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The "Crater" Arteriotomy: A Technique Aiding Precise Intimal Apposition in End-to-side Microvascular Anastomosis

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Summary: End-to-side arterial anastomoses require a high level of technical competency. The main challenge to a successfully patent anastomosis is intimal interposition during the standardized microvascular suturing. Technical errors during arteriotomy pose a significant challenge for the microsurgical technique, making the end-to-side anastomosis prone to failure. We describe a basic yet fundamental method of performing an arteriotomy, the "crater" technique, which facilitates good visualization of all vessel layers before placement of microsurgical sutures. Using curved microsurgical scissors, the adventitia layer is dissected off the outer surface of the side vessel, a V-shaped cut is then made obliquely at a 30–45 degrees angle to the longitudinal axis of the vessel, and a full thickness oblique cut is made along an elliptical circumference, as the curved scissors enable the creation of a slope-like crater. This concept ensures the intimal layer is adequately exposed through the complete circumference of the arteriotomy rim, while enabling a variable increase in the arterial wall hypotenuse-width circumference. When performed in a standardized manner, the crater arteriotomy can minimize the risk of endothelial misalignment and further technical errors during suturing, thus minimizing the risk of anastomotic failure. *(Plast Reconstr Surg Glob Open 2020;8:e3014; doi: 10.1097/GOX.0000000000003014; Published online 28 October 2020.)*

INTRODUCTION

End-to-side (ETS) microvascular anastomoses have been reported to be equally successful to "end-to-end" anastomoses, with the former often being preferred in cases of vessel size discrepancy.[1] Technical competency has been shown to be paramount in achieving patent vessels and producing a successful outcome, following a microvascular anastomosis procedure.[2] One of the most technically challenging steps is vessel interposition in suturing, during which unintended misalignment of the intima can cause failure of the anastomosis.[3]

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Such failures presumably result from intimal hyperplasia at the suture line, impacting blood flow and causing turbulent currents. It is widely accepted that creating a smooth opening in the arterial wall is challenging and time-consuming[4]; however, it is imperative in preventing intimal injury. Studies in the literature report that direct visualization of the intimal surface during microsuture placement can indeed reduce the risk of intimal dislodgement and sub-intimal dissection, consequently minimizing the occurrence of anastomoses failures.[5]

There are many different micro-arteriotomy techniques described, which can be broken down into 3 broad categories: (1) simple slit arteriotomies, creating a longitudinal or transverse cut in the vessel wall using a knife,[4,6] (2) "inside-out" arteriotomies performed with a "micropunch" to create a clean elliptical arteriotomy, as described by Hallock et al in an experimental study in the living rats,[4,7] (3) excision arteriotomies that involve excising from "outside-in" and for which several techniques have been described, such as circular arteriotomy.[4] In this article, we describe the "crater" technique, which is a type of "excision arteriotomy."

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THE TECHNIQUE

Using curved microsurgical scissors, the adventitia layer is dissected off the outer surface of the side vessel to be used for the ETS anastomosis. This creates a "clean" area, which is slightly larger than the end-vessel diameter, ensuring that the adventitial strands do not interfere with the arteriotomy rim and ultimately the anastomosis.

Using microsurgical forceps (5s), the external 30%–50% of the vessel diameter is gripped transversely, tenting the vessel upwards. A V-shaped cut is then made obliquely, at about a 30–45 degree angle to the longitudinal axis of the vessel, using adventitia scissors (Fig. 1A). Following that, a full thickness cut is made into that 30%–50% of the vessel external diameter, until blood is seen to extravasate, indicating that the intimal layer has been breached.

To make space for the subsequent cut, the vessel needs to be taut enough. To achieve this, the tip of the V-shaped cut in the arterial wall is gripped and gently pulled at 45 degrees to the vessel in the longitudinal direction, while rotating the microsurgical forceps (5s) 90 degrees. Finally, the scissors are rotated so that their convex side is parallel to the vessel and a cut is made at each side of the "V," at a 30–45-degree angle (Fig. 1B, C). The 2 cuts should eventually meet, creating a bi-convex/oval hole in the vessel wall (Fig. 1D).

The curve of the adventitia scissors helps form this elliptical-shaped slope-like crater, ensuring the intimal layer is adequately exposed through the complete circumference of the arteriotomy rim (Fig. 2). (**See Video [online]**, which displays the crater arteriotomy for ETS microvascular anastomosis.)

DISCUSSION

Alternative micro-arteriotomy techniques for ETS microvascular anastomosis have been previously described: transverse or longitudinal slit arteriotomies without defect, excision arteriotomies with traction suture in triangular or diamond shape, or even an excision arteriotomy with a vascular micropunch. A noteworthy advantage of the excision versus slit techniques is that the former facilitate the placement of sutures by creating a broad aperture, an advanced microsurgical technique that requires experience and expertise.[4,8] However, most techniques, being operator-dependent, suggest that the end result can vary from surgeon to surgeon. Particularly when performed by less-experienced microsurgeons, the risk of erroneous vessel defect may prove challenging.[4] The micro-arteriotomy using curved adventitia scissors has been described as easy, reproducible, and effective technique, with a resulting uniform width and clear-cut vessel wall edges. The crater concept enhances the excisional micro-arteriotomy with curved adventitia micro-scissors, by allowing wall cutting from inside out, preventing delamination in cases of atherosclerosis, and further adjusting the ratio between

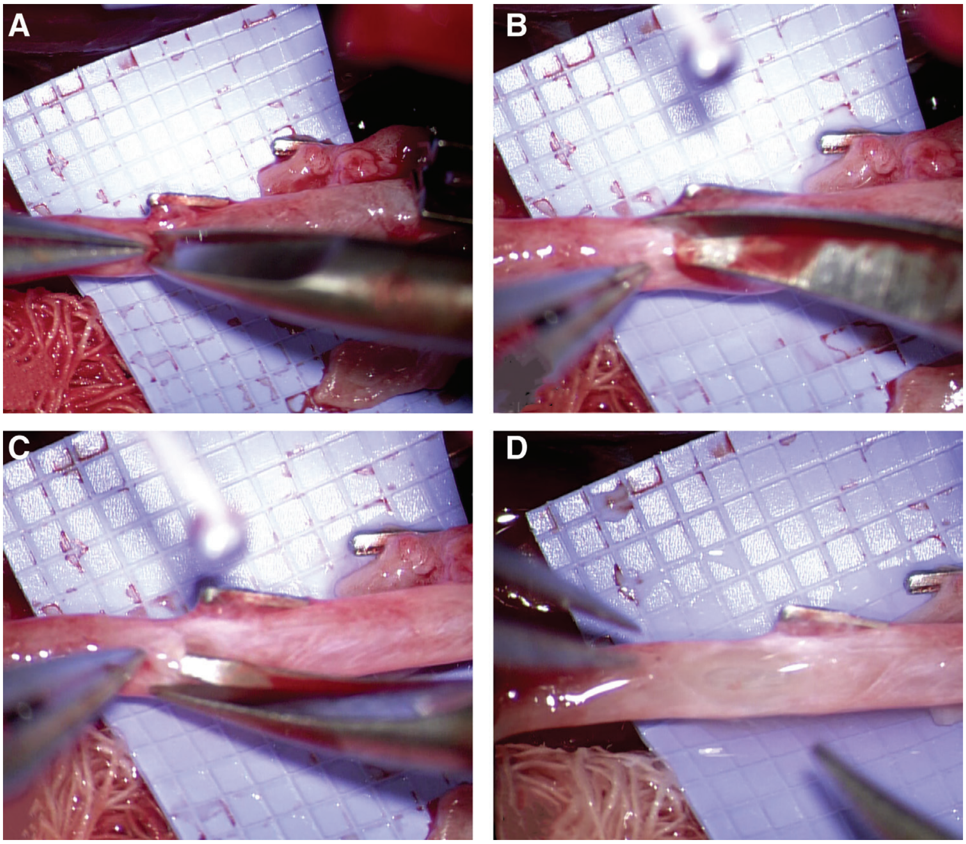

Fig. 1. A step-by-step representation of the crater arteriotomy technique.

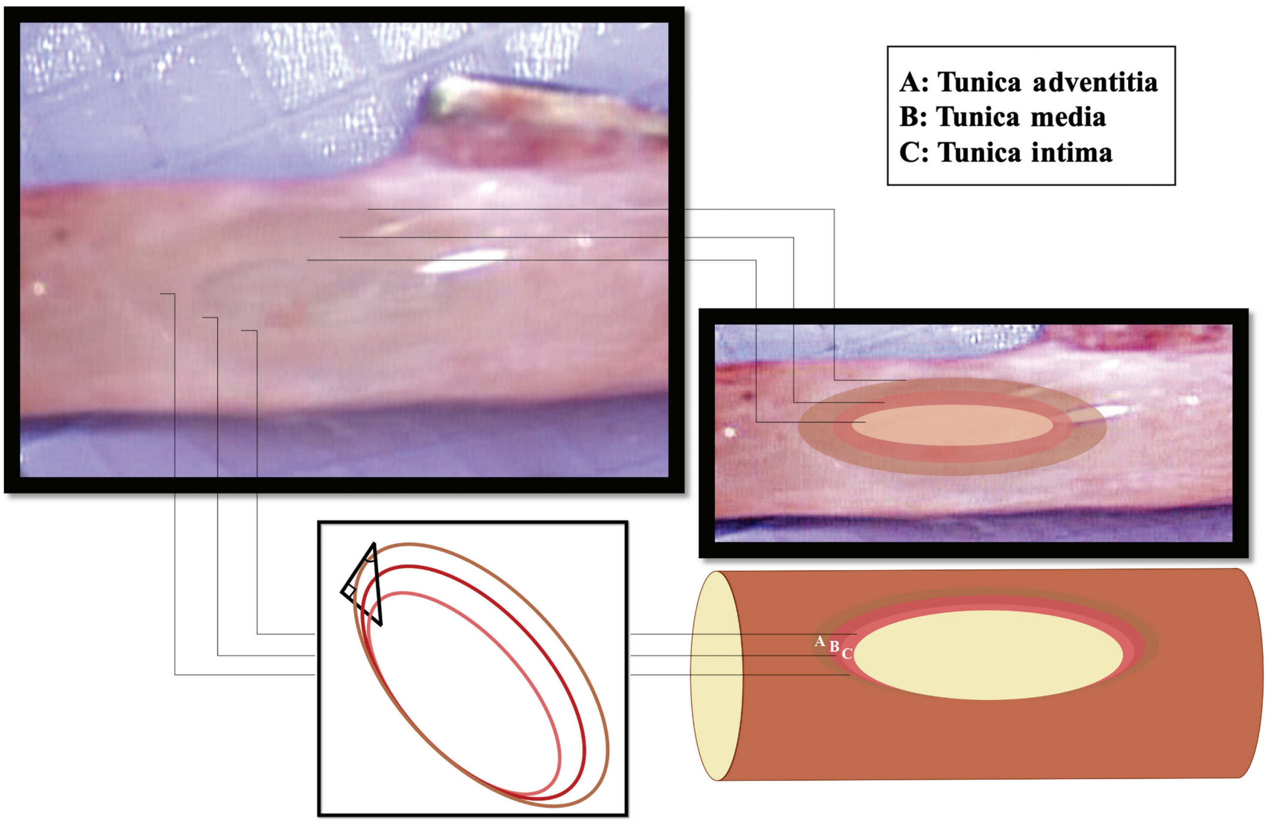

Fig. 2. Elliptical crater arteriotomy. A, Tunica adventitia; B, tunica media; C, tunica intima.

arteriotomy aperture and end vessel, with carefully tailored oblique cuts to increase the length of the hypotenuse, as demonstrated in Figure 2.[4]

The vessel wall configuration after a micro-arteriotomy may pose technical challenges when sutured by an inexperienced microsurgeon or when ETS is not routinely performed. We therefore believe that precise handling of the vessel, oblique cutting with curved scissors to increase or decrease the arterial wall hypotenuse-width circumference, and a crater layer exposure of the media and intima, allows easier and more accurate interposition during microsuturing.

Onoda et al[3] reported that the main cause of failure in arterial anastomosis is endothelial layer misalignment. The crater arteriotomy technique ensures that all layers of the vessel wall are adequately visualized, even without the help of an assistant, and enables accurate intimal closure with each suture "bite," with the "side" vessel intima protruding into the arteriotomy rim and then overlapping with the intimal layer of the "end" vessel (Fig. 2). We believe that this oblique intimal and media overlap allows optimal intimal alignment while suturing, which can ensure faster and uncomplicated neo-intima regeneration and vessel wall healing.[9] Nevertheless, evidence regarding healing of the total circumference of the intimal suture line remains questionable due to the inability to visualize the interior of the anastomosis, once the free tissue has been transferred and connected intraoperatively. When the side vessel media is relatively thick, the end vessel can be bevelled into a truncated cone, so that the media thicknesses of end and side match. The step-by-step nature of the micro-arteriotomy using adventitia curved scissors, allows refinements of the crater formed. This can be achieved through adjusting the obliqueness of the arterial wall cut, allowing subsequent a variable increase in arterial wall hypotenuse-width circumference and opposing medias, while overlapping and sealing the anastomosis suture line with the intima layer.[10]

The crater arteriotomy technique provides a succinct step-by-step guide, on the precise placement of sutures, enabling a consistent and adequate intimal exposure, thus achieving successful alignment when performing ETS anastomosis.

CONCLUSIONS

We describe a simple, step-by-step guide to a consistent and reliable technique, the crater arteriotomy. This technique aims to facilitate optimal visualization of the vessel walls, and assists in reducing technical errors caused by misalignment and an intimal surface deformity, which lead to anastomotic thrombosis.

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