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Anterolateral Popliteal Puncture Technique: A Novel Retrograde Approach for Chronic Femoropopliteal Occlusions

Michinao Tan, MD[1], Kazushi Urasawa, MD, PhD[1], Ryoji Koshida, MD, PhD[1], Takuya Haraguchi, MD[1], Shunsuke Kitani, MD[1], Yasumi Igarashi, MD, PhD[1], and Katsuhiko Sato, MD, PhD[1]

Abstract

Purpose: To describe the feasibility and safety of an anterolateral popliteal puncture technique as a retrograde access to chronic total occlusions (CTOs) in the femoropopliteal segment. **Methods:** Twenty consecutive patients (mean age 75.1±10.9 years; 13 women) with symptomatic femoropopliteal occlusive disease underwent endovascular therapy via a retrograde access using the anterolateral popliteal puncture technique. With the patient supine, the P3 segment of the popliteal artery was accessed with a sheathless technique intended to provide minimally invasive access. Subsequent to a wire rendezvous technique in the CTO, the antegrade guidewire was advanced to the below-the-knee artery. Hemostasis across the P3 segment was secured with balloon inflation alone or combined with thrombin-blood patch (TBP) injection. **Results:** Both the anterolateral popliteal puncture technique and subsequent revascularization were successful in all patients. Mean hemostasis time for balloon inflation only was 7.73±4.03 vs 4.78±0.78 minutes for balloon inflation with TBP injection. There were no in-hospital deaths or complications, including pseudoaneurysms, arteriovenous fistulas, hematomas, embolic complications, or nerve damage. **Conclusion:** The anterolateral popliteal puncture technique is useful as an alternative retrograde access vs a conventional transpopliteal approach for CTOs in the femoropopliteal segment if antegrade recanalization has failed. This technique may become one option for retrograde access in patients with severe below-the-knee lesions or with CTOs that extend to the P2 segment of the popliteal artery. Furthermore, this technique has the added benefit of allowing patients to remain in the supine position throughout treatment.

Keywords

chronic total occlusion, endovascular intervention, femoropopliteal segment, outcome analysis, peripheral artery disease, popliteal artery, retrograde access, superficial femoral artery, vascular access

Introduction

Although considerable progress has been made in the application of endovascular therapy for femoropopliteal occlusive disease,[1,2] chronic total occlusion (CTO) in this vascular segment remains technically challenging. If an antegrade wire maneuver fails, reentry devices are sometimes useful, and although Kitrou et al[3] reported a 93% success rate with the Outback catheter, the use of such devices adds to the cost of the procedure. Should a reentry device fail to access the distal true lumen, a retrograde approach might be considered to achieve successful recanalization. The conventional transpopliteal approach has been used successfully,[4] but this technique requires that the patient be moved to a prone position. More recent reports[5–7] have described retrograde approaches in the supine position, but each has advantages and disadvantages. This study reviews a single-center experience with a novel anterolateral popliteal puncture technique that enables access to the P3 segment of the popliteal artery without the need to reposition the patient during the procedure.

[1]Cardiovascular Center, Tokeidai Memorial Hospital, Sapporo, Hokkaido, Japan

Corresponding Author:
Michinao Tan, Cardiovascular Center, Tokeidai Memorial Hospital, 2-3 North-1, East1, Chuo-Ku Sapporo, Hokkaido 060-0031, Japan.
Email: m-tan@tokeidaihosp.or.jp

Methods

Patient Population

Between December 2013 and October 2016, 273 symptomatic patients with femoropopliteal CTOs underwent endovascular treatment of total femoropopliteal occlusions (>3 months old by history) without inflow lesions evident on the diagnostic arteriogram. In 117 patients, a retrograde access was necessary after failure of antegrade access. The preferred puncture site was the distal superficial femoral artery (SFA; n=69) or infragenicular arteries (n=17). Transcollateral angioplasty was used in 11 cases. However, these options were not feasible in 20 patients (mean age 75.1±10.9 years; 13 women) who were treated via a retrograde access to the P3 popliteal segment [center of the knee joint space to the origin of the anterior tibial artery (ATA)[8]] using the anterolateral popliteal puncture technique. These patients constitute the cohort for analysis.

The baseline patient and lesion characteristics are presented in Table 1. The majority of lesions spanned the SFA to the P1 segment of the popliteal artery. All lesions were classified TransAtlantic Inter-Society Consensus (TASC) II[9] C and D. The mean total lesion length was 30.2±3.8 cm (mean CTO length 26.4±7.5 cm). The majority of patients had 0- or 1-vessel runoff.

Table 1. Baseline Characteristics of the 20 Patients in the Study.[a]

Patient characteristics	
Age, y	75.1±10.9
Men	7
Hypertension	10
Dyslipidemia	5
Diabetes	10
Body mass index, kg/m^2	21.9±3.68
Coronary artery disease	11
Cerebrovascular disease	5
Hemodialysis	5
Current/previous smoker	4 / 8
Rutherford category 3 / 4 / 5	11 / 1 / 8
Medications	
Aspirin	13
Thienopyridine	18
Cilostazol	10
Lesion characteristics	
SFA only / SFA-popliteal	4 / 16
TASC C / D	20
Lesion length, cm	30.2±3.8
CTO length, cm	26.4±7.5
Runoff 0 /1 / 2	1 / 13 / 6
PACSS 0 / 1 / 2 / 3 / 4	1 / 10 /2 / 3 / 4
ABI pre/post	0.39±0.26 / 0.87±0.24
SPP, mm Hg	
Dorsalis pedis pre / post	18.5±11.2 / 51.1±28.3
Plantar pre / post	17.2±9.79 / 45.0±17.1

Abbreviations: ABI, ankle-brachial index; CTO, chronic total occlusion; PACSS, Proposed Peripheral Arterial Calcium Scoring System; SFA, superficial femoral artery; SPP, skin perfusion pressure; TASC, TransAtlantic Inter-Society Consensus.
[a]Continuous data are presented as the means ± standard deviation; categorical data are given as the counts.

Retrograde Access

All procedures were performed by 4 experienced doctors trained in this specific technique. After insertion of a 4.5-F or 6-F sheath from the ipsilateral or contralateral common femoral artery, unfractionated heparin (5000 units) was injected from the sheath and an additional 2000 units were given every hour. After antegrade recanalization failure and unavailability of other distal access routes, a retrograde approach via the P3 segment was performed (Figure 1). To avoid turning the patient to the prone position, the P3 segment was approached coaxially. First, an angiogram in an ipsilateral oblique (30°–45°) view (eg, right oblique view for the right popliteal artery) was taken to determine the appropriate puncture site (Figure 2A). Under fluoroscopy guidance, a 10-cm-long, 20-G needle (Medikit, Tokyo, Japan) was inserted several centimeters below the superior tibiofibular joint on the body surface (Figure 2B). While advancing the needle, the distance to the popliteal artery was periodically confirmed using fluoroscopy in a contralateral oblique (45°–60°) view (Figure 2C). During these procedures, contrast was injected to visualize the P3 segment; when appropriate, guidance via calcification was useful to reduce the need for contrast. After successful puncture, a 0.014-inch guidewire (Regalia XS 1.0; Asahi Intecc Co Ltd, Aichi, Japan) was advanced into the popliteal artery, and the needle was carefully extracted. Using a sheathless technique, a 2.6-F microcatheter, such as the 60-cm Prominent neo (Tokai Medical Co, Aichi, Japan) or Ichibanyari PAD2 (Kaneka Corp, Osaka, Japan), was then introduced to support the 0.014-inch guidewire (Figure 2D).

Retrograde Recanalization

If the first attempt to penetrate the distal end of the CTO with the 0.014-inch Regalia XS 1.0 supported by the microcatheter failed due to hard plaque or heavy calcification, a 0.014-inch tapered and stiff-tipped guidewire, such as Astato XS 9-12 or Astato XS 40 (Asahi Intecc Co Ltd.), was used to penetrate the distal cap of the CTO. Once those 0.014-inch guidewires passed the distal cap, they were exchanged for either a 0.014-inch hydrophilic-coated polymer-jacketed guidewire (Chevalier floppy; Cordis, a Cardinal Health company, Milpitas, CA, USA) or a 0.014-inch, nontapered, stiff-tipped guidewire (Naveed4 Hard15; Terumo, Tokyo, Japan). Subsequent to using a wire rendezvous technique[10] in the CTO, the antegrade 0.014-inch

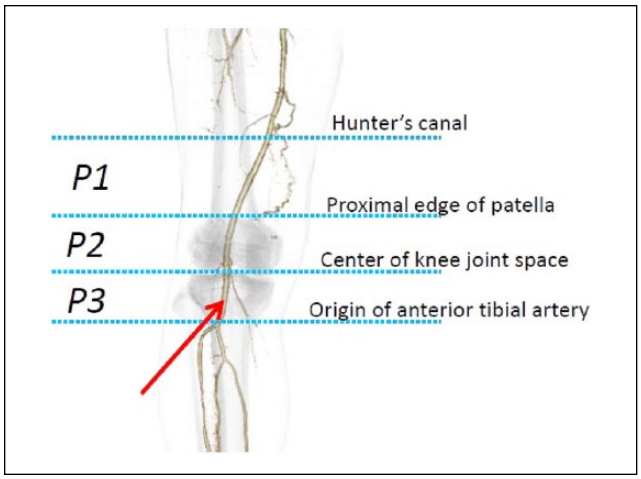

Figure 1. A drawing of a right leg in the supine position. The arrow indicates the entry direction and puncture site for a retrograde approach via the P3 segment of the popliteal artery using the anterolateral popliteal puncture technique.

guidewire was advanced to the below-the-knee (BTK) artery (Figure 2E) using intravascular ultrasound (IVUS) to confirm the location of the guidewire, the diameters of both the SFA and popliteal artery, and the characteristics of the plaque.

After IVUS examination, the occluded SFA was dilated with a 3- or 4-mm standard balloon. The retrograde 0.014-inch guidewire and microcatheter were then pulled back to just above the P3 segment, a 3- or 4-mm standard balloon was inflated across the puncture site to achieve hemostasis (Figure 3A). In addition, at the discretion of the operators, a transcatheter thrombin-blood patch (TBP) injection[11] (1000 units) was given through a microcatheter from the outside of the vessel to effectively facilitate hemostasis; the injection was given under balloon inflation within the vessel to avoid iatrogenic embolic complications. After successful hemostasis was confirmed by digital subtraction angiography (Figure 3B), balloon angioplasty with a 5- or 6-mm standard balloon was performed along the entire SFA followed by bare metal stenting if necessary.

Definitions and Outcomes

The primary outcome was successful revascularization leaving <30% residual stenosis in the SFA and popliteal artery. The secondary endpoints were in-hospital mortality and morbidity (pseudoaneurysms, arteriovenous fistulas, hematomas, embolic complications, and nerve damage). Clinical follow-up including duplex ultrasound was scheduled for 1 month after the procedure.

All angiograms were evaluated independently by 2 operators for procedure success, complications, and calcification. Calcium in the SFA and popliteal artery was assessed using unsubtracted angiograms; the degree of lesion calcification was categorized utilizing the Proposed Peripheral Arterial Calcium Scoring System (PACSS): grade 0 was defined as no visible calcium at the target lesion site; grades 1 and 2 were unilateral calcification <5 or ≥5 cm, respectively; and grades 3 and 4 were bilateral calcification <5 or ≥5 cm, respectively.

Preprocedure computed tomography (CT) scans acquired as part of a research protocol in the study patients were reviewed to measure the depth of the popliteal artery from the body surface relative to an anterolateral popliteal puncture vs a conventional transpopliteal approach.[4] The distance from the body surface on the anterolateral side of the knee through the interosseous membrane to the P3 segment was compared with the distance from the back of the knee to the P2 segment in the same patient (Figure 4).

Statistical Analysis

Continuous data are presented as the means ± standard deviation; categorical data are given as the counts. An unpaired *t* test was used to compare continuous variables and a chi-square test was used for categorical data, with statistical significance set at $p<0.05$. Statistical analysis was performed using Dr SPSS open access software.

Results

Both the anterolateral popliteal puncture technique and subsequent revascularization were successful in all patients. Hemostasis across the P3 segment of the popliteal artery was secured by balloon inflation alone in 8 patients and by balloon inflation with TBP injection in 12. Mean hemostasis time for balloon inflation only was 7.73±4.03 minutes vs 4.78±0.78 minutes ($p=0.021$) for balloon inflation with TBP injection. There were no in-hospital deaths or complications.

The mean distance from the body surface of the anterolateral side of the knee through the interosseous membrane to the P3 segment in the 20 patients was 41.8±3.3 vs 24.1±3.8 mm ($p<0.001$) for the distance from the back of the knee to the P2 segment, for a mean difference of 17.7±4.8 mm.

Discussion

Endovascular therapy for femoropopliteal CTOs, especially long segment lesions and those with severe calcification, have remained technically challenging. Reentry devices, such as the Pioneer[12] and the Outback[13] catheters, are useful for femoropopliteal CTOs, but long segmental subintimal angioplasty may sometimes lead to flow-limiting dissections that require implantation of multiple stents extended to the popliteal artery. Although Scheinert et al[14] reported a high patency rate for SUPERA stents implanted for

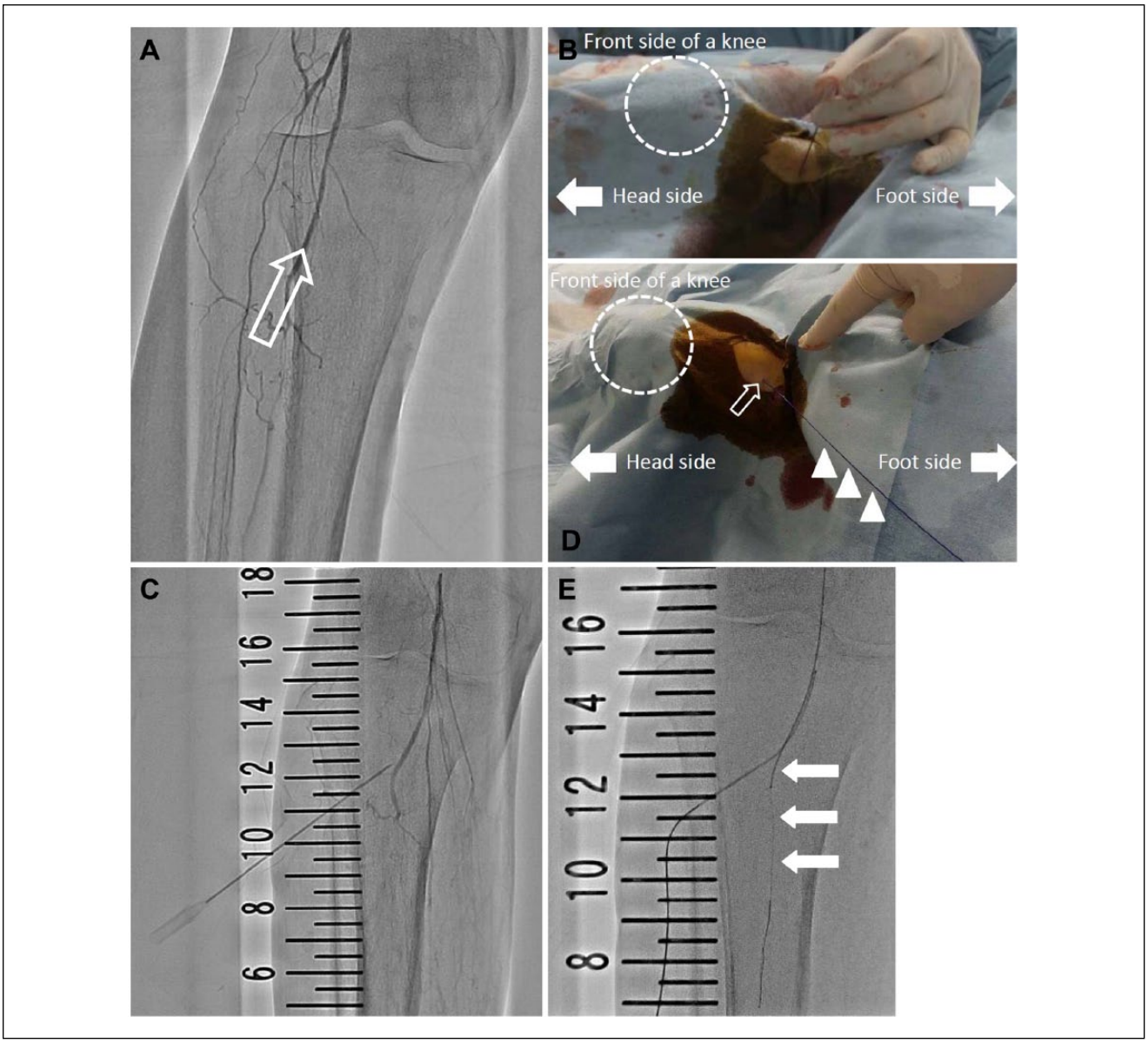

Figure 2. (A) An angiogram in an ipsilateral oblique (30°–45°) view shows a right oblique view for a right popliteal artery. The open arrow indicates the entry direction and puncture site. (B) This picture shows a right leg with a needle inserted from several centimeters below the superior tibiofibular joint on the body surface. (C) An angiogram in a contralateral oblique (45°–60°) view shows a left oblique view of the right popliteal artery that confirms the distance between the needle and the popliteal artery. (D) A microcatheter (arrowheads) introduced to support the 0.014-inch guidewire with a sheathless technique. The open arrow indicates the puncture site. (E) The antegrade 0.014-inch guidewire with a microcatheter was successfully advanced to the below-the-knee artery (arrows).

popliteal artery disease, these stents are not available in Japan. Thus, if these reentry devices fail to engage the distal true lumen in our patients, a bi-directional approach using retrograde access was considered. Transcollateral angioplasty of long SFA CTOs avoids the need for distal puncture,[15] but this technique requires a less tortuous collateral channel with an adequate diameter into which a microcatheter can pass.

Schmidt et al[5] demonstrated a technique using a retrograde SFA puncture distal to the adductor canal in the supine position, but this puncture method cannot be applied in cases when the occlusions extend distally beyond the adductor canal. The majority of our 20 cases had CTO lesions spanning the SFA to the popliteal artery.

The conventional transpopliteal approach is one of the techniques that should be considered for retrograde access,

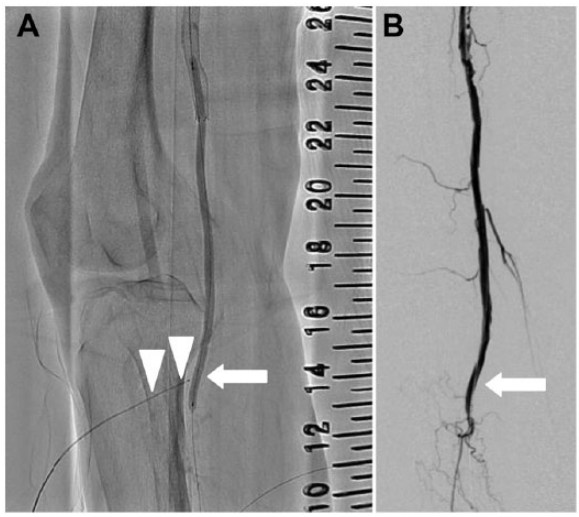

Figure 3. (A) A 3- or 4-mm standard balloon was inflated across the puncture site (arrow) to achieve hemostasis. Arrowheads show the retrograde microcatheter and wire out of the vessel. (B) Confirmation of hemostasis by digital subtraction angiography; the arrow indicates the puncture site.

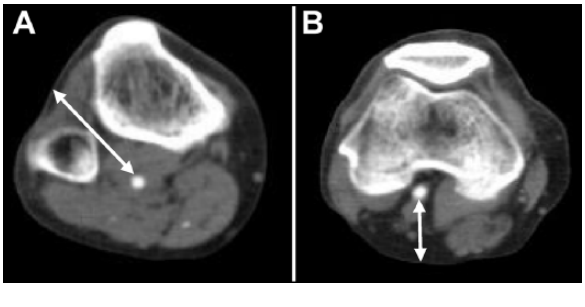

Figure 4. Evaluation of the depth of the popliteal artery from the body surface using computed tomography images; these images are from the right leg in the same patient. (A) The distance from the body surface of the anterolateral side of the knee through the interosseous membrane to the P3 segment. (B) The distance from the back of the knee to the P2 segment.

but it has several shortcomings, notably the need to change the patient to the prone position during the procedure. To overcome this weakness, Kawarada et al[6] reported the transpopliteal approach in the supine position with the patient's heel elevated, but an anterolateral popliteal puncture does not require heel elevation. In contrast to the conventional transpopliteal approach, the anterolateral popliteal puncture technique involves no change in patient position and operators can simultaneously manipulate both the antegrade and retrograde guidewires.

In our cohort, the difference in the depth of the popliteal artery for access from the front (anterolateral popliteal puncture) vs the back of the knee for the conventional transpopliteal approach was a mean 18 mm. Operators should take note of this difference when deciding how to perform a retrograde approach, especially in obese patients or those with a severely calcified popliteal artery or a bleeding tendency in light of the potential for access site complications. Although our patients had contrast-enhanced CT imaging before the procedure as part of a research protocol, not every patient can undergo contrast-enhanced CT owing to renal insufficiency. In general, ultrasound is widely used and is effective as a guide for puncture, but ultrasound imaging of the P3 segment from the body surface on the anterolateral side of the knee is not always clear, especially in obese patients. In those cases, fluoroscopy guidance with a small amount of contrast or carbon dioxide angiography could be useful for this puncture technique.

In this study, the retrograde approach was performed in all cases with a sheathless technique intended to provide minimally invasive access. Although a "double-balloon" maneuver[5] or use of reentry devices via the retrograde access site were not available, the retrograde 0.014-inch guidewire could successfully approach the antegrade guidewire thanks to new supportive microcatheters. Although strong support using a ≥3-F sheath may be favorable in severely calcified lesions, the safety of sheath insertion in terms of access site complications is currently unclear.

In the treatment of long occluded femoropopliteal disease, distal BTK arteries and the proximal ATA are also common puncture sites. In fact, a high ATA puncture[7] is close to the P3 segment of the popliteal artery. However, in the patients with an occluded ATA, as shown in Figure 2, A and C, the anterolateral popliteal puncture technique can be an alternative. Since conventional retrograde approaches via the BTK arteries require sufficient runoff, they are not feasible in patients with severe BTK lesions. In our patients, most had ≤1 runoff vessel and 9 were Rutherford category ≥4. These characteristics discouraged us from performing conventional retrograde approaches via the BTK arteries for fear of blood flow deterioration due to vasospasm or injury to those vessels. Therefore, the anterolateral popliteal puncture technique is suitable for the patients with severe BTK lesions.

Achieving successful hemostasis is just as important as successful revascularization. Comparing balloon inflation alone across the P3 segment to inflation with TBP injection demonstrated a tendency for shorter hemostasis time in the group with TBP injection. Maluenda et al[11] reported the efficacy and safety of TBP injection for catheterization-related arterial perforation, and Iida et al[7] applied this technique to their high ATA punctures. In our study, TBP injection was performed from a microcatheter outside the vessel across the puncture site under balloon inflation to

prevent iatrogenic embolic complications, which were successfully avoided. Although TBP injection under the inflation of a balloon is an effective method for hemostasis, it should not be used if blood flow cannot be stopped by balloon inflation or when the area around the puncture site is rich in collateral arteries. It is feasible that TBP injection might be applied if balloon inflation alone fails. If both antegrade and retrograde recanalization maneuvers fail, external compression should be applied for hemostasis using techniques such as tourniquet pressure.[16]

Limitations

This study was a nonrandomized, retrospective, single-center analysis of a small number of patients with heterogeneous lesion characteristics. Although the mean body mass index was almost normal in this study, in obese patients, the P3 segment is deeper from the body surface, and a longer needle may be required for this technique. The retrograde approach was performed in all cases with a sheathless technique intended to provide minimally invasive access, so this retrograde system might be less supportive in comparison with the conventional transpopliteal approach using a retrograde sheath.

Conclusion

The anterolateral popliteal puncture technique is a useful alternative to a conventional transpopliteal approach for femoropopliteal CTOs, most especially if antegrade recanalization has failed. This technique is one option for retrograde access in patients with severe BTK lesions and with SFA CTOs that extend to the P2 segment. Furthermore, this technique has the added benefit of allowing patients to remain in the supine position throughout treatment.

Declaration of Conflicting Interests

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