# Interventional Strategies for Atherosclerotic Popliteal Disease

A review of the limitations and therapeutic options available for treating this challenging segment.

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The popliteal segment is a frequent location of atherosclerosis stenosis and occlusion, as well as the site of unique vascular occlusive entities, such as adventitial cystic disease, popliteal entrapment syndrome, and aneurysms occurring in association with arteria magna syndrome. A nonobstructed popliteal artery is a critical determinant of long-term patency after femoropopliteal bypass surgery and is critical if synthetic bypass conduits are utilized.[1]

Endovascular strategies for atherosclerotic popliteal lesions have unique limitations due to distinct anatomic features. The popliteal artery extends from the adductor hiatus in the adductor magnus muscle to the origin of the anterior tibial artery and has a tapering diameter from its above-knee to below-knee segment.[2]

Consequently, noncompliant balloons, as well as uniform diameter stents, may therefore be oversized in the more distal treatment zone, risking arterial damage or a propensity to restenosis. Similarly, the use of undersized stents, fitted to accommodate the distal portion of a lesion, may not have adequate wall apposition at their upper margin, again increasing the likelihood of restenosis.[3] Wire purchase across distal popliteal lesions has the potential to injure the crural runoff, requiring careful attention to wire positioning during interventions.

The popliteal artery is also subject to dynamic biomechanical forces during normal activities. Limited cadaver studies have shown shortening of the popliteal artery of 9% to 14%, comparable to the adductor canal region of the superficial femoral artery.[4] Stents placed within the popliteal artery have the potential for marked compression, particularly with longer, more flexible stents. Although the long-term implications of this phenomenon specific to popliteal stents are not yet established, there is clearly a risk for restenosis due to axial or bending stent fatigue and subsequent fractures or overt kinking resulting in catastrophic stent failure. In addition, for patients with isolated popliteal stents, the resulting compliance mismatch between the upper edge of the stent and the adjacent bare artery results in a propensity to native arterial kinking during physiologic stresses.[4]

## APPROACH TO ENDOVASCULAR TREATMENT

Despite the singular anatomic and biologic properties of the popliteal artery and evidence of a higher rate of failure after revascularization when compared with the superficial femoral artery,[5] there is little published information differentiating popliteal artery outcomes after endovascular interventions.[6] In fact, most series generally publish the results of intervention in the femoropopliteal artery as a whole, making it impossible to distinguish strategies or results of popliteal disease management per se. As a result, no guidelines can be established, and a personalized approach is necessary to match available devices and expertise to each treated individual's patterns of stenosis or occlusion.

## Angioplasty

Conventional or plain old balloon angioplasty should remain the mainstay of therapy for patients with isolated short-segment popliteal lesions that can be successfully and atraumatically traversed with a guidewire (Figure 1). The interventional wire should be maintained in view whenever possible to avoid movement into the smaller tibial arteries. Alternatively, in patients with critical limb ischemia undergoing concomitant popliteal and infrapopliteal interventions, a low-profile wire may be maintained with its tip distal to the target crural stenosis. The goal is to avoid blind trauma to the tibial arteries. Balloons should be sized to the diameter of the artery at the distal margin of the popliteal lesion; if necessary, repeat larger-size balloon inflations can be performed in the cephalad aspect of the diseased segment for the treatment of any residual narrowing.

## Cryoplasty

Cryoplasty (PolarCath, Boston Scientific Corporation, Natick, MA) also represents a reasonable treatment option for stenoses or short occlusions located at flexion points, including the midpopliteal artery. Distal embolic protection has been promoted by some operators in


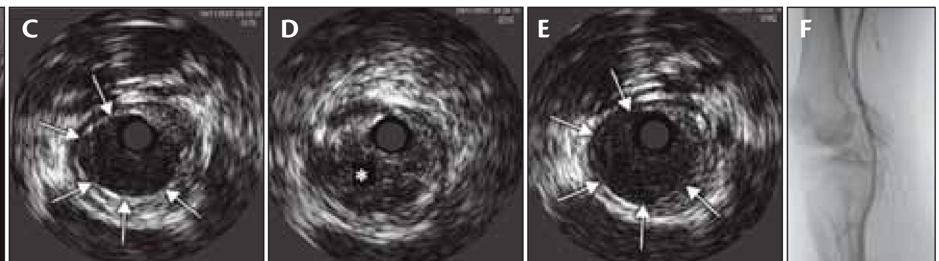


**Figure 1. The patient was a 40-year-old man with severe claudication. CTA shows a focal calcific stenosis in the midpopliteal artery at the origin of the sural artery (A, arrow). There is preservation of the distal popliteal artery and runoff (B). Sequential intravascular ultrasound images above the lesion (C), at the lesion (D), and below the lesion (E) show plaque filling the arterial lumen within the stenosis (*) but a patent lumen at adjacent levels (arrows). Intravascular ultrasound can be particularly useful for sizing balloons and stents, as well as for evaluating an adequate lumen or complete stent apposition after intervention. Angiography after balloon angioplasty alone shows a nonflow-limiting focal dissection at the treated site (F). There were strong palpable distal pulses after the procedure.**

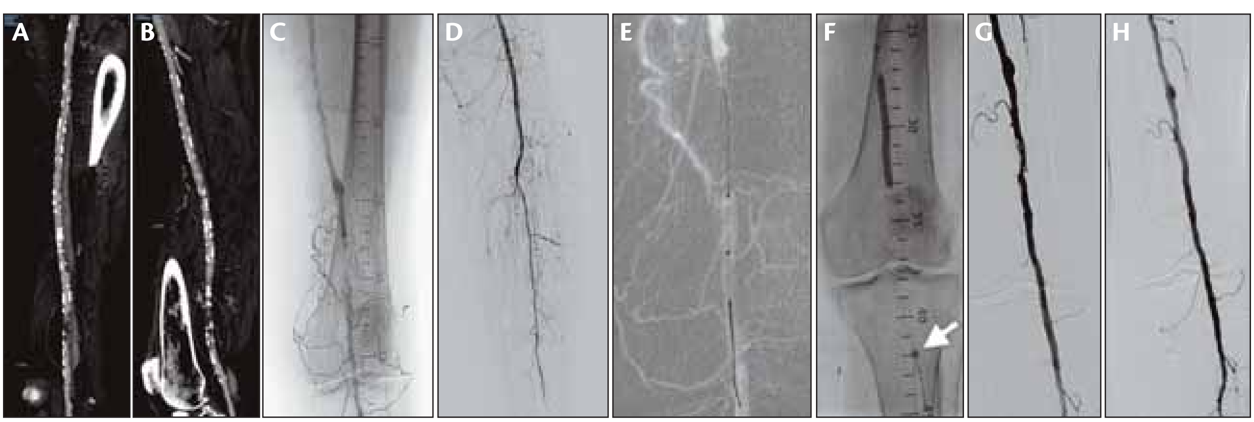


**Figure 2. The patient was an elderly woman with severe disabling claudication. Curved planar reconstruction images from a CTA show a short occlusion of the popliteal artery at the level of the upper patella (circled segment) (A, B). Angiography again demonstrates the popliteal occlusion and single-vessel peroneal artery runoff (C, D). Recanalization was performed under digital road mapping guidance using a coaxial 4-F Glidecath (Terumo Interventional Systems, Somerset, NJ), a low-profile Quick-Cross catheter (Spectranetics Corporation, Colorado Springs, CO), and a floppy-tipped .014-inch guidewire (E). Due to the compromised tibial circulation, a GuardWire (Medtronic Vascular, Santa Rosa, CA) balloon-occlusion distal embolic protection device was inflated in the distal popliteal artery during angioplasty (F, arrow). Due to suboptimal residual stenosis after angioplasty alone (G), stenting was performed to restore the arterial lumen (H). Distal embolic protection and subsequent aspiration of debris was separately performed for each component of the procedure.**

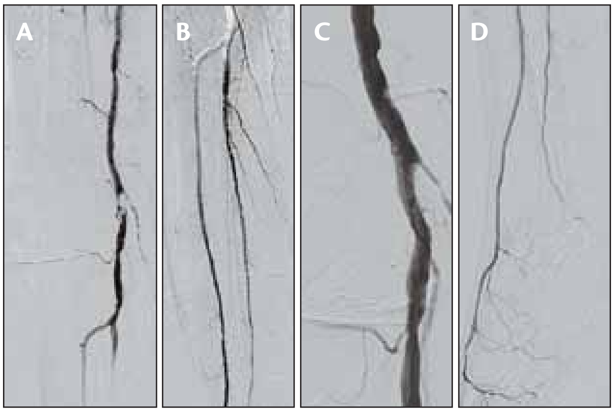


**Figure 3. The patient was a 78-year-old woman with acute onset of a cool, pulseless foot. Angiography shows a suspected embolus causing severe midpopliteal stenosis. Two-vessel runoff was preserved (A, B). To allow rapid restoration of flow, the lesion was primarily stented with a short nitinol stent with complete effacement of the embolus and no evidence of further distal embolization (C, D).**

patients with compromised tibial runoff (Figure 2), particularly to prevent conversion of claudication patients to a scenario of acute ischemia and limb salvage.

### Stenting

Nitinol stents remain a viable option for popliteal stenoses with residual narrowing or flow-limiting dissection after angioplasty and should be positioned so that the entirety of the diseased arterial segment is covered (Figure 2). Lateral flexion arteriography may provide additional benefit to evaluate for stent kinking, as well as acute flow-limiting angulation of the artery above and below the stent margins. In these cases, additional stent placement should be considered. Long-segment disease is probably also best treated with primary stenting, although this has not been specifically shown in the popliteal segment. Stents may also be used to "tack up" eccentric stenoses caused by friable atheroma or even in cases of focal embolic involvement of the popliteal artery to trap the thrombus and allow rapid restoration of flow (Figure 3).

### Atherectomy

The intermediate and long-term results of extirpative (eg, SilverHawk, ev3 Inc., Plymouth, MN) or ablative (eg, Turbo Elite, Spectranetics Corporation) atherectomy have not been defined in the popliteal artery. However, there is good rationale for the use of atherectomy as a debulking tool if it can facilitate successful angioplasty. Atherectomy using the SilverHawk device is also particularly useful for highly eccentric stenoses that may not respond to angioplasty alone. Another uniquely beneficial role of atherectomy is for the treatment of recurrent lesions after previous endovascular treatment. These fibrous intimal hyperplastic lesions can often be successfully treated with multidirectional atherectomy alone or as an adjunct to subsequent angioplasty or stenting (Figure 4).

### Unique Strategies

Subintimal recanalization of the popliteal artery can be achieved with a high success rate when needed, particularly with the judicious use of currently available reentry devices (Pioneer Catheter, Medtronic; Outback Catheter, Cordis Corporation, Warren, NJ). Generally, subintimal recanalization should be reserved for cases of limb salvage due to lower patency rates than standard revascularization techniques. In patients with lesions that cannot be traversed in an antegrade fashion, retrograde recanalization via a popliteal (Figure 5) or even a pedal approach is possible. After retrograde traversal, the intervention can either be completed from the original arterial access site, or the patient can be placed supine, and the crossing wire snare retrieved via a contralateral (over the bifurcation) or ipsilateral (antegrade) femoral puncture, allowing completion of the case from the femoral approach. If stent placement is anticipated, this latter approach has the advantage of avoiding the placement of large sheaths in the popliteal artery, with the risk of arterial injury or difficulty with subsequent hemostasis.

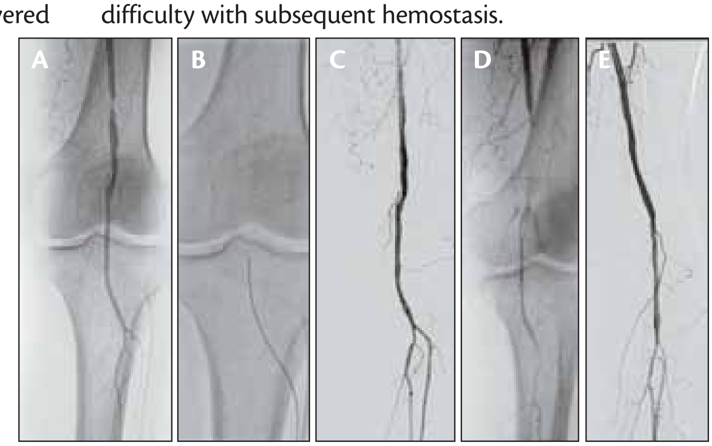


**Figure 4. The patient was a middle-aged woman with claudication. Angiography shows a focal popliteal stenosis above the knee, which was initially treated with the PolarCath (A, B). Angioplasty after the initial cryoplasty shows no residual arterial narrowing and maintained crural flow. Note the optimal position of the interventional wire above the tibial vessels (C). The patient had recurrent claudication 1 year later, and angiography shows a short occlusion at the site of previous intervention. This intimal hyperplastic lesion was treated with directional atherectomy, and stent placement yielded an excellent result. The patient has remained asymptomatic for 15 months following the second intervention (D, E).**

## PUBLISHED RESULTS OF POPLITEAL STENTING

As noted earlier, the results of interventions in the popliteal artery have not been routinely singled out in series describing femoropopliteal treatment. Onohara et al described the results of popliteal angioplasty adjunctive to femoral to above-knee bypass grafting in 27 patients.[7] One-year primary patency rates of 69% and secondary patency rates of 82% were achieved, and the results of bypass grafts performed with concomitant popliteal angioplasty exceeded that achieved with a matched group of patients undergoing femoral to below-knee bypass. Five-year primary patency was noted in 51% of patients. In a more contemporary series of 50 patients with patent femoral arteries undergoing popliteal angioplasty, Raouf and colleagues reported a comparable 2-year primary patency rate of 57%.[8] Patency was better for claudicants compared with limb salvage (*P*=.006), focal versus long segment disease (*P*=.01), and in the upper versus lower popliteal artery (*P*=.03). There was no difference between stenoses and occlusions. These results are similar to previous pooled 1-year primary patency data of 67% for percutaneous transluminal angioplasty of combined femoropopliteal lesions.[9]

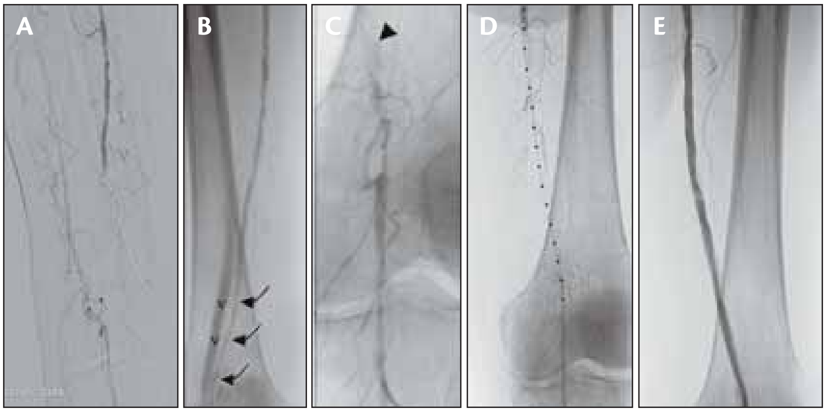


**Figure 5. Angiography shows a complex femoral and upper popliteal occlusion in an 80-year-old patient with ischemic rest pain (A). Attempted subintimal recanalization from a contralateral femoral approach resulted in the creation of a communication between the artery (curved arrow) and popliteal vein (v). Successful reentry into the small popliteal artery could not be achieved (B). Ultrasound-guided retrograde popliteal puncture allowed angiographic visualization of the popliteal occlusion (arrowhead), which was successfully traversed with an angled 4-F catheter and hydrophilic wire (C), allowing placement of a marker catheter to define the lesion length (D). After stenting from the popliteal puncture site, there is unobstructed flow in the artery (E).**

There are equally limited publications specifying popliteal stent outcomes. A series of Strecker stent implantations (Boston Scientific Corporation) in 32 popliteal arteries with residual post-percutaneous transluminal angioplasty stenoses reported 1- and 2-year primary patency rates of 81% and 74%, respectively.[10] Equivalent patency was described for stents in the upper (P1 segment) and middle (P2 segment) third of the popliteal artery, although there was a trend for reduced results when treating occlusions and in patients with impaired runoff. The use of 4-F sheath-compatible self-expanding popliteal and tibioperoneal stents has been recently reported in 35 patients with severe claudication and critical limb ischemia.[11] A total of 33 stents were placed in the distal popliteal artery (P3 segment) with a combined 6-month primary cumulative patency rate of 82% and a 1-year rate of approximately 50%. Stent fractures were not described in either of these series.

## CONCLUSION

The popliteal artery segment presents challenging problems to the endovascular interventionist due to its distinct anatomy, the various disease entities affecting it, its importance in bypass surgeries, and the unique dynamic forces it is subjected to during normal activity. These same factors can have an adverse impact on the long-term success of endovascular interventions on this arterial segment.

Although conventional balloon angioplasty remains the optimal therapy for de novo short-segment popliteal lesions, there are many other therapeutic options available to the interventionist for lesions with more complex anatomical and clinical characteristics. These include cryoplasty, primary or secondary stenting, atherectomy, and the use of reentry devices. Endovascular techniques, such as retrograde catheterization of the popliteal artery, can be helpful in the difficult-to-cross popliteal lesions. The use of these therapeutic options and their success will ultimately depend on their appropriate application and the experience of the operator. These devices and techniques should always be employed with careful consideration of the delicate distal crural arteries. Distal embolic protection and the careful positioning of guidewires can be helpful in this regard.

Many inferences on the best treatment for complex popliteal lesions are best drawn from the experience in the trials on the endovascular treatment of the diseased femoropopliteal segment and those of the operator. Ultimately, there is a need for high-quality randomized clinical trials that specifically target the diseased popliteal artery segment and the appropriate application of the techniques and devices we have described. ■

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1. Veith FJ, Gupta SK, White-Flores S, et al. Six-year prospective multicenter randomized comparison of autologous saphenous vein and expanded polytetrafluoroethylene grafts in infrainguinal arterial reconstructions. J Vasc Surg. 1986;3:104-114.
2. Woodburne RT, Burkel WE, eds. Essentials of Human Anatomy. 7th ed. New York, NY: Oxford University Press. 1979;551-552.
3. Buckley CJ, Arko FR, Lee S, et al. Intravascular ultrasound scanning improves long-term patency of iliac lesions treated with balloon angioplasty and primary stenting. J Vasc Surg. 2002;35:316-323.
4. Smouse HB. Changes in major peripheral arteries during joint movement before and after stent placement in the cadaver model. Presented at Midwest Institute for Interventional Therapy Annual Meeting, Peoria, Illinois, October 28-30, 2004. Available at www.miit.com/2004/slides.htm. Accessed April 7, 2007.
5. Vroegindeweij D, Tielbeek AV, Buth J, et al. Patterns of recurrent disease after recanalization of femoropopliteal artery occlusions. Cardiovasc Intervent Radiol. 1997;20:257-262.
6. Intersociety Consensus for the Management of Peripheral Arterial Disease (TASC II). Eur J Vasc Endovasc Surg. 2007;33(suppl 1):S1-S75.
7. Onohara T, Arnold TE, Maekawa T, et al. Popliteal angioplasty as an adjunct to above-the-knee synthetic femoropopliteal bypass: comparison of long-term results with below-the-knee bypass. Vasc Endovasc Surg. 1999;33:151-155.
8. Raouf AA, Rouleau Y, Clement A, et al. Endoluminal angioplasty of the popliteal artery. Review of 54 consecutive patients. Eur J Vasc Endovasc Surg. 2005;30:610-613.
9. Becker GJ, Katzen BJ, Dake MD. Noncoronary angioplasty. Radiology. 1989;170:921-940.
10. Strecker EPK, Bos IBL, Gottman D, et al. Popliteal artery stenting using flexible tantalum stents. Cardiovasc Intervent Radiol. 2001;24:168-175.
11. Kikuth R, Keo HK, Triller J, et al. Initial clinical experience with the 4-F self-expanding XPERT stent system for infrapopliteal treatment of patients wit severe claudication and critical limb ischemia. J Vasc Interv Radiol. 2007;18:703-708.