



SFA Disease: The Lay of the Land

How anatomical challenges affect device
choices for revascularization.

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Revascularization procedures in the superficial femoral artery (SFA) account for more than half of all endovascular procedures that are performed. The SFA also remains the most difficult peripheral artery in which to maintain reliable long-term patency despite the rapidly increasing availability of endovascular therapy tools. This paradox is most likely a result of its long course within the adductor canal, which exposes it to unique mechanical forces unlike any other vascular territory. A discussion on how to plan and perform a percutaneous endovascular intervention in the SFA would be incomplete without recognition of its unique anatomical location.

The SFA is the longest artery in the human body, and it originates at the junction of the common femoral artery as it bifurcates to the deep femoral (profunda) and the SFA. This anatomical location is fixed by a flexible joint above at the femoral head and a flexible joint below at the knee. The SFA has a tortuous course within the muscular adductor canal and does not normally feature any major branches. It emerges out of the adductor canal and just above the knee joint through the adductor hiatus, continuing into the popliteal fossa as the popliteal artery. It is, however, important to note that there is no defined boundary delineating the popliteal artery from the SFA. Distal collateralization of the SFA when occluded is derived from the deep femoral artery. These collaterals are less evident in the SFA stenotic lesions. The SFA itself may become the source of bridging collaterals.

The superficial femoral vein lies close to the corresponding artery within the adductor canal, and recognition of each vessel is important to appreciate late filling of the vein during endovascular procedures, especially because microperforations may result during true lumen re-entry from the subintimal space. These microperforations are usually benign and can be simply treated with prolonged balloon inflations. The tortuous course of the SFA, which lies within a muscular canal in one of the most dynamic areas of the human body, exposes it to compression, extension, bending, and torsion; these forces are believed to be the cause for the vessel's exuberant atherosclerotic involvement. These mechanical forces are also one of the agreed causes of stent fracture, and therefore, the resultant mechanical force distribution after stent placement is difficult to predict. Appreciation of the SFA course and the presence of stent fracture is best obtained by performing laterally angulated angiography apart from the traditional

anterior-posterior imaging used most commonly in the angiography suite. It is not uncommon to obtain bent-leg anterior-posterior and lateral angiograms in patients after an SFA percutaneous intervention, especially after the deployment of long segments of overlapping stents. Apart from stent fracture, kinks within the SFA may arise at stent edges, even with relatively short stent lengths.

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Imaging of the SFA origin is best obtained from an ipsilateral lateral projection. The mid-SFA is generally shown from an anterior-posterior view. Stent fracture and vessel kinks can be recognized by performing additional laterally angulated views. Digital subtraction angiography (DSA) is the preferred imaging modality during SFA interventions. Use of DSA can reduce time, cost, and patient discomfort when compared to standard arteriographic study. Although DSA is limited by field size and patient cooperation in some instances, the added anatomic detail for road mapping and delineation of small distal vessels provides the basis for its obligatory use during SFA interventions.

The strategy and technique of planning and performing a percutaneous intervention on SFA stenoses or occlusions requires recognition of its unique anatomic location to achieve predictably high procedural success rates.

The aspects that are unique to performing percutaneous interventions in the SFA are based largely on its location. In the ostial and proximal SFA, each of the following can be encountered: SFA and profunda femoral artery bifurcation lesions; noncalcified and calcified lesions; thrombotic occlusion; chronic total occlusions (CTOs); graft anastomotic lesions; focal or diffuse lesions; in-stent restenosis (ISR); and stent crush and vessel kink. Typical lesions in the ostial location are moderately calcified and eccentric. They are often a continuation of the atherosclerotic process from the common femoral artery into the SFA/profunda junction.

Generally, these lesions will require a contralateral approach; the brachial and popliteal approaches are rarely needed. Occasionally, nonatherosclerotic lesions from the use of closure devices occur in this location. A 6- or 7-F, 45-cm sheath placed proximal to the common femoral artery bifurcation is optimal.

Because this is often considered a “no-stent zone,” the common femoral artery bifurcation and lesions involving the ostial portion of the SFA deserve special mention. At the ostial SFA, debulking or angioplasty remain the preferred strategies. Excisional atherectomy, cutting balloon, cryoplasty, and excimer laser-assisted angioplasty are the potential nonstent options. The profunda femoris artery (PFA) is essential for maintaining limb viability when severe occlusive arterial disease affects the extremity. It provides the primary blood supply to the tissues of the thigh, and it is also the most important collateral vessel for bypassing an obstructed or occluded SFA. Historically, significant occlusive disease of the common femoral artery bifurcation and PFA has been treated surgically with low risk and sustained patency and clinical benefit. However, atherosclerosis of the PFA is usually focal, preferentially involving the origin and the very proximal portion of the artery in the majority of limbs, which is essential to consider during strategic planning of an ostial or proximal SFA intervention.

Excimer laser can debulk and atheroablate ostial SFA lesions, thus decreasing the risk of distal embolization. It can also be delivered through an eccentric catheter to direct the laser energy to further reduce the risk of embolization. Excimer laser atherectomy is also used to create a channel in the occluded segments to facilitate further angioplasty. In addition, after laser atherectomy, lower pressure balloon inflations may be needed, which may reduce arterial wall stress and the risk of subsequent dissection and side branch occlusion from plaque shift. Similarly, cryoplasty of ostial SFA lesions offers certain conceptual and realized advantages over conventional balloon angioplasty. Excisional atherectomy is an ablative technique that avoids barotrauma and plaque displacement that often occur during balloon angioplasty of ostial SFA lesions. Proponents of this therapy have demonstrated its efficacy in longer diseased segments as well, often as stand-alone therapy. Severely calcified SFA lesions are still difficult to treat with atherectomy devices; it is difficult to cut away the calcium, and there may be an increased risk of embolization.

The Cutting Balloon (Boston Scientific Corporation, Natick, MA) is a balloon-expandable device that uses three or four fixed atherotome blades. As the balloon expands, the atherotomes cut into and score the stenotic plaque, allowing lower balloon inflation pressures and resulting in less distension, vessel stretch, and barotrauma compared to conventional angioplasty. Furthermore, cutting-balloon

angioplasty may limit distal dissection in heavily calcified vessels. In addition to yielding improved early outcomes, use of this device may limit restenosis. For flow-limiting dissections of the SFA ostium, placement of self-expanding stents is a viable alternative, and in our experience, it can be safely performed to restore distal flow. Extension of self-expanding nitinol stent struts across the ostium of a nondiseased PFA is acceptable and is generally well tolerated. When contemplating complex endovascular strategy options for treating SFA-PFA bifurcations, the operator should give the surgical endarterectomy option serious consideration.

Treatment of proximal SFA CTO is one of the most challenging lesion subsets in infrainguinal revascularization. Finding the SFA CTO origin can often present as a significant challenge. A 30° to 50° ipsilateral lateral view will often help exclude overlying branches. Probing the presumed SFA ostium with an angled Terumo Glidewire and Glidewire (Terumo Interventional Systems, Somerset, NJ) is often revealing, and imaging the contralateral SFA origin can provide helpful clues to the origin of SFA at the site of CTO. When an occluded femoropopliteal graft is present, the SFA CTO is most often located medial to the graft. Careful attention to collateral filling and distal reconstitution of an occluded SFA is important, because multiple angulated views are often needed to best delineate the site of SFA reconstitution, especially in the presence of multi-level occlusion and presence of bridging collaterals. Placement of the guiding sheath across the ostium of the ipsilateral PFA can often cause delayed filling of the distal SFA via collaterals originating from the PFA, inhibiting the progress of intervention, and it is generally recommended that it be avoided.

Crossing an SFA CTO using a hydrophilic wire is gradually being replaced by subintimal dissection, blunt microdissection, and true lumen re-entry techniques. After establishment of the wire through the CTO, a confirmatory distal angiogram is mandatory, and the final result is secured with balloon angioplasty and the placement of self-expanding nitinol stents. The results of angioplasty in the SFA are dismal, especially in diabetics; however, the current generation of nitinol self-expanding stents has shown the most predictable and more durable results. Recrossing the distal cap into the true lumen is performed with a straight wire, after which a distal confirmatory angiogram is obligatory. Considerable attention should be paid to the site and level of re-entry. A broad, distal, reconstituted SFA segment increases the success of true lumen re-entry compared to narrow segments (Figure 1). Re-entry catheters have the highest degree of success in lesions that reconstitute above the adductor canal where the vessel is relatively large. Moreover, fluoroscopic road map imaging is helpful in

avoiding distal propagation of the subintimal dissection plane. Re-entry catheters, such as the Outback LTD (Cordis Corporation, Warren, NJ) and Pioneer (Medtronic, Inc., Minneapolis, MN), allow for predictable distal vessel re-entry. In principle, these devices are delivered at least 1 cm distal to the point of reconstitution over a 0.014-inch wire. These devices allow for safe and predictable re-entry in more than 80% of cases; however, no head-to-head comparison of the devices is currently available. The Pioneer catheter relies on ultrasound imaging but at the cost of a larger catheter profile. The final result after subintimal dissection and re-entry in treating a proximal SFA CTO is secured by balloon predilation and self-expanding nitinol stent placement. Although stenting of an SFA CTO after subintimal crossing is currently considered the standard of care, some have advocated limited stenting alone in the distal re-entry site. The value of anticipation and preparing ahead for complications during an SFA CTO subintimal crossing cannot be overemphasized. Although venous filling or perforations are uncommon, they can occur and are simply treated with prolonged balloon inflations. In the event of unsuccessful distal vessel true lumen re-entry during percutaneous intentional subintimal revascularization of an SFA CTO, the operator may choose to reattempt the procedure after a 4-week period to allow for healing of the pre-existing dissection flap.

Long segments of occlusions and proximity to the popliteal artery are unique to the mid and distal SFA. In addition to the techniques described previously, the long segments of the mid and distal SFA CTO could be crossed using a blunt microdissection technique. The Frontrunner XP catheter (Cordis Corporation) is a blunt microdissection device that takes advantage of the elastic properties of adventitia versus the inelastic properties of fibrocalcific plaque to create fracture planes. This technique may be effective in penetrating the hard fibrous caps of SFA occlusions. The device separates atherosclerotic plaque in various tissue planes, creating a passage through the CTO. The single most strategic advantage of this device is its increased success rate of intraluminal CTO crossing based on clinical trial data. As for the proximal SFA, and more importantly in the distal SFA, the operator should avoid injecting contrast through the catheter to confirm luminal or subintimal position after an attempted wire crossing or blunt microdissection of an SFA stenosis or occlusion. First, the presence or absence of blood return through this small-caliber, endhole catheter placed in a tortuous artery is not a reliable indicator of intraluminal access. Second, contrast staining of the subintimal space, especially in the distal SFA, may completely obscure future visualization of the SFA and distal vessels, making the procedure extremely challenging and often difficult to complete.

The recognition and treatment of ISR and stent fractures in the SFA also deserves special mention. Placement of stents in the SFA, contained within the adductor canal, exposes it to highly dynamic forces of flexion, extension, and torsion, resulting in stent fractures, restenosis, and kinking of the artery along stent edges or between two interspaced stents. Such mechanical disruptions in the integrity of stents are best recognized by fluoroscopic imaging of the stent in anterior-posterior and laterally angulated views. Most ISR, however, are not associated with stent fractures, and improvements in stent design have made stent fractures much less common in our practice today. Most ISR lesions can be treated with balloon angioplasty, cryoplasty, or atherectomy and rarely require stenting in the absence of an associated stent fracture. Early recognition of more focal areas of restenosis during periodic duplex ultrasonographic follow-ups is critical and is generally associated with doubling of the peak systolic velocity within the stent compared to postprocedural baseline. In our practice, we perform duplex ultrasound 3, 6, 9, and 12 months after SFA stenting, and we believe that this strategy improves primary assisted patency given the more focal nature of early restenotic lesions. Uniquely, the percutaneous intentional subintimal revascularization strategy can be used to deal with long segments of completely occluded SFA stents.

Careful assessment of the final postprocedural angiogram is important because recognition of brisk flow through the treated segments of the SFA and distal vessels is vital. The operator should have a low threshold to interrogate areas of concern that commonly arise, especially at the ostium of the SFA, moderately diseased distal SFA around the adductor hiatus, or along underexpanded segments of the stent, with intravascular ultrasound and/or by measuring the pressure gradient with a 5-F endhole catheter or pressure wires. This due diligence improves acute procedural success and may enhance primary patency rates. ■

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