Successful CTO Recanalization

A case-based review of new tools and techniques.

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In all of endovascular medicine, the most challenging subset of lesions to treat is that of the chronic total occlusions (CTOs) we face on a regular basis. The difficulty is rarely linked to traversing the length of disease, but rather to the safe re-entry into the target lumen distally. Although the subintimal technique has been with us for many years now, the increasingly complex nature of the lesions that present to the interventional suite have rendered this technique inefficient and unable to succeed in an increasing number of cases. Thankfully, numerous new approaches to CTOs now exist. This article seeks to shed light on some of the more novel approaches to CTOs by means of a case-based approach.

The subintimal approach to occlusions utilizes hydrophilic wires and catheters to glide past the lesion and safely into the lumen distally. Often, the first hurdle that the interventionist must overcome is an understanding of which lesion can be crossed; with certain CTOs, the attempt to cross is a fruitless venture. Ideally, the occlusion should have a lead-in stump that allows the subintimal cleavage plane to safely initiate. Distally, the key factor to subintimal success is linked to having a relatively healthy, noncalcified target for re-entry. Lesions with dense calcification, diffuse disease of the distal target, and small-caliber lumens are not ideally approached via the subintimal technique. In such cases, access to a re-entry tool or consideration of a more novel approach may prove helpful.

CASE 1

A 67-year-old man with a 100-pack-year smoking history who initially presented with left greater-than-right-lower-extremity claudication (Figure 1). His symptoms had been present for a few years and involved his hip and buttocks, as well as his calves. Baseline angiography revealed that he had a moderate-to-severe stenosis of the right common iliac artery and total occlusion of the left common iliac artery. Despite the fact that the aorta poses as a large-diameter, receptive lumen for a subintimal attempt at recanalization, the reality is that a hydrophilic wire will frequently stay subintimal with a retrograde approach. This situation produces an uncomfortable circumstance wherein one is tempted to keep pushing a plane of dissection into the aorta in hopes of eventually re-entering the true lumen. In such cases, a re-entry tool such as the Pioneer catheter (Medtronic, Inc., Santa Rosa, CA) can be extremely useful. This catheter utilizes an incorporated solid-state IVUS probe to visualize the target lumen and to direct a nitinol, hypotube needle safely into the true lumen of the aorta, without needless lengthy dissection planes.

Several points are worthy of mention relative to this case

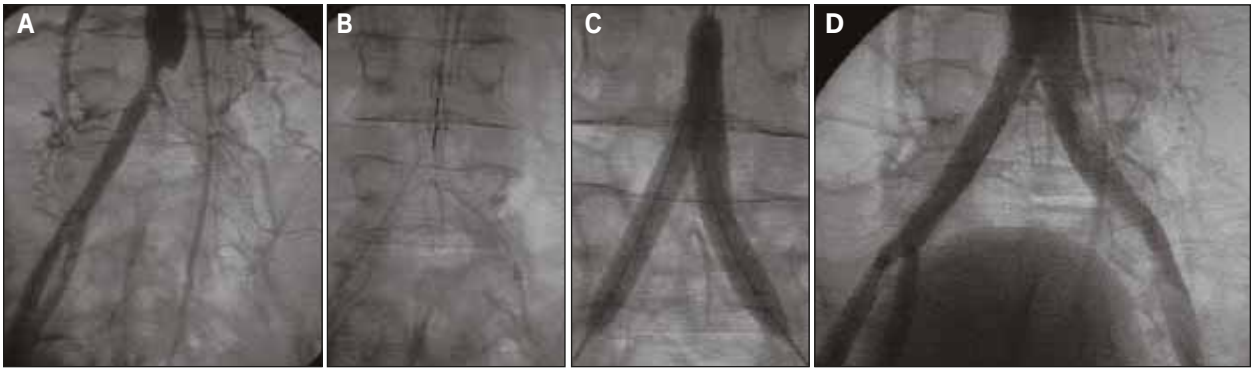

Figure 1. Baseline angiogram showing left common iliac occlusion (A); re-entry with a Pioneer catheter (B); kissing stent technique with balloon-expandable stents (C); final angiogram (D).

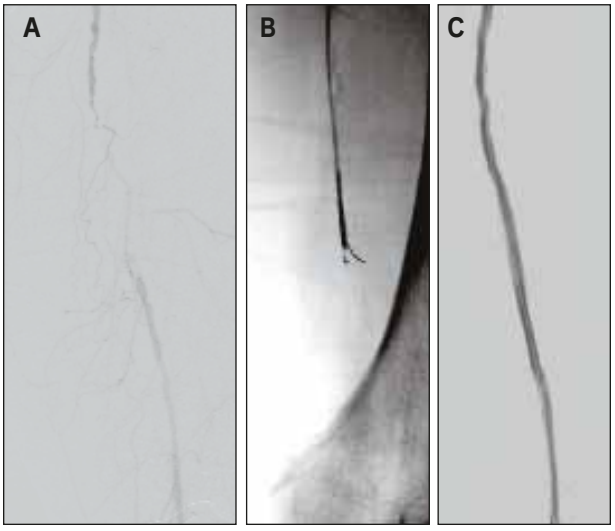

Figure 2. Baseline angiogram demonstrates occlusion of femoropopliteal junction (A); use of an Outback re-entry catheter (B); and final angiogram after self-expanding nitinol stent placement (C).

and this approach. First, this author strongly believes that true lumen re-entry in the aortoiliac region should be performed with an IVUS-based device because errant needle punctures may have profound consequences, such as retroperitoneal bleeding. One should have immediate access to a covered stent prior to initiating a procedure involving an occluded intrapelvic artery. Accurate re-entry utilizes a real-time IVUS image of the target lumen, which is positioned at the 12-o'clock position on the screen before firing the incorporated hypotube, nitinol needle. These devices operate on a .014-inch platform, and it is ideal to convert back to a .035-inch platform for most of these interventions. We routinely dilate the re-entry site with a 4-mm coronary balloon and then make an exchange for a .035-inch wire using an angled Glide catheter (Terumo Medical Corporation, Somerset, NJ). The remainder of the case, as in this situation, lies in merely executing a properly sized kissing balloon dilation with balloon-expandable stents.

CASE 2

A 65-year-old diabetic patient man with Rutherford Category 3 claudication of the left lower extremity was found to have an occluded femoropopliteal junction and moderate distal trifurcation disease (Figure 2). Although the lesion itself was not particularly lengthy, there are unfavorable characteristics that ultimately led to a failed subintimal approach. One of the challenges was that the origin of the occlusion was located adjacent to the take-off of a well-developed collateral branch. Perhaps more importantly, the distal target vessel was relatively small in caliber and undoubtedly circumferentially diseased with plaque. Because a hydrophilic wire would not re-enter the popliteal artery distally, we made an exchange for a .014-inch wire and proceeded to use an Outback catheter (Cordis Corporation, a Johnson & Johnson company, Miami, FL). This re-entry tool uses fluoroscopy to guide optimal device positioning, and orthogonal views are ideally needed to expedite successful wire placement. The re-entry site is predilated as discussed previously, and the finale of the procedure simply involves the placement of self-expanding nitinol stents and appropriate postdilatation.

CASE 3

A 70-year-old diabetic man with multiple medical problems presented with dense claudication of the left lower extremity that prevented him from walking more than a maximum of one block at any given time. Not surprisingly, he was found to have an occluded distal popliteal artery and compromised trifurcation runoff (Figure 3). Such cases are very difficult to address because the distal target lumen is often not obvious. In addition, the aforementioned re-entry tools are far too bulky for reliable use below the knee. As a result, we have been left with limited subintimal options for intervention at these locations. We are currently evaluating a new CTO tool, the Crosser (FlowCardia, Sunnyvale, CA), which may be ideally suited for the more challenging, smaller-vessel lesions. This patient was treated under the auspices of the PATRIOT Trial, wherein we used the high-frequency ultrasound properties of the device to quickly and easily cross what would otherwise have been a very difficult and low-yield intervention. Once across the occlusion, we were able to proceed with intervention; at this location, we prefer a nonstent solution if at all possible. We therefore performed laser atherectomy with a 2.5-mm

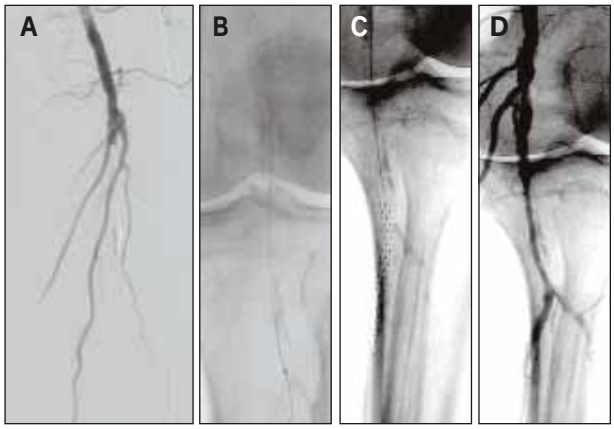

Figure 3. Baseline angiogram showing occluded distal popliteal artery (A); use of a high-frequency ultrasound Crosser catheter (B); post-laser and cryoplasty (C); and final angiographic result (D).

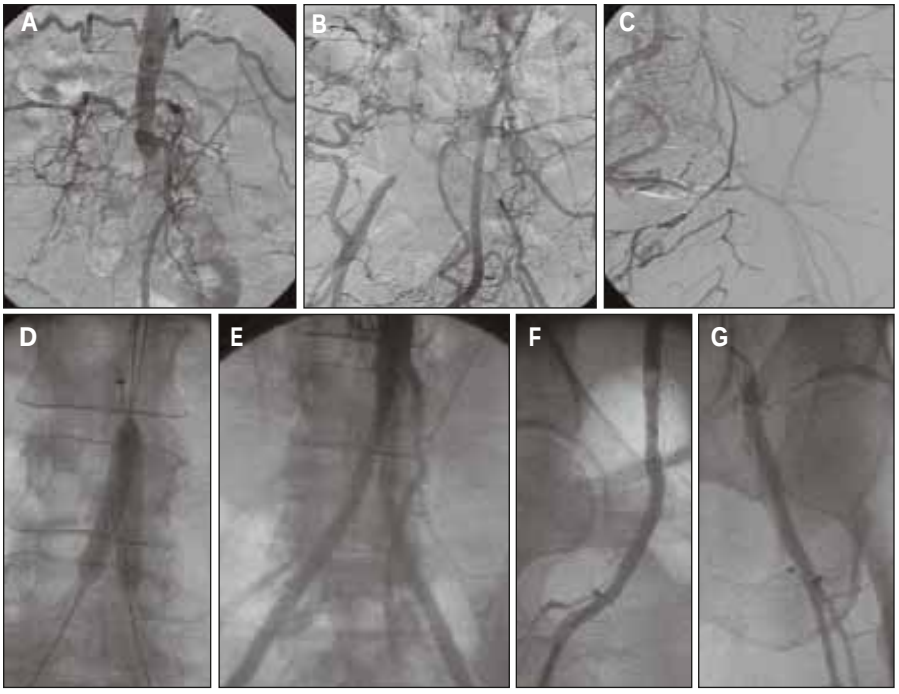

Figure 4. Baseline angiogram from a left brachial cutdown shows occlusion of the abdominal aorta at the level of the IMA (A). Late-phase arterial angiograms (B,C) demonstrate distal targets of reconstitution. Kissing balloon angioplasty of occluded iliac segments (D); final angiogram after bilateral endograft placement (E); distal angiograms (F,G) of the final flow into the profundae bilaterally.

Extreme catheter (Spectranetics Corporation, Colorado Springs, CO), followed by cryoplasty with a 4-mm X 60-mm PolarCath (Boston Scientific Corporation, Natick, MA). The acute result was quite acceptable, and there was complete resolution of left leg symptoms at midterm follow-up.

CASE 4

A 60-year-old woman with a heavy remote smoking history presented with severe bilateral lower-extremity claudication, rest pain, and ischemic ulceration of her feet (Figure 4). She had had two major anesthesia complications during previous nonvascular surgery and was not interested in a surgical option. Angiography was performed and revealed occlusion of the midabdominal aorta at the level of the inferior mesenteric artery extending to the common femoral arteries bilaterally. To make matters worse, both superficial femoral arteries were also found to be completely occluded, with reasonable distal runoff. After much consultation, we agreed to attempt aortoiliac reconstruction via an endovascular approach. Care was taken to identify the segment at which the vessels reconstituted distally and access was safely achieved. We then proceeded to pass a Glidewire (Terumo Medical Corporation) and a Quick Cross catheter (Spectranetics Corporation) in retrograde subintimal fashion. The right and left iliac arteries were crossed without difficulty, but true lumen reentry was elusive.

Given the location, we again chose to use a Pioneer catheter, which succeeded in gaining access to the aorta. A catheter placed from a third access site in the left brachial artery was useful in monitoring the procedure. Given the nature of the lesions, their length, and the risk of vessel trauma with excessive dilation, we chose to place Viabahn endografts (Gore & Associates, Flagstaff, AZ) at this location. The final result was excellent and succeeded in restoring unperturbed flow into the profunda femoris bilaterally. The patient has been pain free for more than 1 year.

CASE 5

A 79-year-old vasculopath presented with disabling right-leg claudication (Figure 5). She had undergone venous femoropopliteal bypass grafting 14 years earlier, but no longer had flow through the graft as determined by ultrasound. Her baseline angiograms revealed stump occlusion of the right superficial femoral artery (SFA), reconstitution of the proximal popliteal artery via collaterals, a hint of the prior distal attachment of the graft, and two-vessel runoff. Our intended endovascular strategy was to attempt to reclaim the chronically occluded native vessel with a subintimal approach. As fate would have it, the buckled tip of the Glidewire diverted into the chronically occluded bypass graft and relatively easily traversed its length. There was moderate resistance to wire passage at the distal anastomosis, presumably related to fibrotic neointimal buildup, but the wire entered the true lumen of the right popliteal artery with relative ease. Regardless of the age of the graft occlusion, we were reasonably certain that a component of the contents that filled the graft was likely to be thrombotic in character. It was believed that overnight thrombolysis in this elderly woman would potentially be problematic and might have a low likelihood of succeeding given the age of the graft failure. Alternatively, we proceeded to debulk the graft with a 2.5-mm Turbo Laser catheter (Spectranetics Corporation). We then proceeded to line the entire length of the old graft

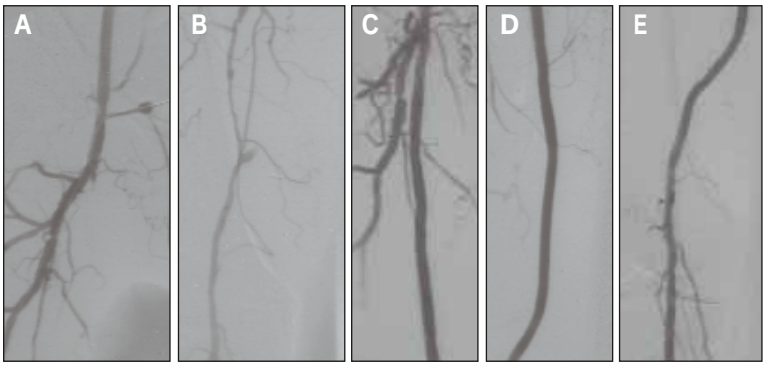

Figure 5. Baseline angiogram of an occluded native proximal SFA (A); distal reconstitution of the popliteal and hint of old graft via collaterals (B); final angiograms of the restored graft after laser and stent grafting (C-E).

with 6-mm Viabahn stent grafts. The end result was a remarkable transformation of an old occluded graft into a fresh conduit with markedly improved runoff. The patient has done well clinically for more than 1 year, with one interval treatment of edge restenosis only.

CASE 6

A 74-year-old diabetic man with lower-extremity neuropathy and rest pain presented for evaluation of possible endovascular options. Like many diabetics, he had unobstructed flow through the femoropopliteal segments, but severe occlusive trifurcation disease. In particular, angiography found him to have proximal occlusion of the anterior tibial artery, proximal occlusion of the posterior tibial artery, and an atretic peroneal artery that reached the high ankle but did not collateralize the foot adequately (Figure 6). He was enrolled in the PATRIOT Trial, and we were able to successfully cross a 20-cm occlusion of the anterior tibial artery with the high-frequency ultrasound Crosser catheter. In such a lesion, the resistance to flow can be dramatic, and unless adequately dilated, the existing peroneal flow may continue to command the preferred route for blood flow. In this case, we therefore chose to place a series of Expert self-expanding, nitinol, small-vessel stents (Abbott Vascular, Redwood City, CA) followed by aggressive dilation with an Amphirion Deep 3-mm X 120-mm balloon (ev3, Minneapolis, MN). The acute angiographic result was excellent, and the rest pain was promptly resolved. The longer-term effects of below-the-knee stenting are not well characterized. To better understand the role of stenting in critical limb ischemia, the VIVA group has initiated a physician-sponsored IDE study that will investigate this scenario in detail.

CASE 7

An 87-year-old, remarkably vital diabetic man presented with a nonhealing ulcer of the right heel with associated severe rest pain. He had exhausted potential venous conduits due to previous harvesting for coronary bypass surgery and was now facing below-the-knee amputation (Figure 7). Baseline angiograms further made surgical bypass less desirable because his only target was a very distal posterior tibial reconstitution. We elected to attempt an endovascular solution, and this case points out the lengths to which one must sometimes go in order to save a limb. The initial angiograms were daunting because the popliteal artery terminated with no hint of a tibioperoneal stump. What we could see, however, was that the posterior tibial artery reconstituted approximately 5 cm above the medial malleolus. In such cases, we will attempt a retrograde approach via pedal puncture, and we have enjoyed reasonable success in doing so. In this case, a puncture was not achievable, and we thus resorted to a posterior tibial cut-down, through which access was more easily gained. Using a .014-inch PT Graphix and .018-inch V-18 wire (Boston Scientific Corporation) and a .018-inch Quick Cross catheter (Spectranetics Corporation), we were able to cross the 20-cm right posterior tibial occlusion in a retrograde fashion and safely re-entered the popliteal artery. At this point, the wire was snared from a catheter position above the trifurcation, and the wire was reversed so that the intervention could be carried out from above to avoid larger catheter trauma of the distal entry site. The posterior tibial puncture site was then primarily closed with a single 6–0 suture. With a .014-inch wire now safely through the lesion, we defaulted to our usual below-the-knee treatment strategy of laser atherectomy followed by

Figure 6. Baseline angiogram shows suboptimal single vessel runoff via an atretic peroneal artery (A); successful distal access using a Crosser catheter (B); and final angiographic results after subsequent angioplasty and Xpert stenting (C,D).

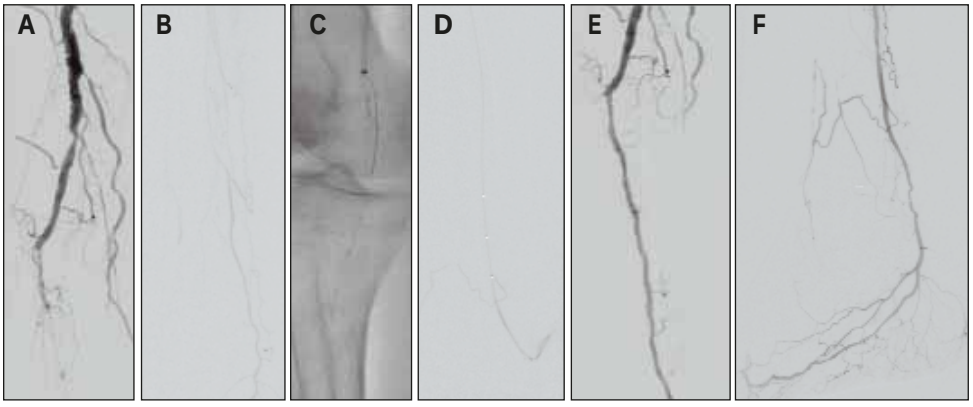

Figure 7. Baseline image shows terminal popliteal occlusion with no hint of a residual lumen (A); faint reconstitution of the very distal posterior tibial artery (B); snare retrieval of PT Graphix after successful lesion crossing via posterior tibial cutdown (C); selective catheter injection of distal target after wire reversal (D) (Note extravasation of contrast at distal cutdown); final angiograms after laser and cryoplasty (E,F).

cryoplasty. The angiographic result was excellent, flow to the unhealed region of the foot was pulsatile, and the patient's pain resolved quickly.

CASE 8

A 76-year-old man with a remote 100-plus pack year smoking history presented with severe, lifestyle-limiting claudication secondary to dense, calcific occlusion of his left SFA. He had previously undergone coronary bypass grafting after myocardial infarction that left him with an ischemic cardiomyopathy and an ejection fraction of 25%. His immediate surgical option was a prosthetic above-the-knee femoropopliteal bypass, but given his comorbidities, an endovascular solution was sought. The baseline angiographic image in this case showed severe calcification of the distal SFA with reasonably healthy reconstitution of the popliteal artery distally, and two-vessel runoff (Figure 8). There are numerous factors that contribute to restenosis after endovascular treatment, and calcified lesions of the distal SFA and adductor canal are particularly problematic. This is a prime area for strut fracture, and the ability to adequately expand stents or stent grafts in such an environment may significantly limit the luminal gain realized. With these thoughts in mind, we elected to treat the patient with a bypass—percutaneously!

Figure 8. Baseline image of densely calcified femoropopliteal occlusion (A), and final result following percutaneous femoropopliteal bypass grafting (B).

Through an antegrade puncture, we approached the leading edge of the lesion by intentionally exiting the artery and entering the adjacent femoral vein using a Pioneer catheter. We then traversed the length of the lesion within the vein until we were at a level where we knew the artery reconstituted. At this point, we exited the vein and re-entered the artery in a similar fashion. The procedure was then completed by placing two overlapping 6-mm X 15-cm Viabahn endografts from the popliteal artery, through the length of the femoral vein, and safely back into the proximal SFA. The patient has been free of claudication for more than 1 year.

CONCLUSION

CTOs of the lower extremities represent some of the more challenging lesions that we face in the endovascular arena. These procedures take more time and have higher complication rates compared to similar interventions in stenosed vessels. They require more patience and often more creativity to overcome the obstacles at hand. To adequately approach such lesions, one needs to have access to the necessary tools and it is necessary to master the techniques that are vital to success. ■

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