemorrhage originating from a left basal ganglion AVM. The patient demonstrated moderate improvement in her hemiparesis and aphasia over the next 2 weeks. Occlusion of the AVM by embolization alone or combined embolization and stereotactic radiosurgery was planned. At 3 weeks after the hemorrhage occurred, the patient underwent diagnostic angiography and embolization of the left basal ganglion AVM under general anesthesia. A diagnostic cerebral angiogram confirmed an approximately 3.4×2.5×2.5 cm left basal ganglia AVM with arterial supply from multiple ipsilateral lenticulostriate and

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thalamostriate perforators and deep venous drainage via the internal cerebral veins.

Approximately 0.75 ml of Onyx 18 was used to embolize the AVM via a large lenticulostriate-perforating artery arising from the left ICA. As with the first case, the microcatheter was entrapped within the Onyx plug. Removal of the microcatheter by traction alone failed, but use of a coaxial Outback catheter allowed successful extraction. Post-extraction angiography and a CT scan revealed no evidence of vascular injury or hemorrhage. A second vessel was then successfully catheterized and the embolization was completed with an additional 1.0 ml of Onyx 34. The patient was neurologically unchanged following the procedure and remained so at 2-year follow-up. Approximately 95% of the AVM nidus was embolized in total.

TECHNIQUE

Both cases were performed with nearly identical techniques. After diagnostic angiography had been completed, 6 French Northstar Lumax guide catheters (Cook, Inc.; Bloomington, Indiana, USA) were placed into the right vertebral (case 1) and left internal carotid (case 2) arteries. Echelon 10 microcatheters (eV3 Neurovascular) were navigated over Transend Ex 0.014 inch microwires (Boston Scientific; Natick, Massachusetts, USA) into the left lateral posterior choroidal artery (case 1) and left lenticulostriate artery (case 2) arteries feeding the AVMs. Superselective angiography confirmed satisfactory microcatheter positioning in each case.

The arteries were then embolized with Onyx 18 using the "plug-and-push method". Reflux was not allowed to exceed an estimated 3 cm proximal to the microcatheter tip; post-procedure review showed that reflux of 8 mm (case 1) and 25 mm (case 2) had actually occurred. Following embolization, we attempted to retrieve the microcatheters with gentle traction. Despite minimal and typical reflux around the microcatheters, both microcatheters were entrapped within the Onyx casts.

Because surgical resection of the AVMs was not planned in either case, we wanted to avoid permanent microcatheter implantation if possible, although this is well known to be tolerated. We then proceeded to cut the hubs off of the microcatheters. While maintaining visualization of the proximal tip of the guide catheter and the entire exposed length of the microcatheter under direct fluoroscopy, a 4.3 Fr Concentric Outreach distal access catheter (DAC) (Concentric Medical, Inc.; Mountain View, California, USA) was advanced over the microcatheters and through the guide catheters in a coaxial fashion. Continuous fluoroscopic visualization of the DAC as it is advanced is critical ensure that there was no buckling of the distal microcatheter segments during positioning of the Outreach catheters. The distal tips of the concentric catheters were positioned adjacent to the proximal Onyx casts. Using the Concentric catheters to brace against the Onyx casts, the Echelon microcatheters were successfully removed using relatively gentle traction. There was minimal distortion of the vascular pedicles during this extraction of the microcatheters. Follow-up angiograms and CT scans did not demonstrate any evidence of vessel or AVM perforation or dissection. There were no complications related to this portion of the procedure.

DISCUSSION

Catheter dimensions

In this work, we used the following: Concentric Outreach Distal Access catheter: outer 4.3 Fr/0.056 inch, inner 3.3 Fr/0.044 inch; Echelon 10 Microcatheter: outer 2.1 Fr, inner 1.7 Fr.

Onyx has become an indispensable tool in the endovascular treatment of intracranial AVMs. As compared to Trufill NBCA (Codman Neurovascular; Raynham, Massachusetts, USA), the risk of microcatheter entrapment and subsequent microcatheter retention or complications relating to excessive traction during attempted removal is higher. Microcatheter retention rates range from 0% to 8%.[2 8–11] This fact is acknowledged by the manufacturer and is explicitly mentioned in the Onyx instructions for use. Microcatheters with detachable tips are not yet available in the USA. In the case of an entrapped microcatheter, simply increasing traction until the catheter is freed is inadvisable and may result in devastating consequences such as catheter separation, vessel rupture, vasospasm, or stroke. If surgical resection is planned, some authors have reported successful microcatheter removal at the time of surgery.[12]

In our series, we successfully employed the 'push–pull' technique to extract an entrapped microcatheter. The 'push–pull' approach is accomplished by advancing a larger caliber support catheter over the entrapped microcatheter allowing the transmission a counterbalancing 'push' force against the Onyx mass allowing for a greater pulling force on the microcatheter with minimal displacement of the delicate vasculature in and surrounding the targeted vascular malformation. Occasionally, microcatheters may be left intravascularly indefinitely if no options for endovascular or open removal are available. Retained microcatheter fragments are intra-arterial foreign bodies and may represent an ongoing risk for thromboembolic complications.[13] Many authors advise maintaining the patient on antiplatelet therapy indefinitely if a microcatheter is left intravascularly, however consensus for the management of a retained microcatheter fragment does not exist among experts. The risk a retained microcatheter poses to a patient in terms of stroke, embolic phenomena or inducing stenosis is unknown. Over time, the catheter does appear to incorporate into the vessel wall, however this effect may not be uniform throughout the arterial system. Peripheral vascular complications have been reported with retained microcatheters.[13]

Techniques for removal of entrapped microcatheters have been reported by several authors. Santillan *et al* describe the inflation of a balloon adjacent to the Onyx mass for stabilization.[14] Kelly *et al* reported the successful use of a monorail snare for the retrieval of a stuck microcatheter, although it is important to note that the authors cautioned against the use of this technique for use with AVMs,[6] presumably due to the risk of excessive traction on the friable AVM vessels. While the risk of thromboembolic complications due to a chronically retained microcatheter is unknown, it is important to at least consider leaving the microcatheter in place and mitigating this risk with antiplatelet medications, as the maneuvers described here may expose the patient to more risk yet.

Continuous fluoroscopic visualization of the DAC as it is advanced over the microcatheter is essential to avoid buckling of the microcatheter. We found that the additional rigidity afforded due to the presence of Onyx within the microcatheter minimizes buckling. Gentle twisting of the DAC as it advanced appears to mitigate the buckling of the microcatheter. Consideration was given to securing an exchange length microwire to the proximal, cut end of the microcatheter however this was not necessary in these cases. Practitioners who find that they need this additional step to allow positioning of the DAC are cautioned not to advance the microwire into the microcatheter as this may result in additional Onyx extrusion at the distal tip in an uncontrolled fashion. We have successfully used a small drop of NBCA in other circumstances to secure an exchange

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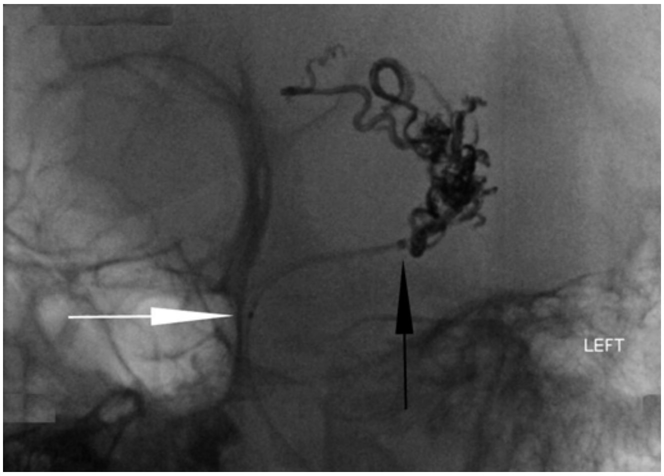

Figure 1 Unsubtracted left anterior oblique (LAO) projection depicting the distal marker of the distal access catheter (DAC) (gray arrow) abutting the Onyx cast in patient 1. The proximal marker of the microcatheter (white arrow) is seen as well. Applying traction to the microcatheter while pushing the DAC forward allowed removal of the microcatheter, which was entrapped in the Onyx mass.

length microwire to the proximal end of an entrapped microcatheter in the past (figures 1 and 2).

As practitioners, our goal should be, of course, to avoid entrapping a microcatheter within the Onyx mass to begin with. General guidelines for how much reflux can be tolerated around the catheter tip are impossible to deliniate. For example, a much greater degree of reflux can be tolerated in the external carotid circulation as these vessels are tethered to more robust, less delicate structures. Some degree of reflux is expected in nearly all cases and, if this proximal 'kernel' is allowed to solidify, can allow for a deeper penetration into the nidus or tumor vasculature. In general, the further distally the embolization is undertaken, the less reflux can be tolerated. Methodical injection allowing ample time for proximal solidification if reflux is noted, coupled with high magnification, biplanar fluoroscopic visualization will give the neurointerventionalist the best chance of accurately assessing the degree of reflux and distal penetration

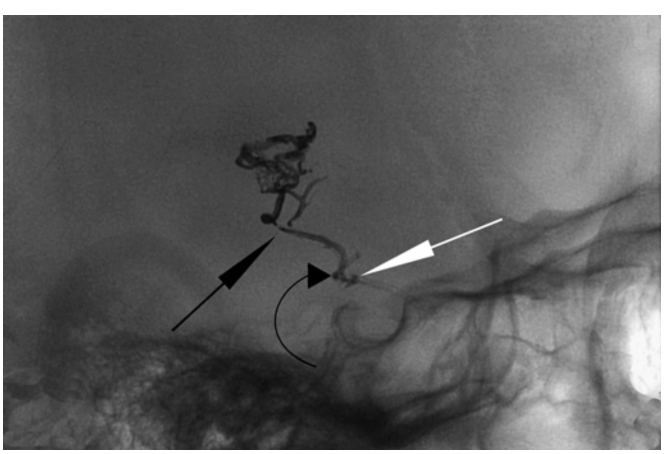

Figure 2 The distal (black arrow) and the proximal (curved arrow) markers of the microcatheter are seen within the Onyx cast in patient 2. The tip of the distal access catheter (DAC) (white arrow) has been advanced to abut the proximal edge of the Onyx cast. The positioning of the DAC allowed for stabilization of the feeding vessel and Onyx cast while traction was applied to the microcatheter.

to hopefully avoid excessive reflux and subsequent catheter entrapment. Additional in vitro or possibly animal studies examining the magnitude of the forces involved in extracting an encased microcatheter and the mechanical advantage afforded by this technique may be helpful in determining when this technique may be best employed.

Our subjective impression is that the coaxial catheter system focuses the applied forces directly to the point of microcatheter adhesion, thereby reducing the forces applied elsewhere within the vessels. This permitted successful microcatheter extractions without apparent vascular injury as may occur when traction alone is employed.

Conclusions

The coaxial catheter 'push–pull' retrieval method of extricating retained microcatheters following 'plug-and-push' Onyx embolization of AVMs is a novel technique designed to minimize complications associated with use of this embolic device. Our new technique may become an important part of the neurointerventional armamentarium. In our limited experience, it appears to be a safe and effective means of reducing the incidence of retained catheters during these procedures. Of course, further studies and more experience are required to conclusively demonstrate the efficacy of this technique.

Competing interests None. The authors have not received any financial assistance in the preparation of this manuscript.

Patient consent Obtained.

Ethics approval Ethics approval was provided by UCSD.

Contributors CBN and MSP, manuscript preparation; RSP and CWK, concept, manuscript critical review; MLL and JDB, manuscript critical review.

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