Antegrade and Retrograde Crossing of Chronic Total Occlusions Using the Outback Re-entry Device

Timothy W.I. Clark, MD, MSc[1]; Ansar Z. Vance, MD[1]; Mark P. Mantell, MD[2]; Shilpa Reddy, MD[1]; Christopher Shackles, DO, MPH[1]

Abstract

Purpose. The Outback device (Cordis) enables true lumen re-entry during subintimal recanalization of chronic total occlusions (CTOs). This study compared outcomes of patients who underwent subintimal recanalization of lower-extremity arterial CTOs utilizing the Outback device via antegrade and retrograde approaches. **Methods.** A retrospective analysis identified 39 patients with Rutherford 3 (n = 13), 4 (n = 13), and 5 disease (n = 13) where the Outback device was utilized (19 antegrade crossing femoropopliteal CTOs, 20 retrograde [17/20 transpedal access crossing femoropopliteal/tibioperoneal CTOs, 3/20 femoral access crossing iliac CTOs]) after conventional techniques failed. Mean age was 70.5 years and 67% were men. Most patients had multifocal and/or long-segment occlusions, with 41% having combined above- and below-knee disease. **Results.** Overall technical success was 90% (95% antegrade and 85% retrograde cohort; *P*=.15). There were no major complications and 4 minor complications (prolonged bleeding, femoral pseudoaneurysm requiring thrombin injection, and 2 small access-site hematomas). Fifteen percent of the retrograde cohort subsequently underwent distal bypass, compared with 0% in the antegrade cohort (*P*=.23). A single amputation occurred, in the antegrade group. Twelve-month target-vessel unassisted primary patency was higher with antegrade use (76% in the antegrade group vs 48% in the retrograde group; *P*=.03), but 12-month assisted primary patency was similar (85% in the antegrade group vs 79% in the retrograde group; *P*=.85). **Conclusion.** The Outback can be used safely and effectively from both antegrade and retrograde approaches during recanalization of CTOs. Lower target-vessel unassisted primary patency using the retrograde transpedal approach indicates the need for closer surveillance to achieve high rates of limb salvage.

J CRIT LIMB ISCHEM 2021;1(1):E11-E16.

Key words: chronic total occlusions, lower-extremity occlusions, retrograde transpedal approach

Peripheral arterial disease affects nearly 20% of the population and more than 200 million people worldwide.[1] Chronic total occlusions (CTOs) of lower-extremity vessels are present in more than 40% of patients with symptomatic peripheral vascular disease.[2] Successfully traversing these lesions with endovascular techniques can be challenging secondary to a variety of lesion-related characteristics, including a resistant fibrous cap, severe calcification, and long lesion length.[3] While the development of subintimal and rendezvous techniques has increased the success rate in traversing CTOs, re-entering the true lumen of the target vessel remains a challenge.[4,5] Failure to gain re-entry into the true lumen after attempting subintimal recanalization can lead to significant increases in procedure-related complications secondary to compromise of collateral vasculature and may result in subsequent amputation.[3,5]

The Outback re-entry catheter (Cordis) is one of several devices that has been developed to overcome this challenge of true lumen re-entry. The Outback catheter has a hollow, curved needle attached to the distal end of the catheter. This needle can be properly aligned and advanced through a side port under fluoroscopic guidance to achieve re-entry and 0.014″ diameter guidewire passage into the true lumen of the target vessel.[6]

The Outback device is intended for crossing of lower-extremity CTOs from an antegrade direction. However, there are circumstances in which the Outback device may be advantageous from a retrograde access when spontaneous re-entry fails. For example, when attempting antegrade crossing of a CTO from a contralateral femoral approach, advancement of the Outback device over a steep aortic bifurcation may be challenging. Advancing the Outback device antegrade through the subintimal space

TABLE 1. Patient demographics.

Patient Demographics	Patients (n = 39)
Men	26 (67%)
Age (years)	
Mean	70.5 ± 9.6
Range	44-90
Diabetes mellitus	
Type I	12 (31%)
Type II	13 (33%)
Insulin dependent	17 (44%)
Hypertension	39 (100%)
Dyslipidemia	36 (92%)
Chronic kidney disease	16 (41%)
Hemodialysis	8 (20.5%)
Coronary artery disease	36 (92%)
Ambulatory	38 (97%)
Smoking	
Never	9 (24%)
Prior	20 (54%)
Active	8 (22%)
Rutherford class	
3	13 (33%)
4	13 (33%)
5	13 (33%)
6	0 (0%)
Prior amputation	4 (10%)
Prior bypass	5 (13%)

Data presented as mean ± standard deviation or number (%).

may also be difficult due to cumulative friction from proximal calcified plaque. Finally, retrograde use of the Outback device may be helpful when crossing tibial vessel CTOs. However, there are limited data on the use of the Outback device from a retrograde approach. This study compares clinical outcomes of patients who underwent subintimal recanalization of lower-extremity arterial lesions utilizing the Outback re-entry device via antegrade and retrograde approaches.

Methods

A retrospective, single-center study was performed at a tertiary referral center and was approved by the institutional review board. Using a prospectively maintained database, 42 patients with symptomatic lower-extremity peripheral arterial disease treated via endovascular intervention with the Outback device over a 9-year period ending in 2020 were identified. Three of these patients were lost to follow-up, leaving 39 patients included in the study. Patients in whom the Outback device was used in the aorta (for example, during aortic dissection fenestration) were excluded from the study.

Patient population. Patient demographics and comorbidities are detailed in Table 1. The mean patient age was 70.5 ± 9.6 years and 67% were men. Rutherford classification of patients in the study cohort is also summarized in Table 1. The Outback device was used in conventional antegrade technique in 19 cases, all of which were femoropopliteal CTOs, and in retrograde technique in 20 cases after conventional endovascular crossing techniques had failed. In 17/20 retrograde cases (85%), the Outback device was introduced via transpedal access to cross femoropopliteal or tibioperoneal CTOs and in 3/20 cases (15%), the device was introduced via a common femoral access to traverse iliac CTOs. The majority of patients had multifocal and/or long-segment (>10 cm) occlusions, with 49% involving the femoropopliteal segments and 41% with combined above- and below-knee disease.

Endovascular treatment. Endovascular treatment was performed at the discretion of the performing provider, as described briefly. Initial access of the common femoral artery was gained in antegrade or retrograde fashion, based on the location of the diseased arterial segment. When treating distal disease without a more proximal lesion, the common femoral artery was accessed in an antegrade fashion whenever possible. Access was performed under direct ultrasound guidance and using standard micropuncture technique with subsequent placement of a 5-7 Fr vascular sheath. After performing diagnostic angiograms, the patient was systemically heparinized using a weight-based bolus of heparin (70 U/kg) and intermittent boluses to maintain activated clotting times > 250 seconds during the procedure. We then attempted to cross the diseased arterial segment in antegrade fashion, while remaining intraluminal using a 4 Fr catheter system and a 0.035″ hydrophilic wire. When intraluminal attempts to cross the lesion were unsuccessful, an intentional subintimal access was achieved utilizing established techniques.[5] If conventional attempts to re-enter the true lumen were unsuccessful, retrograde transpedal access was obtained with placement of only a 3 Fr inner micropuncture initially (Figure 1). Sequential escalation of transpedal access size was performed as needed for intended devices. True-lumen re-entry was typically first attempted utilizing traditional catheters, snares, controlled antegrade and retrograde tracking (CART) technique, or reverse CART technique, per operator preference.[7] If true-lumen re-entry was still unsuccessful from rendezvous techniques, sharp re-entry with the Outback device was attempted via the antegrade access or with placement of a 6 Fr thin-walled

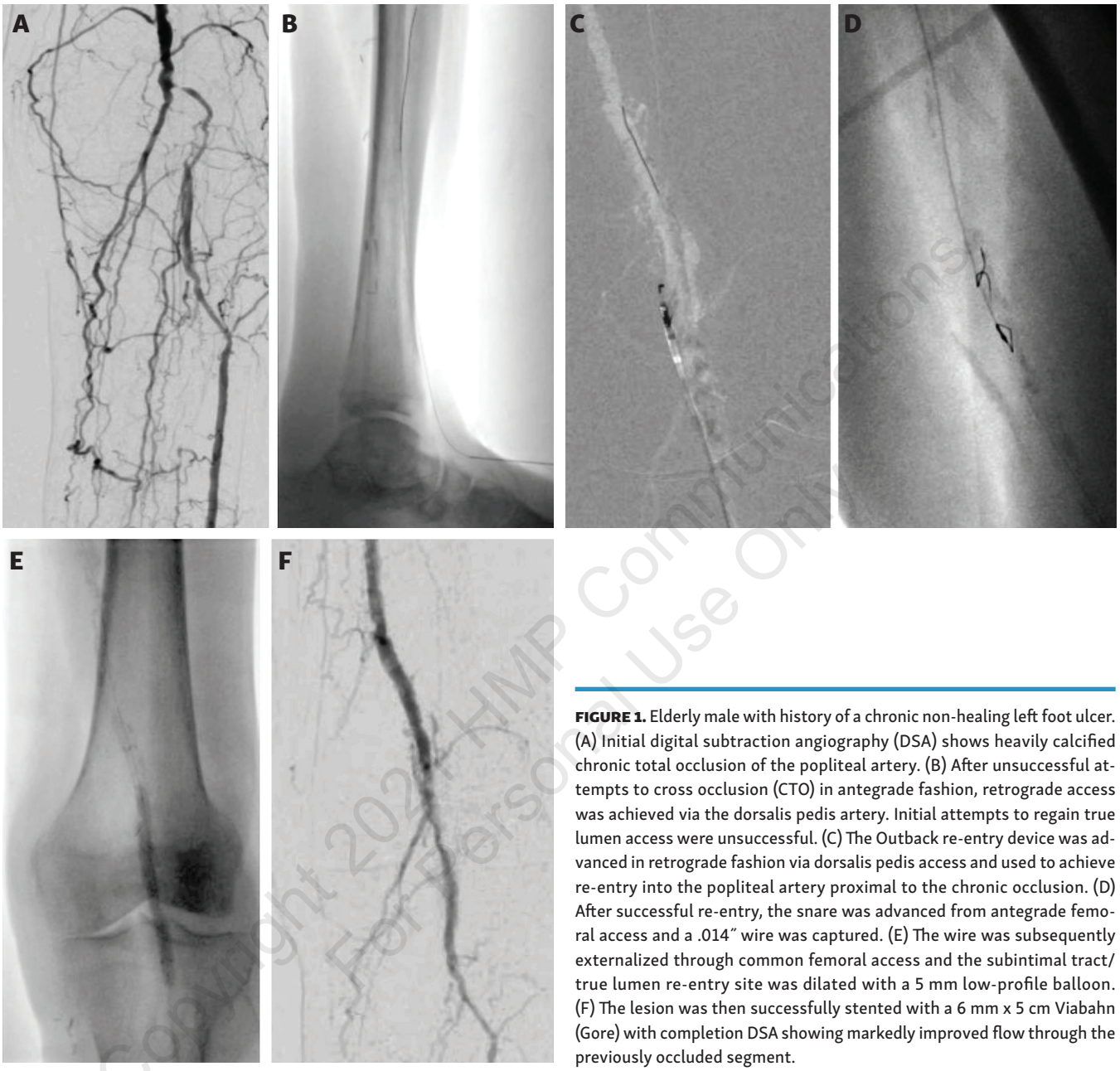

FIGURE 1. Elderly male with history of a chronic non-healing left foot ulcer. (A) Initial digital subtraction angiography (DSA) shows heavily calcified chronic total occlusion of the popliteal artery. (B) After unsuccessful attempts to cross occlusion (CTO) in antegrade fashion, retrograde access was achieved via the dorsalis pedis artery. Initial attempts to regain true lumen access were unsuccessful. (C) The Outback re-entry device was advanced in retrograde fashion via dorsalis pedis access and used to achieve re-entry into the popliteal artery proximal to the chronic occlusion. (D) After successful re-entry, the snare was advanced from antegrade femoral access and a .014″ wire was captured. (E) The wire was subsequently externalized through common femoral access and the subintimal tract/true lumen re-entry site was dilated with a 5 mm low-profile balloon. (F) The lesion was then successfully stented with a 6 mm x 5 cm Viabahn (Gore) with completion DSA showing markedly improved flow through the previously occluded segment.

sheath (Terumo) via retrograde access. The preference was for antegrade Outback re-entry when possible to minimize pedal access size. After reaching the distal end of the target lesion, re-entry was performed utilizing the Outback catheter as close to re-established true lumen as possible (Figure 1). In patients with issues deterring conventional femoral access (hostile anatomy from prior surgical bypass/revision or concomitant common femoral disease), a primary pedal approach was undertaken.

The Outback catheter was advanced over an 0.014″ guidewire. The orientation of the needle tip toward the intraluminal re-entry site was established utilizing 2 orthogonal fluoroscopic views and appropriately aligning the integrated fluoroscopic markers.[6] After withdrawing the 0.014″ wire back into the Outback catheter, the curved nitinol needle of the device was advanced into the vessel lumen. The 0.014″ wire was advanced into the true lumen of the vessel, and the Outback catheter was subsequently exchanged for a low-profile balloon, which was used to predilate the site of re-entry to allow for 0.035″ wire exchange and ultimately definitive treatment (Figure 1).

The diseased arterial segments were then treated at the discretion of the operator utilizing balloons, atherectomy devices, or stents. A completion angiogram was performed to ascertain the presence of a persistent flow-limiting dissection, rupture, or

TABLE 2. Lesion characteristics and interventions performed.

Characteristic	Patients (n = 39)
Retrograde Outback use	19 (45.2%)
Antegrade Outback use	20 (47.7%)
Lost to follow-up	3 (7.1%)
Lesion location	
Aortoiliac	3 (7.7%)
Femoropopliteal	19 (48.7%)
Infrapopliteal	1 (2.6%)
Femoropopliteal + infrapopliteal	16 (41%)
Outcomes	
Technical success	35 (89.7%)
Technical failure	4 (10.3%)
Major complications	0 (0%)
Minor complications	4 (10.3%)
Interventions performed	
PTA alone	8 (22.9%)
Stent placement	27 (77.1%)
Above knee	22 (62.3%)
Below knee	0 (0%)
Above and below knee	5 (14.2%)
Drug-eluting balloon	8 (22.9%)
Drug-eluting stent	9 (25.7%)
Rheolytic mechanical thrombectomy	4 (11.4%)
Atherectomy	2 (5.7%)

Data presented as number (%).

TABLE 3. Comparison of retrograde vs antegrade Outback utilization cohorts.

	Retrograde (n = 20)	Antegrade (n = 19)	*P*-Value
Technical success	17 (85%)	18 (95%)	.15[a]
Technical failure	3 (15%)	1 (5%)	
Subsequent amputation	0 (0%)	1 (5%)	.29[a]
Mean time to amputation	n/a	5 days	
Type of amputation			
Ray	0 (0%)	0 (0%)	
Transmetatarsal	0 (0%)	0 (0%)	
Below knee	0 (0%)	1 (5%)	.29[a]
Above knee	0 (0%)	0 (0%)	
Limb salvage rate	20 (100%)	18 (95%)	.29[a]
All-cause mortality	5 (25%)	7 (37%)	.25[a]
Subsequent bypass	3 (15%)	0 (0%)	.01[a]
Follow-up procedures (n)			
Mean	0.9 ± 1.1	0.4 ± 0.7	.08[b]
Range	0-4	0-2	

Data presented as number (%).
[a]Fisher's exact test; [b]Unpaired t-test.

distal embolus. Tibial run-off vessels were described as patent if they provided in-line flow to the foot or occluded if they contained proximal or mid-level occlusions with or without distal reconstitution.

Post procedure and follow-up. Patients were started on clopidogrel with initial 300 mg oral loading dose followed by 75 mg daily for a minimum of 3 months if stents were placed. Patients were maintained on aspirin 81 mg oral daily for life. Postprocedural follow-up comprised clinic visits at 1, 3, 6, and 12 months after the procedure and yearly thereafter. At each visit, clinical evaluation included non-invasive studies (ankle-brachial indices [ABIs] ± pulse volume recordings [PVRs]/segmental limb pressures [SLPs] and Doppler ultrasound). Cross-sectional imaging (computed tomographic angiography and magnetic resonance angiography) was reserved for patients with significant clinical concerns for restenosis/occlusive disease and suboptimal evaluation with ABI, PVR/SVP, or Doppler ultrasound.

Statistical analysis. Demographic data were used to tabulate the characteristics of the included patients as reported in the hospital clinical database. Complications were defined in accordance with consensus reporting guidelines.[8] Statistical evaluations were conducted to investigate associations/differences in technical success, subsequent amputation, all-cause mortality, complications, primary/assisted primary/secondary patency, and reintervention frequency. All statistical analyses were conducted using STATA software, version 11 (STATA SE). A *P*-value of ≤.05 was considered statistically significant. Subgroup Kaplan-Meier analyses were constructed using Prism (GraphPad Software).

Results

Procedure outcomes. Technical success in crossing the CTO was achieved in 35 of 39 total cases (90%) (Table 2). Technical success was 95% in the antegrade group (18/19 cases) and 85% in the retrograde group (17/20 cases), which was not statistically significant (*P*=.15) (Table 3). Of note, even in the failure cohort, there were no instances in which the Outback device could not be advanced in retrograde fashion to engage the target lesion.

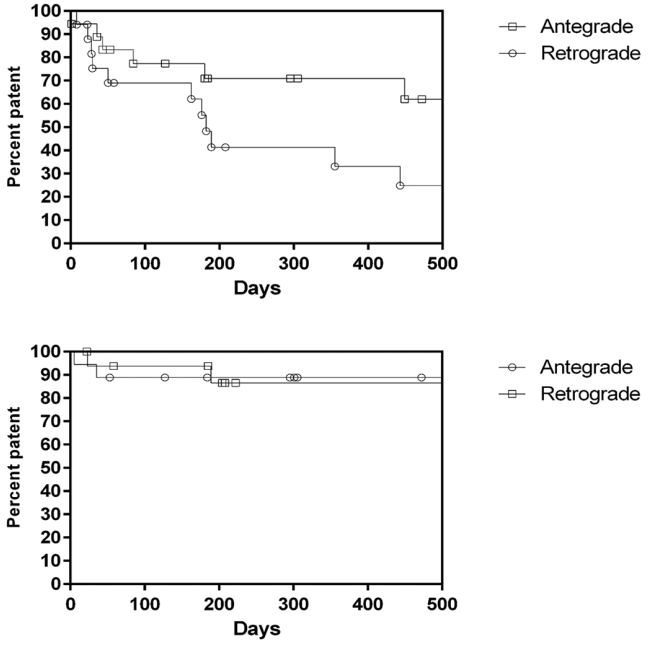

FIGURE 2. Kaplan-Meier estimates of (A) primary unassisted patency and (B) primary assisted patency between antegrade and retrograde use of the Outback re-entry catheter. There was superior 12-month target-vessel primary unassisted patency with antegrade use (76% antegrade vs 48% retrograde; *P*=.03), but similarly high 12-month assisted primary patency (85% antegrade vs 79% retrograde; *P*=.85).

The majority of patients (77%) required stent placement secondary to insufficient luminal gain after angioplasty, with the majority of the stents (62%) placed above the knee. Although almost half of the study cohort (44%) suffered from a component of infrapopliteal disease, only a small fraction of patients (14%) required both above- and below-knee stent placement for combined disease (Table 2).

There were no major procedure-related complications and 4 minor complications reported (2 in the antegrade group and 2 in the retrograde group). The minor complications were prolonged bleeding in 1 patient, femoral pseudoaneurysm requiring thrombin injection in 1 patient, and small access-site hematomas in 2 patients. The difference in incidence of complications between the antegrade and retrograde groups was not statistically significant (Fisher's exact test *P*=.96).

Follow-up outcomes. A single amputation occurred in the antegrade group on postprocedure day 5, while none occurred in the retrograde group. The single patient requiring amputation initially presented with acute critical limb ischemia secondary to a thrombosed stent complex. While this lesion was able to be successfully recanalized utilizing the Outback device in the traditional antegrade fashion, the foot remained cool and mottled, requiring eventual amputation.

There was no significant difference in all-cause mortality between groups (*P*=.50). A total of 3 patients (15%) in the retrograde cohort subsequently underwent successful distal bypass, compared with 0% in the antegrade cohort (*P*=.23). Almost half of all patients (18/39) required reintervention, with a mean number of 0.4 reinterventions in the antegrade group (range, 0-2) and 0.9 reinterventions in the retrograde group (range, 0-4). While there was a trend toward an increased reintervention rate in the retrograde group, this did not reach statistical significance (*P*=.08).

Subgroup Kaplan-Meier analysis of antegrade vs retrograde transpedal cohorts among technically successful Outback utilizations showed superior 12-month target-vessel primary unassisted patency with antegrade use (76% in the antegrade cohort vs 48% in the retrograde cohort; *P*=.03), but similar 12-month assisted primary patency (85% in the antegrade cohort vs 79% in the retrograde cohort; *P*=.85) (Figure 2).

Discussion

Endovascular recanalization of CTOs can be achieved either via intraluminal or subintimal approaches, with similar clinical outcomes between both approaches.[9-11] Intraluminal crossing cannot always be achieved and remains particularly challenging in the setting of long-segment or heavily calcified CTOs. The development of subintimal crossing techniques has increased the ability to traverse these occlusions; however, true-lumen re-entry can remain challenging.[4,5,9] Prior studies have demonstrated the feasibility, safety, and efficacy of subintimal flossing with antegrade and retrograde intervention (SAFARI) to enable true-lumen re-entry.[12-16] While SAFARI technique is associated with high technical success, advanced techniques may be necessary if re-entry still cannot be achieved. Re-entry devices, such as the Outback re-entry catheter, have been developed to address this need.

Recent studies have shown high success rates of true-lumen re-entry utilizing the Outback catheter, with 96% reported technical success rate and 2% major complication rate.[17,18] However, limited data are available regarding outcomes and complication rates of Outback re-entry device use in retrograde fashion. The present study aims to report institutional experience with retrograde Outback re-entry device use and compare outcomes with antegrade use. The results showed no statistically significant difference in technical success, overall survival, or complication rates when the Outback re-entry catheter was utilized in antegrade or retrograde directions. Notably, no complications directly related to retrograde use of the Outback device, such as retrograde access-site occlusion/dissection or tibial vessel perforation, were observed. While antegrade Outback device use showed superior 12-month target-vessel unassisted primary patency as compared with retrograde use (76% in the antegrade cohort vs 48% in the retrograde cohort; *P*=.03), 12-month assisted primary patency was similar in both groups (85% in the antegrade cohort vs 79%

in the retrograde cohort; *P*=.85). There was a trend toward an increased reintervention rate in the retrograde group; however, this did not reach statistical significance (*P*=.08). It is possible that this observation is influenced by a larger percentage of the retrograde cohort comprising patients with infrapopliteal disease (antegrade 36% vs retrograde 50%). The smaller vessel caliber and often concomitant above-knee disease represent a more advanced disease presentation, which may require closer attention during follow-up.

Study limitations. This study has several limitations. The sample size was small and data were collected retrospectively. Use of the Outback re-entry device and decision to obtain retrograde access was left to the operator, thus introducing significant selection bias. Furthermore, treatment of the target lesion was determined by the operator and subject to heterogeneity within the cohort. Patients did not undergo routine surveillance cross-sectional imaging of the distal access site; therefore, delayed access-site occlusions or stenoses may have been under-reported. Given the smaller size of pedal vessels, potential loss or compromise of the distal access site due to the need for a sheath when using Outback device in retrograde fashion should be considered. We also recognize the potential for inadvertent vessel injury resulting in arterial extravasation and possible compartment syndrome when performing Outback-facilitated re-entry. Although this complication was not observed in the present series, it is imperative to keep appropriate stent-grafts on hand in case vascular re-entry results in vessel rupture.

Conclusion

Use of the Outback re-entry catheter was associated with similarly high rates of technical success when comparing antegrade and retrograde use, even when the latter approach required tibioperoneal access and Outback device advancement via tibial arteries. Higher primary-assisted patency was observed in the antegrade group, although assisted patency rates were similar. The use of this technology for these applications appears safe and effective and has the potential to further increase the spectrum of patients who can benefit from successful endovascular recanalization.

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From the [1]Section of Interventional Radiology, Department of Radiology, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania; and [2]Division of Vascular Surgery, Department of Surgery, Penn Presbyterian Medical Center, University of Pennsylvania, Philadelphia, Pennsylvania.

Disclosure: The authors have completed and returned the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Clark reports royalties from Teleflex and Merit Medical; consultant income from Teleflex, Becton Dickinson, Forge Medical, and B. Braun; shareholder in Forge Medical and Verix Health. The remaining authors report no conflicts of interest regarding the content herein.

The authors report that patient consent was provided for publication of the images used herein.

Manuscript accepted February 12, 2021.

Address for correspondence: Timothy W.I. Clark, MD, Professor of Clinical Radiology and Surgery, University of Pennsylvania Perelman School of Medicine, Division of Interventional Radiology, Penn Presbyterian Medical Center, 51 N 39th St., Philadelphia, PA 19104. Email: Timothy.Clark@pennmedicine.upenn.edu