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TECHNICAL NOTE ARTERIAL INTERVENTIONS

Percutaneous Trans-venous Femoropopliteal Bypass in Long Occlusions of the Superficial Femoral Artery

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Abstract

Purpose This technical note describes a total percutaneous technique to perform ultrasound and fluoroscopy-assisted femoropopliteal bypass in long superficial femoral artery (SFA) lesions, using standard equipment, through a juxta-anatomical superficial femoral vein (SFV) tunnel.

Materials and methods Three percutaneous accesses were obtained under ultrasound guidance. The first was retrograde, with crossover maneuver, at the contralateral groin. The second was a proximal SFV-to-SFA stump puncture. The third was a distal popliteal artery-to-popliteal vein puncture. Through the described snaring and capture maneuvers, one single 0.018″ guide wire entered the femoral vein through the SFA stump and re-entered the popliteal artery distally. The fistulous tracts were then dilated and covered stents deployed and post-dilated.

Results Three patients aged 68 ± 3 years and presenting Rutherford 4 chronic limb ischemia were treated with this technique. The mean SFA lesion length was 22.6 ± 3 cm. The mean procedure duration was 88 ± 18 min. No intraoperative complication occurred. The postoperative course was uneventful. In particular, no deep vein thrombosis occurred. Rutherford stage decreased from 4 to 1 in all patients, with a mean follow-up duration of 6.6 ± 2 months.

Conclusion The main advantage of the technique is avoiding calcification issues by abandoning the trans-arterial recanalization approach for long calcified lesions. The second interest is its feasibility by simple endovascular means without any particular or dedicated device. However, longer follow-up is needed to assess safety and durability.

Introduction

Long occlusions of the superficial femoral artery (SFA) are challenging lesions when endovascular strategies are considered. Recent European guidelines recommend endovascular approach for < 25 cm occlusive lesions and femoropopliteal open surgical bypass for longer occlusions due to better performance at 5 years of follow-up [1–3]. However, the evidence level is low, and endovascular strategies are numerous. Increasing interest is noted in covered stents use for long SFA lesions [4]. In all scenarios, the main problem remains the endoluminal calcium [5]. With that in mind, alternate tunnels for "exotic" covered stenting have been reported, and dedicated devices are under evaluation [6, 7]. We describe a total percutaneous femoropopliteal endo-bypass in long superficial femoral artery lesions, using the femoral vein as a juxta-anatomical route to the covered stents that constitute the bypass, with the use of standard endovascular equipment.

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Materials and Methods

Patients Selection

Patients considered for this technique were all presenting 1/ TASC-D lesions of the superficial femoral artery [2]; 2/ ≥ Rutherford 4 stage of occlusive disease; 3/a clinical status deemed unfit for open surgery; 4/a ≥ 10 mm diameter femoral vein. Patients did not have any history of DVT, and informed consent was obtained.

Technical Aspects

The present cases were performed in a surgical theater equipped with a flat detector mobile C-Arm (Philips Veradius, Philips Medical systems, Netherlands, B.V) and a mobile ultrasound system (Toshiba Aplio i900, Toshiba, Tokyo, Japan). The procedure was done under general anesthesia or local anesthesia with sedation. The entire lower limb was draped as well as the contralateral groin.

The first step was to perform two separate percutaneous accesses. First, femoral arterial puncture was performed at the contralateral groin under ultrasound guidance, a 7F 45-cm sheath (Terumo Destination, Terumo) inserted and a crossover was achieved. The tip of the sheath was positioned in the ipsilateral external iliac artery (EIA). Intravenous heparin was administered (50 IU/kg). A first angiogram was performed (Fig. 1). The second access was primarily venous, obtained at the medial and proximal aspect of the thigh, with an 18G 64-mm needle that punctured in a specific order the superficial femoral vein, then the stump of the occluded SFA, under thorough ultrasound guidance. The medial position of the vein makes the entry point located at an unusual internal side of the thigh (Fig. 2), and the needle is oriented upwards and laterally. When a pulsatile arterial flow was obtained, a 0.018″ (V18, Boston Scientific) guidewire was inserted retrogradely and fluoroscopically positioned facing the tip of the 7F sheath. No sheath was inserted in this access. A 6F snare was then inserted through the upper access and the 0.018″ guidewire was snared and served to advance a 4F vertebral catheter that was externalized through the skin at the medial side of the thigh. Having a through-and-through wire configuration and pulling both wire extremities during this step helped the catheter emerge at the skin (Video 1). The catheter was then carefully withdrawn under fluoroscopy until it fell in the venous lumen that was initially punctured. The guidewire was then pushed distally inside the femoral vein through the valves of the vein.

Afterwards, a third access was obtained at the distal part of the SFA, below the occlusion, by puncturing under ultrasound guidance, in a reversed order, first the popliteal artery (P1 or P2 segments) then the popliteal vein. A guidewire was inserted retrogradely inside the vein and positioned at the middle part of the femoral vein.

Now two wires were present in the same venous lumen. The distal guidewire was then inserted in the tip of the proximal 4F vertebral catheter by rotating the latter until its lumen met the wire tip. A single through-and-through wire was therefore obtained. The 4F catheter was then pushed distally until it emerged at the popliteal access. Then it was carefully withdrawn under fluoroscopy until it fell in the

Fig. 1 Baseline angiogram showing long SFA occlusion with **A** presence of a proximal SFA stump, **B** distal P2 segment of the re-injected popliteal artery, **C** patent outflow arteries

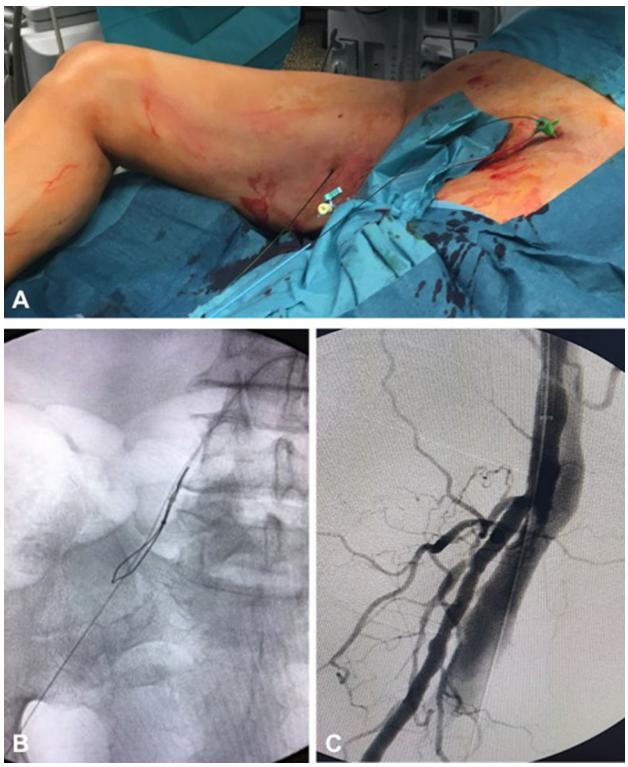

Fig. 2 Intraoperative elements. **A** Patient in supine position. The second access is at the medial side of the right thigh, in order to obtain alignment of the femoral vein and superficial femoral artery during the puncture. A 4F catheter is externalized through the skin (see Fig. 3B). The contralateral sheath is a 6F sheath that has been replaced by a 7F sheath later during the procedure. **B** The 0.018″ inserted from below is being snared from above. **C** Intended communication between the SFA stump and the adjacent femoral vein

arterial lumen that was the first to be punctured at this site. The V18 guidewire was then advanced below the knee. The punctures, snaring, and capture maneuvers are depicted in Fig. 3. The fistulous artery-to-vein and vein-to-artery tracts were dilated using a 3-mm and then a 5-mm compliant 0.018″ balloons (Advance 18LP, Cook Medical, Bloomington, In), and when required, a 6-mm high-pressure non-compliant balloon (Conquest, Bard Medical, Covington, GA). Six-millimeter Viabahn covered stents (W.L. Gore and associates, Flagstaff, AZ) were then deployed with a 2-cm minimal overlap zones from the SFA stump to the popliteal artery (Fig. 4). In one patient, Covera Plus self-expandable stents were used, and 8F proximal sheath was necessary (Bard Medical, Covington, GA). The stents were post-dilated at the overlapping segments and the sealing zones. A control angiogram was performed (Fig. 5).

Results

Three patients aged 68 ± 3 years were treated from July 2018 to November 2018. All of them presented Rutherford 4 chronic limb ischemia. The mean SFA lesion length was 22.6 ± 3 cm. Two procedures were performed under general anesthesia and one under local anesthesia and sedation. The mean procedure duration was 88 ± 18 min. 50 ± 13 ml of contrast medium were used. No intraoperative complication occurred. The mean postoperative hospital stay was 2 days. The postoperative course was uneventful. In particular, no deep vein thrombosis (DVT) occurred. All patients were put under double antiplatelet therapy for 3 months then on long-term single antiplatelet drug. Rutherford stage decreased from 4 to 1 in all patients, with a mean follow-up duration of 6.6 ± 2 months.

Discussion

This technical note describes the feasibility of total percutaneous femoropopliteal bypass through an endovenous tract with simple means for extremely long lesions of the SFA. The concept is not new but becomes accessible with standard equipment and unspecific endovascular devices. This approach is justified by a global failure context for current endovascular procedures in the presence of a TASC-D [2] lesion of the SFA. According to the latest European guidelines, lesions longer than 25 cm should be treated with surgical femoropopliteal bypass. When lesions less than 25 cm are considered, endovascular solutions are the first line option, but this recommendation is based on low level of evidence (level C) and studies reporting acceptable outcomes with the use of covered stents inside the occluded SFA [8, 9]. Data exceeding 24-month FU duration in complex lesions are scarce, whereas surgical bypasses are patent in 80% of patients at 5 years [3]. The percutaneous bypass combines the durability of surgical bypass and the mini-invasive endovascular procedures.

For this purpose, the DETOUR system (PQ bypass Inc., Milpitas, CA) already exists. It is not commercially available and is currently evaluated in the DETOUR trials [10]. It consists of performing two accesses: one arterial at the contralateral groin and one in the tibial ipsilateral vein. The arterio-venous crossing also lies on needle perforation and double snaring maneuvers with a double-cage system, which equals in complexity the technique that we describe. The dedicated Torus stent in the DETOUR system is composed of nitinol and polytetrafluoroethylen, which also compose the stents that were used in this report. The 25-cm-long Gore Viabahn stent would be interesting in this

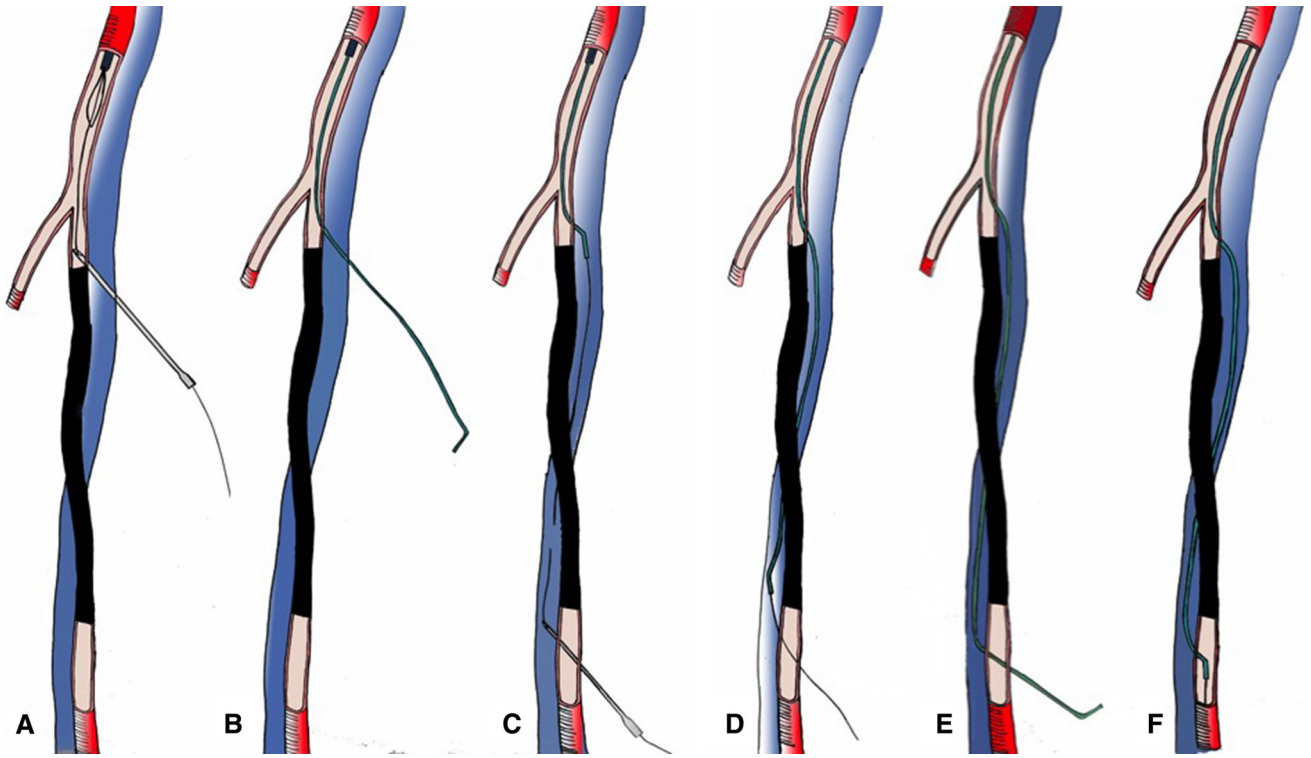

Fig. 3 Crossing punctures and snaring maneuvers. **A** Femoral vein-to-SFA stump puncture and 0.018″ guidewire snaring through the upper 7F sheath. **B** 4F catheter pushed retrogradely and externalized through the two vessels and the skin. **C** Withdrawal of the catheter until it falls in the venous lumen. A guidewire is inserted downwards in the vein. Distal popliteal artery-to-vein puncture. An 0,018″ guidewire is inserted upwards in the same lumen. **D** Distal wire capture through the tip of the 4F catheter, under fluoroscopy guidance. **E** With the help of the obtained through-and-through wire configuration, the 4F catheter is further pushed distally, across the artery, through the skin. **F** The 4F catheter is withdrawn until it falls in the artery and the 0,018″ wire rejoins the arterial lumen distally

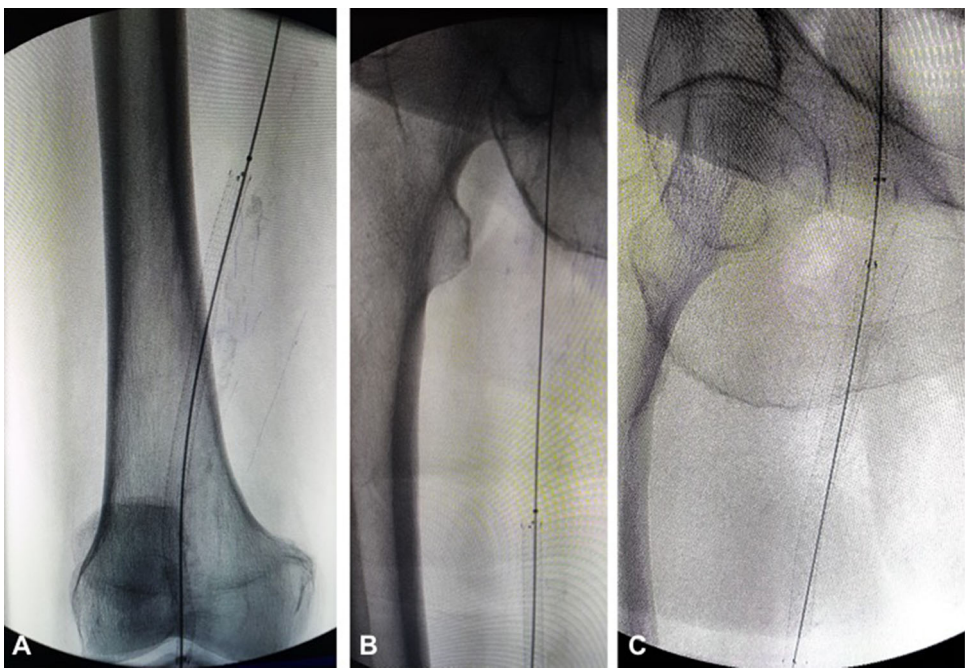

Fig. 4 Three Viabahn stents are deployed in **A** the P2 segment of the popliteal artery, **B** the middle of the SFA, **C** up to the SFA stump, with moderate proximal stent compression that will be post-dilated

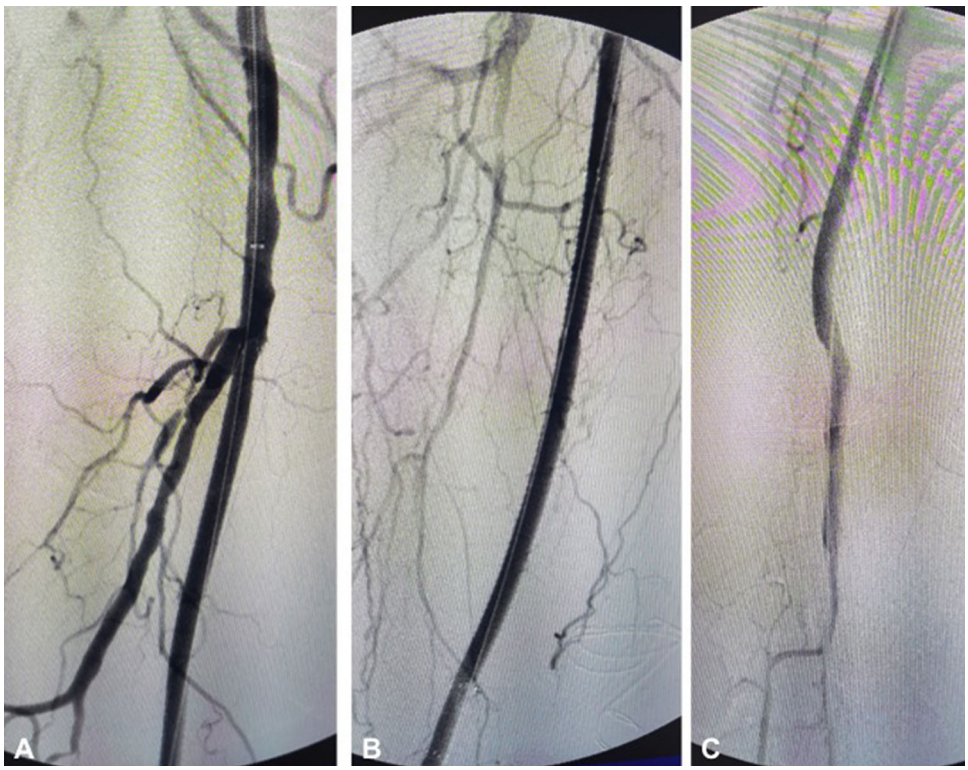

Fig. 5 Final angiogram showing **A** patent femoral bifurcation without stent angulation or compression, **B** patent consecutive Viabahn stents, **C** seamless stent re-entry in the popliteal artery

indication to avoid multiple stenting in moderately long occlusions, but was not available in our experience.

The first results of the DETOUR I trial in 77 patients have been presented by Armstrong et al. (Late-Breaking Clinical Trials. Presented at: VIVA 18; Nov. 5–8, 2018; Las Vegas). Primary and primary-assisted patencies at 12 months were of 73% and 80%, respectively. The mean length of the SFA lesions was 37.1 cm [11]. At 18 months, primary patency was 67.6%, primary-assisted patency was 78.9% and secondary patency was 94.1%. The venous function has not been damaged in any patient. In a precedent experience in five patients [7], at 24 months of follow-up, the primary patency rate was 80% (4/5) and primary assisted patency was 100% (5/5).

The present technique requires experience in ultrasound mode B use. The more the proximal SFA stump locates distally, the more the superficial femoral vein at its level becomes posterior and hard to puncture with standard needles. In this situation, we used 20G, 88-mm long needle and the puncture site is as posterior at the thigh as required. On the other hand, puncturing the vein and artery manually allows to choose the most convenient segment of the vessel wall and to avoid calcifications. Moreover, the step that consists of carefully withdrawing the catheter until it falls in the target vessel (femoral vein at the upper thigh, popliteal artery at the popliteal site) appears to be a "one-shot" maneuver. A double-lumen catheter (over the wire plus monorail configuration) with a guidewire lateral exit would allow securing the target lumen catheterization.

Conclusion

Through this technique, percutaneous femoropopliteal bypass is feasible without any specific device but requires ultrasound mode B intraoperative use. Results appear encouraging in this early experience, but greater experience and longer follow-up are needed to obtain solid conclusions on both safety and efficiency.

References

1. Halliday A, Bax JJ. The 2017 ESC guidelines on the diagnosis and treatment of peripheral arterial diseases, in collaboration with the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg. 2018;55(3):301–2.
2. Norgren L, Hiatt WR, Dormandy JA, Nehler MR, Harris KA, Fowkes FG, et al. Inter-society consensus for the management of peripheral arterial disease (TASC II). Eur J Vasc Endovasc Surg. 2007;33(1):S1–S75.
3. Klinkert P, Post PN, Breslau PJ, van Bockel JH. Saphenous vein versus PTFE for above-knee femoropopliteal bypass A review of the literature. Eur J Vasc Endovasc Surg. 2004;27:357–62.
4. Zhang L, Bao J, Zhao Z, Lu Q, Zhou J, Jing Z. Effectiveness of Viabahn in the treatment of superficial femoral artery occlusive

disease: a systematic review and meta-analysis. J Endovasc Ther. 2015;22(4):495–505.
5. Okuno S, Iida O, Shiraki T, Fujita M, Masuda M, Okamoto S, Ishihara T, Nanto K, Kanda T, Takahara M, Uematsu M. Impact of calcification on clinical outcomes after endovascular therapy for superficial femoral artery disease: assessment using the peripheral artery calcification scoring system. J Endovasc Ther. 2016;23(5):731–7.
6. Sarradon P. LEA 22 totally percutaneous femoral-popliteal bypass: the best of both worlds. J Vasc Surg. 2018;68(5):e122.
7. Krievins D, Savlovskis J, Ezite N, Hill A, Kisis K, Gedins M, Zellans E, Holden A. The DETOUR procedure: no more need for conventional bypass surgery? J Cardiovasc Surg (Torino). 2018;59(2):172–7.
8. Lammer J, Zeller T, Hausegger KA, Schaefer PJ, Gschwendtner M, Mueller-Huelsbeck S, et al. Sustained benefit at 2 years for covered stents versus bare-metal stents in long SFA lesions: the VIASTAR trial. Cardiovasc Interv Radiol. 2015;38(1):25–322. https://doi.org/10.1007/s00270-014-1024-9.
9. Lammer J, Zeller T, Hausegger KA, Schaefer PJ, Gschwendtner M, Mueller-Huelsbeck S, et al. Heparin-bonded covered stents versus bare-metal stents for complex femoropopliteal artery lesions: the randomized VIASTAR trial (Viabahn endoprosthesis with PROPATEN bioactive surface [VIA] versus bare nitinol stent in the treatment of long lesions in superficial femoral artery occlusive disease). J Am Coll Cardiol. 2013;62(15):1320–7.
10. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2000 Feb 29. Identifier NCT03119233, PQ Bypass System for Femoropopliteal Bypass II; 2017 Apr. 18. https://clinicaltrials.gov/ct2/show/NCT03119233