Original Article

Endovascular Treatment of Superficial Femoral Artery Ostial Occlusions and Outcomes of Unexpected Postprocedural Deep Femoral Artery Occlusion

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Abstract

Introduction: This study aimed to demonstrate different revascularization approaches to superficial femoral artery (SFA) ostial occlusion and to evaluate the outcomes of unexpected deep femoral artery (DFA) occlusion encountered during the endovascular treatment (EVT). **Materials and Methods:** This retrospective study included 56 patients diagnosed with ostial SFA occlusion between March 2014 and December 2019. Patients were divided into two groups: the percutaneous transluminal balloon angioplasty (PTA) group, which included 32 patients treated with PTA, and the stent group, which included 24 patients treated with stents. The preferred access site was the contralateral femoral approach, and in 20 patients, access was performed with the popliteal artery (*n*: 13), pedal arteries (*n*: 4), and retrograde occluded SFA (*n*: 3). **Results:** Technical success was 100%. In the PTA group and stent group, primary patencies were 81%, 75%; 62%, 66%; and 56%, 58% and secondary patencies were 92%, 90%; 64%, 63%; and 50%, 54% at 6, 12, and 24 months, respectively, with no significant differences determined between the groups ($P = 0.943$ and $P = 0.640$ by log-rank). DFA occlusion occurred in 8 patients during the EVT. Rutherford score was a statistically significant decrease in both the groups (Wilcoxon signed-rank test, $P = 0.010$). **Conclusion:** Even in challenging SFA ostial lesions, using several different approaches has high success rates in EVT. This study showed no significant difference in PTA and stenting patency rates. Accidentally, DFA occlusion may be encountered, in which case revascularization of the SFA is the priority, even if the procedure ends with occluded DFA. A patent SFA and good distal flow will be sufficient for foot perfusion in DFA's occluded patients.

Keywords: Balloon angioplasty, deep femoral artery occlusion, endovascular treatment/therapy, superficial femoral artery ostial occlusion

Introduction

Endovascular treatment (EVT) for chronic total occlusion (CTO) of the superficial femoral artery (SFA) has evolved over the past decade with the advancements in techniques and devices. However, SFA ostial occlusion is still a challenging procedure in PAD.[1,2] The main reason that makes the process challenging is the difficulty in locating the SFA origin, requiring multiple projection views and wire manipulations. Furthermore, the guidewire can easily slip into the deep femoral artery (DFA) during SFA ostium catheterization and may result in failure. Traditionally, the contralateral femoral route has been the preferred method in SFA stump occlusion.[3] Moreover, the contralateral cross-over approach may not be feasible in patients with extremely tortuous iliac arteries, hostile aortic bifurcations, and abdominal aortic stent grafts.[4] Different approaches have been described to increase the success of the EVT, such as retrograde popliteal, transpedal, transcollateral, and upper extremity access (transradial and transbrachial).[5-7]

The main concern in SFA ostial EVT there is a possibility of damaging the DFA, resulting in occlusion. The DFA is the main artery that supplies the leg when occlusion occurs in the SFA. Therefore, it is a priority to preserve the DFA during EVT. In daily practice despite the great care taken during the treatment, DFA occlusion may still occur in EVT. The aim of this study was to describe the different treatment approaches for ostial

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SFA lesions and to evaluate the outcomes of unexpected DFA occlusion during SFA ostial revascularization.

Materials and Methods

Patient population and study design

A total of 561 patients applied with peripheral endovascular interventions between March 2014 and December 2019 were retrospectively evaluated. The patients' data were accessed through the hospital picture archiving system and electronic medical record system. Of these 561 patients with peripheral vascular disease, patients with SFA ostial occlusion were included in the study, and patients with patent SFA ostium were excluded from the study. The study included 56 patients with ostial SFA occlusions, comprising 39 (70%) males and 17 (30%) females with a mean age of 66.1 ± 9.8 years. The demographic characteristics of patients are listed in Table 1. According to the Global Limb Anatomic Staging System for femoropopliteal segments, the patients were Grade 4 FB arterial occlusions with a mean length of 34 ± 8.1. The primary treatment strategy for SFA ostial lesion was balloon angioplasty, and in 24 patients, a stent was used as rescue treatment. The outcomes of unexpected DFA occlusions after EVT were evaluated. This retrospective study was approved by the Institutional Review Board (Approval No: KA22/105), and written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Angioplasty procedures

Before the procedures, all the patients were evaluated with Doppler sonography, and computed tomography angiography (CTA) was performed when required. All endovascular interventions were performed in a dedicated angiographic room equipped with a C-arm (Axiom Artis C-arm imaging system, Siemens, Germany) and a DUS scanner (Acuson Antares, Siemens, Germany). The preferred access site was the contralateral femoral approach. In addition, popliteal artery *(n*: 13), pedal arteries (*n*: 4), and ipsilateral retrograde occluded SFA (*n*: 3) access were performed to achieve the procedure. Femoral sheath insertion was performed under ultrasound guidance with local anesthesia. Unfractionated heparin of 5000 units was administered after the femoral sheath insertion, and a dose of 1.000 units was administered every 1 h if the procedure continued (if a patient had chronic renal disease, 2500 units was given and continued dose was 500 units).

Table 1: Demographic characteristics of patients

Age	66.1±9.8
Sex (male/female)	39 (70%)/17 (30%)
Risk factor	
Hypertension	29/56 (51%)
Coronary artery disease	23/56 (41%)
Diabetes mellitus	26/56 (46%)
Chronic renal insufficiency (requiring dialysis)	9/56 (16%)
Hyperlipidemia	25/56 (44%)
Rutherford classification	
Category 3	15/56 (27%)
Category 4	28/56 (50%)
Category 5	13/56 (23%)
Lesion side	
Right	27/56 (48%)
Left	29/56 (51%)
Access side	
Contralateral femoral artery	36/56 (64%)
Retrograde popliteal artery	13/56 (23%)
Retrograde pedal artery	4/56 (7%)
Retrograde occluded SFA	3/56 (5%)

SFA: Superficial femoral artery

The classical contralateral retrograde approach was performed with the insertion of a contralateral 6F femoral sheath and then the contralateral iliac artery was traversed with a 0.035" guidewire (Terumo Radifocus) and a 5F guiding catheter. The 0.035" guidewire was then exchanged for a 0.035" stiff guidewire with the insertion of a 6F 45 cm long femoral sheath. It was then attempted to recanalize the SFA origin using a 0.018" (Boston Scientific, Natick, MA, USA) or 0.035" (Terumo, Ann Arbor, MI, USA) guidewire and 4F support catheter (Navicross, Terumo Europe). When the occlusion was passed and the distal patent artery was reached, balloon angioplasty was performed on the occluded segments [Figure 1].

In cases where it was not possible to cross over from the contralateral side or the SFA origin could not be recanalized, the popliteal, pedal approach, or occluded ipsilateral SFA puncture technique was performed to achieve the procedure. The popliteal approach was started with the patient in the prone position, and a 4F sheath was inserted into the patent popliteal artery. The occlusion was passed with a 0.035"–0.018" guidewire and support catheter then balloon angioplasty was performed on the occluded segments.

The pedal approach (via anterior tibial, posterior tibial, or peroneal arteries) was performed with a micropuncture needle (Cook Medical, Bloomington, IN, USA), and a micropuncture sheath was inserted in the pedal artery. A 0.018" guidewire was introduced intraluminally through the microsheath. Usually, 4F occlusion catheters were used to reach the patent common femoral artery, after which the guidewire was removed from the contralateral femoral artery, and classical antegrade recanalization was performed.

When none of these approaches were achievable, direct puncture of the occluded SFA was performed. In this technique, the occluded SFA was punctured with the micropuncture needle under ultrasound guidance and the wire was pushed retrogradely through the needle into the occluded SFA to tried to pass the occluded ostium and reached the patent common femoral artery. Then, 0.018" guidewire was removed from the contralateral sheath by capturing with a snare catheter, and the procedure was continued with classical antegrade recanalization.

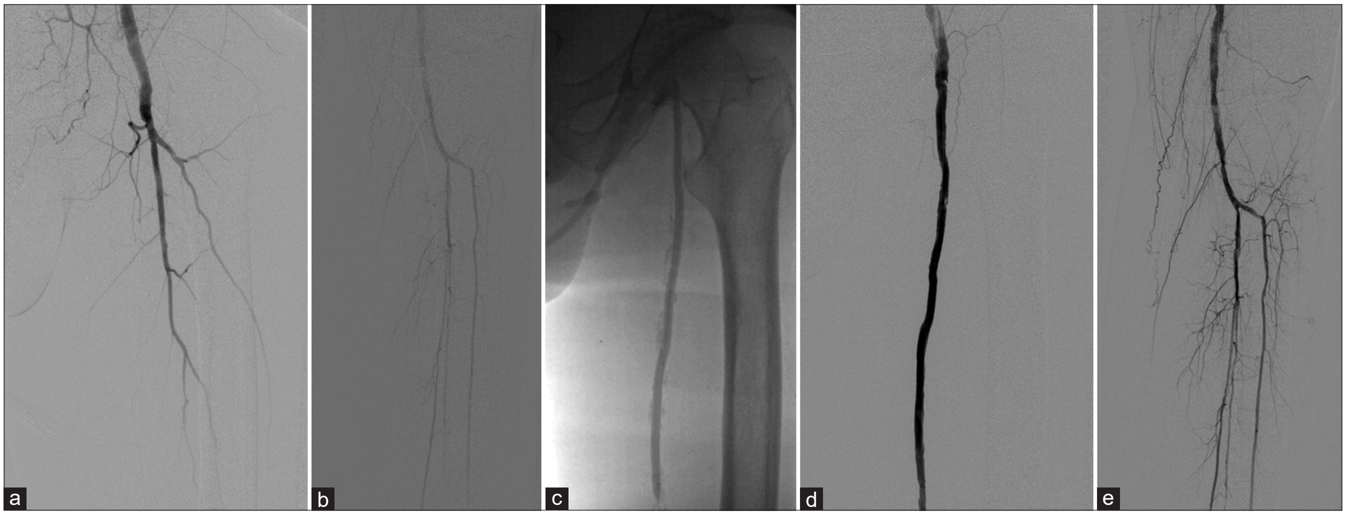

Figure 1: (a) A preprocedural angiogram demonstrates the ostial superficial femoral artery occlusion and a patent deep femoral artery. (b) Angiogram demonstrates a patent popliteal artery and pedal arteries. (c) Balloon angioplasty was performed to SFA with covering the ostium of the DFA. (d) Postintervention angiography demonstrated the ostial calcified flab occluded the DFA ostium. (e) Final angiography demonstrated the flow increase in pedal arteries after revascularization of SFA

Generally, 4-6 mm-sized balloon angioplasty (Mustang, Boston Scientific, Natick, MA, USA) was performed in the occluded and stenotic segments. In cases with insufficient flow or dissection observed on control angiography, a balloon one size larger than the nitinol stent (Protege EverFlex, Medtronic, USA) was used in the occluded segments.

Patient follow-up

Patients were followed up after the procedure with clinical assessment, physical examination, and Doppler ultrasonography at 1, 6, and 12 months and annually thereafter. Patients with DFA occlusion were followed up more closely in this group, with Doppler ultrasound performed on day 1, then at 1, 3, 6, and 12 months, and annually thereafter. Evaluation of each patient was made pre- and posttreatment with the Rutherford scale. Primary and secondary patency rates were evaluated for each patient.

Definitions

Primary patency was defined as the time to >50% restenosis after the initial treatment. Secondary patency was defined as the time to lose patency after repeated intervention in patients with >50% stenosis diagnosed by Doppler US or CTA.

Statistical analysis

Statistical analyses were performed in SPSS Version 23. (IBM Corp, Armonk, NY, USA). The normality of continuous variables was evaluated using the Kolmogorov–Smirnov test. Descriptive statistics were presented as mean and standard deviation values for normally distributed variables and median (minimum–maximum) values for nonnormally distributed variables. The Wilcoxon signed-rank test was applied in the comparison of two nonnormally distributed dependent groups. A value of $P < 0.05$ was accepted as statistically significant. Kaplan–Meier analysis was applied to determine primary and secondary patency rates.

Results

EVT for ostial SFA lesions was applied to 56 patients with a technical success of 100%. The primary treatment strategy was balloon angioplasty, and 24 patients underwent deployment of a self-expandable stent with covering the DFA ostium as a rescue strategy. The remaining 32 patients were treated with balloon angioplasty without stenting. Subintimal angioplasty was determined at similar frequencies (84% and 83%, $P = 0.838$) in both the groups.

In the percutaneous transluminal balloon angioplasty (PTA) group, primary patency was 81%, 62%, and 56%, at 6, 12, and 24 months, respectively. In the stent group, primary patency was 75%, 66%, and 58% at 6, 12, and 24 months, respectively. There were no significant differences between the PTA and stent groups in respect of primary patency ($P = 0.943$ by log-rank) [Figure 2]. In the PTA group, secondary patency was 92%, 64%, and 50% at 6, 12, and 24 months, respectively. In the stent group, secondary patency was 90%, 63%, and 54% at 6, 12, and 24 months, respectively. There were no significant differences between the PTA and stent groups in respect of secondary patency ($P = 0.640$ by log-rank) [Figure 3].

During the procedure, 8 DFAs were immediately occluded, in 5 patients with balloon angioplasty and 3 patients after the DFA ostium was jailed by SFA stenting. CFA and SFA revascularization was successfully performed in those patients, and the procedures were terminated without any additional intervention for DFA occlusion. In one of eight patients who developed SFA restenosis 7 months after EVT, balloon angioplasty was successfully performed with good flow.

With the exception of the 8 patients with DFA occlusion, the Rutherford score was 3.7 ± 0.7 preprocedure, and 0.8 ± 0.8 postprocedure. In the 8 patients with occluded DFA, the Rutherford score was 3.8 ± 0.6 preprocedure and 0.6 ± 0.7

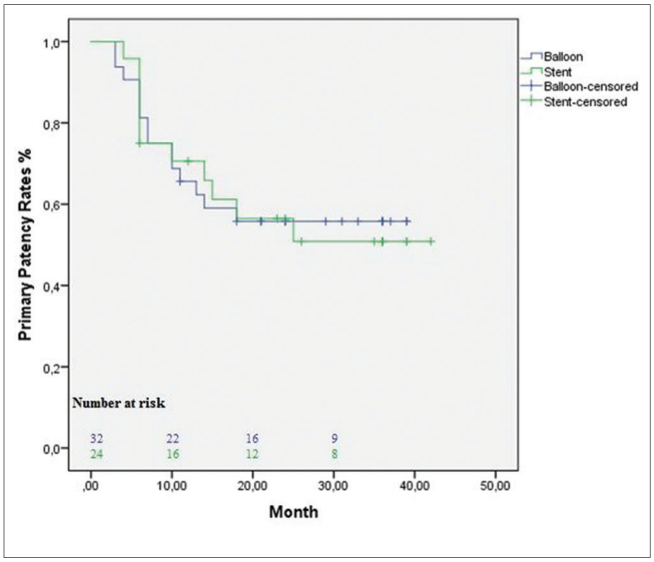

Figure 2: Kaplan–Meier curve showing primary patency of balloon angioplasty and stenting

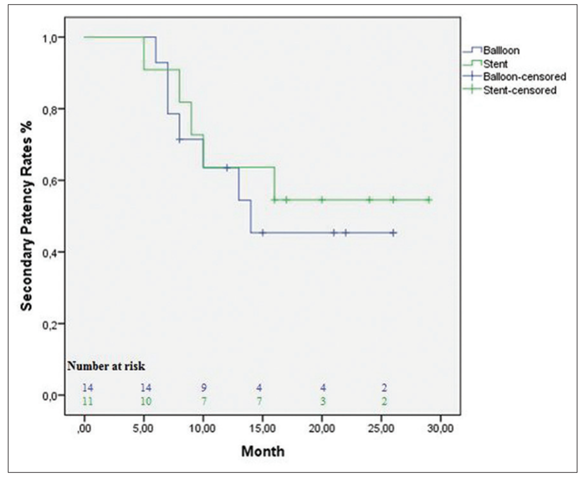

Figure 3: Kaplan–Meier curve showing secondary patency of balloon angioplasty and stenting

Table 2: Rutherford scoring		
	Mean±SD	Median (minimum-maximum)
Rutherford scoring of DFA'S patent patients		
Rutherford (pre)	3.72±0.73	4 (3-5)
Rutherford (post)	0.89±0.80	0 (0-2)
P*	0.010	
Rutherford scoring of DFA'S occluded patients		
Rutherford (pre)	3.87±0.64	4 (4-5)
Rutherford (post)	0.62±0.74	1 (0-2)
P*	0.010	

*Wilcoxon signed rank test. SD: Standard deviation, DFA: Deep femoral artery

postprocedure. A statistically significant decrease was determined in the Rutherford score from preprocedure to postprocedure in both the groups (Wilcoxon signed-rank test, $P = 0.010$) [Table 2]. In both the groups, the limb salvage rates were 100% at 6, 12, and 24 months. There was no statistically significant differences between the groups in respect of limb salvage rates ($P = 0.59$ and $P = 0.63$ by log-rank). The mean procedure time was 56.6 ± 28.2 min. Hemostasis at the femoral, popliteal, and pedal access was achieved with manual compression in all patients.

During the procedure, peripheral distal embolization occurred in two patients, and these patients were successfully treated with catheter thrombectomy and thrombolysis. Among the minor complications, hematoma occurred at the puncture site in one patient with the occluded SFA approach and in three patients with the popliteal artery approach. Of these four cases, three of them were resolved without the need for any intervention. In one case, a popliteal artery aneurysm was observed after the intervention, which was treated with a thrombin injection under ultrasound guidance.

Discussion

Revascularization is an essential procedure for limb salvage in patients presenting with critical limb ischemia. SFA ostial occlusions are challenging procedures in EVT because the penetration of the SFA ostium is not always possible.[8,9] SFA ostial occlusions are usually performed with a contralateral or ipsilateral femoral approach.[10] The antegrade ipsilateral femoral approach is usually inappropriate to deploy the femoral sheath when there is high CFA bifurcation and lesions extend to the CFA. When the antegrade procedure has failed in SFA lesions, the retrograde approach with popliteal artery puncture has become the first-line intervention in recent years.[11] However, the popliteal approach has some drawbacks, especially in obese and elderly patients, where it is difficult to give a prone position and ensure puncture site hemostasis after the procedure. In the current study, three hematomas were observed in the popliteal artery puncture site, two of which resolved spontaneously. In the other patient, a pseudoaneurysm was determined on Doppler USG and this was treated with an ultrasound-guided thrombin injection.

Previous studies have shown that transpedal access is another recanalization option after the antegrade recanalization failure.[12,13] Similar studies have shown that the transpedal approach had a high technical success and is a reliable method for the CTO of SFA.[14,15] In contrast, other studies reported the success of transpedal access to be 52%98%.[16-18] One of the primary reasons for our success in pedal access is the experience of using ultrasound effectively when manipulating the needle during vascular access.

During the SFA revascularization, re-entering the true lumen from the subintimal recess may be challenging or unsuccessful. In the current study, it was unsuccessful to re-enter the true lumen with an antegrade or retrograde approach in three patients. In these patients, direct retrograde puncture was performed to occluded SFA and the SFA ostium was crossed with a 0.018" or 0.035" guidewire, after which the wire was pulled out from the contralateral sheath and the procedure was continued anterogradely.[19] Our study showed that using various approaches and techniques increases the success of EVT in SFA stump occlusion.

In the literature, there is a discrepancy regarding balloon angioplasty and stenting outcomes in SFA treatment. Three major randomized trials comparing stent and balloon angioplasty have been reported and showed different results. The RESILIENT trial was a prospective multicenter trial conducted with 234 patients. Patency in the stent group was reported to be significantly better than in the PTA group at 6 and 12 months: 94.2% and 81.3% in the stent group, compared with 47.4% and 36.7% in the PTA group. A 3-year follow-up showed that the advantages of stents over PTA were continued in the study.[20,21] The ABSOLUTE trial (Balloon Angioplasty vs. Stenting with Nitinol Stents in the SFA) included 104 patients and showed that restenosis rates were significantly lower in the primary stenting group at 2 years (46% vs. 69%).[22] In contrast to those studies, the FAST trial reported that the restenosis rate was not statistically significantly different in the stenting group (32%) and balloon angioplasty group (39%) at 1 year.[23]

In our study, stents were placed as rescue strategy, and stents were placed from the distal CFA covering the DFA ostium. No statistically significant difference was determined between the groups in respect of patencies. Therefore, balloon angioplasty should be the primary treatment strategy for cost efficiency, and stenting should be performed in flow-limiting dissection or after suboptimal balloon angioplasty (residual stenosis of more than 30%).

As far as we know, there is no data regarding the consequences of DFA patency loss during SFA revascularization. Aggressive manipulations of wire and catheter to penetrate the SFA ostium and balloon angioplasty or stenting may cause the plaque to shift to the DFA ostium resulting in DFA occlusion. In patients with occluded SFA, DFA represents the essential accessory vessel to maintain limb viability; therefore, it is critical to maintaining patency. Researchers recommended that a safety guidewire be placed in the DFA during ostial SFA intervention.[24] In the current study, DFA occlusion occurred immediately during the EVT in 8 patients. A safety guidewire for DFA was not used in our study while trying to revascularize the SFA origin. In our patient group, we aimed to revascularize the SFA to provide blood supply to the foot. In 8 patients with occluded DFA, revascularization of the SFA was achieved; therefore, no intervention to the DFA was required. These patients were followed up to observe the DFA occlusion clinical outcomes. If revascularization of SFA fails, it is critical to maintain DFA for limb salvage; therefore, we recommend using a second safety guidewire in case of accidental occlusion occurs in DFA. In addition, many studies in literature have reported that revascularization of DFA in critical limb ischemia has been reported to be effective in wound healing.[25-30] In contrast, Dick *et al*. reported that revascularization of DFA and CLI patients did not benefit from hemodynamics or clinical improvements.[31] Diehm *et al*. also reported that isolated DFA revascularization was insufficient to support wound healing but might be a treatment option in CLI patients with pain at rest.[32] Unlike these studies, in the current study, DFA was occluded during the EVT, and the procedure was completed with the revascularization of the occluded SFA. No additional intervention was applied to the DFA because of the sufficient flow in the SFA and distal arteries. There was no pain at rest or wound healing problems observed in those occluded DFA patients. The main point we want to emphasize here is that DFA occlusion might accidentally occur during EVT. In such a case, if the blood flow to the SFA and distal arteries is sufficient, the EVT procedure could be concluded with an occluded DFA, which can be followed up closely. Further intervention to the DFA involves the risk of re-occlusion of the SFA ostium, which could have catastrophic results for limb salvage and should be avoided.

The main limitations of our study come from the nature of the retrospective design in limited selective cases. The authors believe, however, this study contributes to the literature on revascularization of SFA ostial occlusion methods, long-term follow-up, and accidentally occurring DFA occlusion consequences in EVT.

Conclusion

Even in challenging SFA ostial lesions, the use of several different approaches has high success rates in EVT. The results of this study showed no significant difference in the patency rates of balloon angioplasty and stenting in SFA ostial lesions. Therefore, primary stenting should be avoided for cost efficiency and not to prevent future surgical options. During the SFA ostial lesion intervention, DFA occlusion may be encountered, in which case revascularization of the SFA is the priority, even if the procedure ends with occluded DFA. A patent SFA and good distal flow will be sufficient for foot nutrition and will not cause hemodynamic or clinical complaints.

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Conflicts of interest
There are no conflicts of interest.

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