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Technical Note

A method for complete angiographic obliteration of a brain arteriovenous malformation in a single session through a single pedicle

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ABSTRACT

Historically, the endovascular treatment of arteriovenous malformations (AVM) has largely been relegated to an adjunctive role to open surgical and radiosurgical methods. In this article, we describe a novel endovascular approach to the treatment of brain AVM using Onyx (ev3 Endovascular, Plymouth, MN, USA), which may allow for a complete angiographic obliteration in a single treatment session. Twelve patients underwent Onyx embolization of an AVM using a novel "reverse plug and push" technique in which a plug is formed around the treatment catheter prior to injecting Onyx into the AVM. The plug mitigates the risk of backflow and catheter entrapment, thereby allowing the user to inject higher volumes of Onyx at higher injection rates. Patient demographics, AVM characteristics, and treatment details were reviewed. Using the "reverse plug then push" technique, an average of 8.8 mL of Onyx was injected into the AVM in a single session. In every case, the microcatheter was removed easily with minimal traction pressure. Complete angiographic obliteration was achieved in 83% of patients after a single treatment. Morbidity and mortality were 8% each. The "reverse plug then push" technique allows for a more rapid injection of Onyx due to the formation of a well-controlled plug prior to treatment, mitigating the risk of catheter entrapment by Onyx reflux. With further refinement, this technique may present a viable curative option for treatment of select brain AVM.

1. Introduction

After the US Food and Drug Administration approved Onyx (ev3 Endovascular, Plymouth, MN, USA) in 2005 for the preoperative embolization of brain arteriovenous malformations (AVM), it soon became clear that some brain AVM could be cured with this material. Not only is Onyx non-adhesive, but it is easier to handle, is less inflammatory, and has a longer working time than n-butyl cyanoacrylate (nBCA) [1]. Although it is non-adhesive, the cohesive nature of Onyx can cause functional entrapment of the microcatheter during injection, increasing the risk of complications related to removing the catheter and decreasing the degree of nidal penetration that can safely be achieved. The concern of entrapment has limited the ability to provide curative embolization of brain AVM using Onyx. The recent literature reports curative embolization rates ranging from 10 to 55% using Onyx [2–10].

This paper describes an endovascular technique for Onyx embolization of brain AVM, termed the "reverse plug then push" technique, which entails the retrograde formation of a well-controlled plug around the delivery catheter prior to pushing Onyx forward into the AVM. This technique is to be distinguished from the traditional plug then push technique whereby a plug is created ahead of the catheter during forward injection of Onyx, which can lead to uncontrolled reflux around the microcatheter tip. The "reverse plug then push" technique helps prevent unwanted reflux around the treatment catheter, reducing the concern for catheter entrapment. Since the reflux around the catheter tip is greatly reduced, better penetration of the AVM nidus is possible, increasing the likelihood of angiographic obliteration. In this paper, we describe the technique and subsequent results in 12 patients treated with the "reverse plug then push" technique with intent to cure the AVM.

2. Materials and methods

2.1. Study design

Under the approval of our Institutional Review Board, we performed a retrospective chart review identifying 12 patients who

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underwent brain AVM embolization with curative intent using a "reverse plug then push" technique with Onyx. Patient demographics, radiographic records, and treatment reports were independently reviewed by a member of the research team who was not part of the treatment team.

2.2. Procedure

All procedures were performed under general anesthesia by a single interventional neuroradiologist (A.J.E.). A 6 French guiding catheter was utilized in all cases to allow for either a single or two catheter technique. In patients with a small feeding pedicle or if the site for embolization was relatively distal, a single catheter was employed. In patients with a large feeding pedicle or with relatively easy proximal access, a two-microcatheter technique was attempted. In both types, we performed a "reverse plug then push" technique, as described below.

2.2.1. Single catheter technique

After advancing the microcatheter into the target pedicle, a tiny amount (0.01 ml) of Onyx 34 is pushed through the catheter by rapidly pressurizing then depressurizing the syringe ensuring only a small amount of Onyx rapidly exits the catheter and remains near the catheter tip without flowing into the AVM (Fig. 1a). This process is repeated multiple times at 15–60 second intervals until a very short plug forms at the catheter tip, arresting blood flow through the vessel. Once this small plug is formed, it is possible purposely to reflux the Onyx 34 retrograde around the catheter, forming a controlled 1–2 cm plug behind the catheter tip. Importantly, care is taken to leave the vessel in front of the catheter free of Onyx. This stage of the procedure requires 15–30 minutes.

2.2.2. Two-catheter technique

Two microcatheters are placed in a single guiding catheter. First, the "treatment" microcatheter is advanced distally in the treatment pedicle to the interface with the AVM nidus. The "plug" microcatheter is advanced to a position approximately 15 mm upstream from the treatment microcatheter (Fig. 1b). In every case the treatment microcatheter is a Marathon, and the plug catheter is an Echelon 10 (both ev3 Endovascular). Both catheters are Onyx compatible and fit together through a 6 French guiding catheter. Onyx is then slowly injected under fluoroscopy through the plug microcatheter until a 1–2 cm plug of Onyx forms around the entire circumference of the treatment catheter. Plug formation typically takes 20 minutes or less, after which the plug microcatheter is removed.

2.2.3. Onyx injection

Once the plug is formed, Onyx 18 can be injected as rapidly as 1 cc every 30 to 60 seconds with little risk of reflux (Fig. 1c and d). Two factors encourage the forward movement of the Onyx. First, rather than pressurizing the syringe rapidly, it is slowly

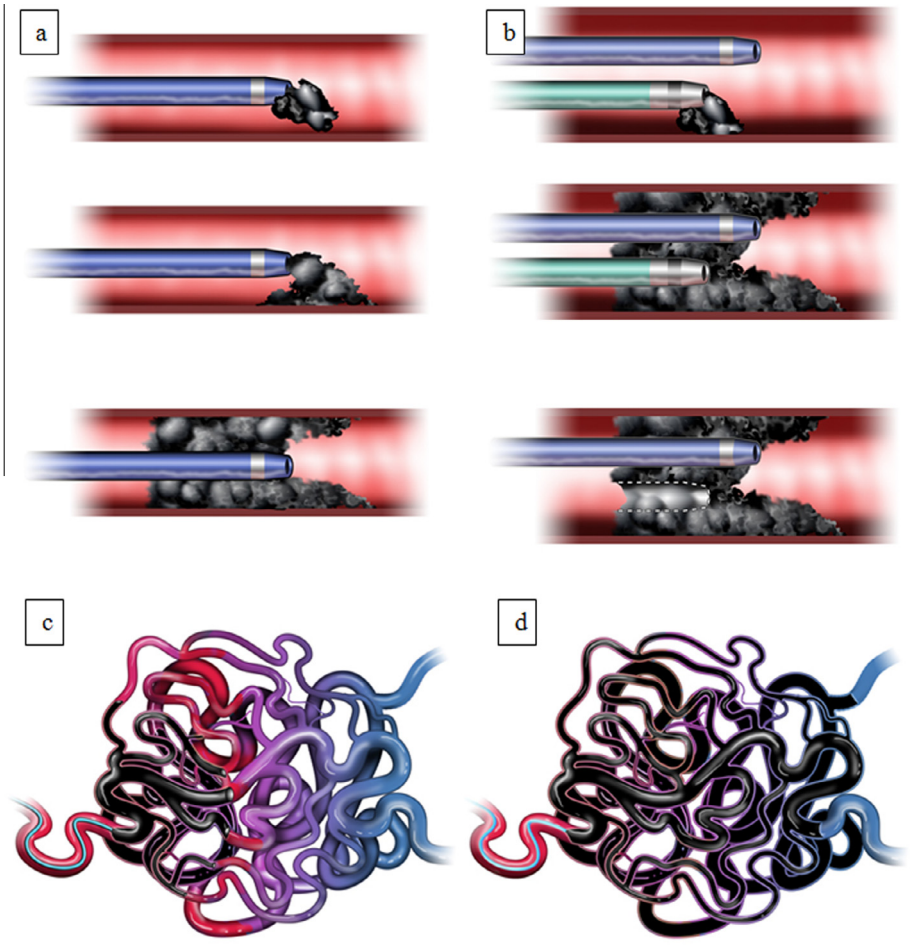

Fig. 1. With the single catheter technique (a), the plug is slowly formed through repeated short pulsed injections during which Onyx (ev3 Endovascular, Plymouth, MN, USA) is intentionally allowed to reflux around the microcatheter tip until a 1–2 cm plug is formed. With the two catheter technique (b), the more proximal "plug" microcatheter is used to slowly build a 1–2 cm cast around the tip of the distal "treatment" microcatheter. The "plug" microcatheter is then pulled prior to treatment. Onyx can then be injected rapidly at up to 1 cc every 30 to 60 seconds (c, black area) until all visible shunting has stopped and the proximal draining veins are casted (d, black area).