Use of Optical Coherence Tomography During Superficial Femoral Artery Interventions

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ABSTRACT: Superficial femoral artery (SFA) disease accounts for approximately 40% of the symptomatic peripheral arterial disease and remains a common cause of critical limb ischemia and lower-extremity amputation. Optical coherence tomography (OCT) has been extensively studied in the coronary circulation; however, its use in the peripheral arterial circulation is scarce. We present two cases of OCT use as an ancillary imaging tool during SFA endovascular interventions.


Key words: peripheral arterial disease, PAD, optical coherence tomography, OCT, peripheral intervention

Superficial femoral artery (SFA) disease accounts for approximately 40% of symptomatic peripheral arterial disease and remains a common cause of critical limb ischemia and lower extremitym amputation. Optical coherence tomography (OCT) has been extensively studied in the coronary circulation; however, its use in the peripheral arterial circulation is scarce. Detailed endovascular imaging with OCT has allowed better understanding of coronary artery disease pathophysiology and its response to percutaneous intervention. While conventional invasive angiography remains the “gold standard” imaging modality for SFA interventions, we present two cases of OCT use as an ancillary imaging tool during SFA endovascular interventions.

Case 1

A 58-year-old female with a history of hypertension, hyperlipidemia, and tobacco use presented with Rutherford class III right lower-extremity claudication and an abnormal ankle-brachial index (ABI) of 0.5 despite maximal medical therapy. She was referred for angiography and possible intervention. Angiography showed a long chronic total occlusion (CTO) of the SFA extending from the ostium to the mid-distal segment, reconstituting via collaterals (Figures 1A-1C). A 6 Fr crossover sheath was placed in the left SFA (Figure 3A). Using right groin access, a 6 Fr crossover sheath was placed. A 0.014” guidewire was advanced into the common femoral artery and a 0.035” angled Glidewire (Terumo Becton, Dickinson and Company) was advanced into the right SFA. After dissection with subintimal tracking and reentry into the distal true lumen, the Glidewire was advanced to the right popliteal artery. It was then exchanged for a 0.014” guidewire and frequency domain (FD) OCT (C7XR; St. Jude Medical) of the SFA was performed. OCT imaging demonstrated long dissection planes with false and true lumens (Figures 2A-2C). After confirming that the guidewire was in the true lumen, balloon angioplasty was performed using a 5.0 x 200 mm balloon, the lesion was stented with a 5.0 x 220 mm Supera stent (IDEV Technologies) and then postdilated with a 6.0 x 200 mm balloon (Figures 1D and 1F). Repeat OCT after stent deployment showed optimal stent expansion and wall apposition (Figures 2D-2F). The patient was placed on dual-antiplatelet therapy with significant clinical improvement and normalization of her ABI at 30-day follow-up.

Case 2

A 62-year-old female with history of hypertension, hyperlipidemia, diabetes, and known PAD was referred for management of lifestyle-limiting claudication of her left lower-extremity despite maximal medical therapy. Her left lower-extremity ABI was 0.7 and she was referred for invasive angiography and possible intervention. Peripheral angiogram showed a significant focal lesion in her left SFA (Figure 3A). Using right groin access, a 6 Fr crossover sheath was placed. A 0.014” guidewire was advanced into the popliteal artery and OCT imaging was performed at baseline (Figures 4A-4C). Measurements were made to delineate an accurate reference vessel diameter (Figure 4C) as well as minimal luminal diameter (Figure 4B) at the lesion site. A fibrocalcific plaque was well described at the lesion site (Figure 4A). We performed predilation with a 5.0 x 20 mm balloon, implantation of a 6.0 x 20 mm self-expanding Xpert stent (Abbott Laboratories), and postdilation of a 7.0 x 20 mm balloon with good results (Figure 3B). Repeat OCT imaging post stenting showed complete expansion of the stent with optimal wall apposition (Figures 4D and 4F). A residual small thrombus on the stent surface was incidentally visualized and three-dimensional quantitation demonstrated a 0.87 mm³ clot volume (Figure 4E). Three-dimensional clot reconstruction was performed by manually tracing clot in sequential OCT B-scans, which are sampled every 203 µm and then converted to a three-dimensional volume using nearest-neighbor interpolation. The patient was treated with dual-antiplatelet therapy for 1 month with significant improvement in her symptoms during follow-up.

Discussion

Over the last decade, OCT has emerged as a novel endovascular imaging modality with excellent axial resolution (10-15 µm),...
providing superior visualization of the vascular wall anatomy. The FD-OCT system allows high-speed image acquisition during contrast injection without the need for arterial occlusion. Recently, upgraded and optimized FD-OCT systems have significantly expanded their scan diameter up to 10 mm, allowing the imaging of larger vessels. Despite the extensive use of OCT in coronary circulation, information about its use in femoropopliteal endovascular interventions is limited. It has been previously hypothesized that OCT may be inaccurate for vessels larger than 3 mm. We have shown that OCT imaging during SFA interventions can be safely performed, offering excellent imaging evaluation of the vessel wall morphology before and after the procedure even in 7 mm SFA vessels.

With the use of OCT, we often identify important information about vascular wall morphology and pathophysiology with unclear clinical significance. The initial use of OCT during coronary interventions “revealed” microdissection, microthrombi, and micromalapposition, which could not be previously assessed with the use of angiography or intravascular ultrasound and needed longer studies to investigate their significance.

In case 1, OCT imaging allowed us not only to confirm true lumen reentry in the distal SFA segment, but also to describe the length of the dissection planes. Subintimal angioplasty (SIA) in the SFA has previously demonstrated variable 1-year restenosis rates ranging from 25%-80%. In the coronary circulation, it has been hypothesized that the subintimal tracking and reentry technique (STAR) may be related to decreased patency rates after recanalization and stenting of CTOs. It is possible that the subintimal tracking length in the SFA may be responsible for the lowest patency rates. Newer CTO devices like the Ocelot catheter with real-time OCT imaging during endovascular interventions may assist the true-lumen to true-lumen recanalization with potentially better long-term patency rates; however, larger studies are needed to prove the clinical significance of such an approach.

Furthermore, OCT provides accurate data regarding the length of the SFA lesion and dissection in order to appropriately size the stent diameter and length. The length and number of stents, stent apposition, uncovered dissection planes, or inappropriately longer stents may all affect the long-term patency rates.
In case 2, we report the presence of a microthrombus after stent placement. The presence of microthrombosis after stent placement in the coronary circulation is approximately 37% and it depends on the plaque composition, the lumen eccentricity, and the stent length. Thrombus is identified as a jagged protrusion into the luminal space in the presence of a stent, whereas tissue prolapse is identified as a smooth and shallow protrusion between stent struts into the luminal space. In some cases, thrombus may also be identified by a texture junction between the protrusion and the arterial wall outside of the stent, whereas prolapse will have no junction between the spaces internal and external to the stent. Although the clinical significance of the angiographically visible thrombosis in the coronary and peripheral circulation is known, the consequences of the presence of such microthrombosis seen in OCT remain unclear. OCT may additionally allow the measurement of the total thrombus burden. Currently, we don’t know whether the total volume of residual thrombus is correlated with the rate of peripheral embolism, restenosis, or long-term stent thrombosis. Larger trials are needed to determine whether postdilatation, aspiration, aggressive antiplatelet/anticoagulation therapy, or watchful waiting is the optimal management of those findings.

**Conclusion**

The long-term patency rates following SFA endovascular interventions remain low. Conventional angiography has been the gold-standard imaging modality for peripheral interventions; however, OCT appears to be superior for the assessment of stent...
edge dissection, residual thrombus burden, optimal stent expansion, and wall apposition. The study of the OCT findings may lead to a better understanding of the underlying pathology, the progression of the SFA disease, and the vascular effects following interventions with newer devices (stents, atherectomy, laser, CTO devices). It can be safely performed as an adjunctive imaging modality providing high-resolution three-dimensional intravascular imaging during the procedure to optimize the immediate procedural results. Future clinical trials are needed to determine the clinical significance of those OCT findings and its use in order to achieve higher long-term patency rates.

References

Figure 4. Optical coherence tomography (OCT) imaging of the superficial femoral artery (SFA). (A) OCT imaging of a fibrocalcific plaque at the SFA lesion site. White arrow shows a fibrofatty plaque with a large lipid core and covering fibrous cap. (B) OCT imaging at the lesion showing minimal intraluminal clot overlying the well-expanded stent struts and optimal vessel wall apposition (white arrow). (C) OCT imaging of distal SFA reference. (D) OCT imaging of distal SFA after interventions shows well-expanded stent struts and optimal vessel wall apposition (white arrow). (E) Minimal intraluminal clot overlying the well-expanded stent struts (white arrow). (F) OCT imaging distal to the small intraluminal clot, white arrow points to one of the stent struts.