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CASE REPORT
Other

'Pave-and-crack' technique for the recanalization of severely calcified occlusive aorto-ilio-femoral disease in type-III Leriche syndrome: a case report

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Background Leriche syndrome is the result of the atherosclerotic occlusion of the distal aorta that may also involve pelvic arteries. The standard treatment for this condition is considered surgical with various techniques available for establishing appropriate flow to both limbs. However, due to the technical advances in the last decades, endovascular approaches are now also capable to tackle such lesions. The 'pave-and-crack' technique enables the treatment of severely calcified lesions. This two-step procedure consists of firstly placing a covered stent prothesis (VIABAHN) into the severely calcified segment, which is afterwards aggressively dilated with high-pressure balloons. Subsequently, an interwoven nitinol SUPERA stent with high radial forces is placed within the prothesis.

Case summary Herein, we describe the case of an 81-year-old male patient, who presented with critical limb-threatening ischaemia of his right leg. Doppler ultrasound revealed a long occlusion of the right external iliac artery, common femoral, superficial femoral, and deep femoral artery. The lesion was successfully tackled using antegrade and retrograde punctures and the 'pave-and-crack' technique.

Discussion The 'pave-and-crack' technique is an endovascular approach for the treatment of severe circumferential calcified lesions. Based on this technique covered stents are initially placed to prevent vessel rupture, which might occur during the aggressive balloon dilatation. Subsequently, the covered stents are relined by interwoven Supera stents, which provide high radial force preventing recoil and restenosis.

Keywords Critical limb ischaemia • 'Pave-and-crack' • Calcified • Peripheral artery disease • Retrograde puncture • Iliofemoral disease • Duplex sonography • Case report

Learning points

- To get familiar with clinical presentations and risk factors associated with Leriche syndrome.
- To recognize clinical and imaging findings in Leriche syndrome, including the use of Duplex sonography and magnetic resonance angiography for the characterization of the pathology associated with this disease.
- To recognize the role of combined antegrade and retrograde access for the treatment of long occlusive peripheral artery disease.
- To recognize the unique ability of the 'pave-and-crack' technique for the treatment of exceptionally long and calcified and otherwise not treatable peripheral lesions.

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Introduction

The occlusion of the distal aorta that extends to both common iliac arteries and to variable degrees to the femoral arteries is defined as Leriche syndrome.[1] This syndrome is characterized by three clinical elements: claudication in both limbs, absence or diminished bilateral femoral pulses and erectile dysfunction. Named also aortoiliac occlusive disease, this entity is classified as a TASC D lesion by the Trans-Atlantic Inter-Society Consensus for the management of peripheral artery disease.[2] A surgical approach with either placement of aorto-bifemoral bypasses or endarterectomy and graft insertion is considered as the standard treatment in such patients.[3] However, with an ageing population and many patients exhibiting relevant comorbidities, risks for significantly increased peri-operative morbidity and mortality of surgical techniques are present. Therefore, endovascular approaches have been proposed and successfully employed for the treatment of Leriche syndrome.[4]

Herein, we present the case of an 81-year-old male patient with critical limb-threatening ischaemia (CLTI) due to aortoiliac occlusive disease, who was successfully treated using an endovascular approach.

Timeline

Day 0	The patient presents with critical limb ischaemia of the right leg.
Day 0	Duplex sonography reveals severally diminished flows in both common femoral arteries.
Day 1	The lesion of the left common iliac artery is treated endovascularly.
Day 2	Performance of a magnetic resonance angiography for a better delineation of the vascular pathology.
Day 3	Endovascular treatment of the right-side lesions using the 'pave-and-crack' technique.
8 weeks	Complete healing of the wounds on the right foot.
3 months	Excellent flow in both common femoral and superficial femoral artery bilaterally.

Case presentation

An 81-year-old Caucasian male patient was referred to our department due to CLTI with ischaemic rest pain accompanied by gangrene of his right leg (Rutherford Class 6), which persisted for more than 2 weeks.

The presence of gangrene was confirmed by clinical inspection (*Figure 1A*) and no pulse was registered at the right inguinal region, whereas a very faint pulse could be palpated at the level of the left inguinal region. No pulses were present in both feet.

The patient had a history of atrial fibrillation (CHA_2DS_2-VASc score = 5), chronic renal disease (creatinine = 1.4 mg/dL, GFR = 45 mL/min/1.73 m^2), chronic obstructive lung disease (GOLD Class 3), type 2 diabetes mellitus, arterial hypertension, and dyslipidaemia. At the time of the presentation, the patient was on anticoagulant (apixaban 5 mg b.i.d.), beta-blocker (bisoprolol 5 mg q.d.), calcium blocker (amlodipin 5 mg q.d), angiotensin-converting enzyme-inhibitor (ramipiril 5 mg q.d) statin (simvastatin 40 mg q.d.), and metformin (500 mg q.d.). The laboratory values showed an HbA1c value of 8.5% and the lipid profile revealed a value for total cholesterol of 128 mg/dL and of LDL-cholesterol of 73 mg/dL. The patient reported taking his anticoagulation medication regularly and clinical history and inspection did not suggest an acute thromboembolic event.

Duplex sonography at presentation revealed a long occlusion of the external iliac (EIA) and common femoral artery (CFA) on the right side with severely diminished monophasic flow in the mid superficial femoral artery (SFA). In addition, diminished monophasic flow was present in the left CFA and SFA, indicating occlusion of the left common iliac artery (CIA).

Due to old age and comorbidities, the patient was scheduled for endovascular treatment. Angiography was performed after puncture of the left CFA and insertion of a 7F sheath, confirming occlusion of the left CIA (*Figure 2A*). After passage with an 0.018″ Advantage guidewire through the occlusion (Glidewire Advantage®, Terumo International, Somerset, NJ, USA), an 0.035″ support catheter was advanced in the distal aorta. Digital subtraction angiography (DSA) confirmed Leriche syndrome with occlusion of the left and right CIA (*Figure 2B*). After pre-dilatation, an 8.0 × 39 mm Viabahn balloon expandable coated stent (Gore® Viabahn® Endoprothesis, Gore Medical) was implanted in the left CIA (*Figure 2C*). Full expansion of the prosthesis was achieved with a good angiographic result (*Figure 2D and E*). Further DSA acquisitions revealed high-grade stenosis of the proximal and subtotal occlusion of the distal right CIA, and a very long occlusion of the EIA and CFA and collateralization of the right deep femoral artery (DFA) by a subtotally occluded right internal iliac artery. No contrast filling was seen in the right SFA (*Figure 2F and H*). Due to the high complexity of the lesion and considering the impaired renal function, we deferred endovascular treatment within the same session and scheduled the patient for magnetic resonance angiography (MRA) to better assess vascular pathology. Magnetic resonance angiography confirmed long occlusion of the right CIA, EIA, and CFA and showed occlusion of the proximal DFA and SFA (*Figure 2I*, magnified in *Figure 2J*). However, good contrast filling was seen in the mid-SFA and DFA by MRA (blue arrows in *Figure 2J*).

After discussion with the patient about the potential success of complete endovascular treatment vs. minimally invasive cross-over bypass surgery and after careful consideration of the associated risks, he was scheduled for an endovascular recanalization attempt. The patient was informed about the risks of the endovascular procedure including degradation of the renal function, infection, bleeding at the access point as well as risk of vessel perforation or rupture that would require urgent transfusion, reinterventions, or open surgery. Thus, after gaining combined antegrade and retrograde access by puncturing the left CFA (7F sheath) and the mid-right SFA (sheathless insertion of a 0.035′ support catheter), respectively (*Figure 3A*, red asterisks depicting the extreme bilateral calcification of the right EIA and CFA, magnified in *Figure 3B*), parallel placement of two 0.018″ Advantage guidewires (Glidewire Advantage®, Terumo International,

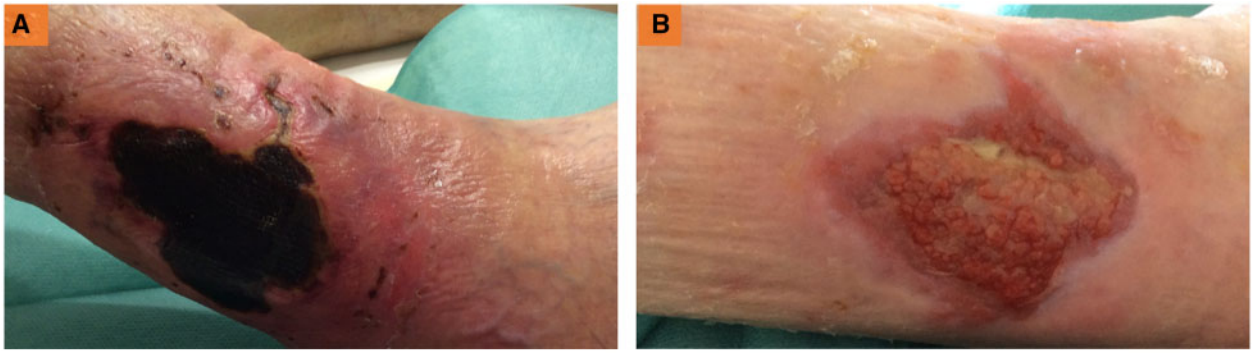

Figure 1 (*A*) Photo acquisition of the wound at the first presentation. (*B*) Photo acquisition of the same region, at 2 months after the successful endovascular treatment.

Somerset, NJ, USA) was achieved. This facilitated insertion of the retrograde wire into an antegrade support catheter at the level of the occluded right EIA (blue arrow in *Figure 3C*). By this manoeuver the wire could be externalized out of the left sheath, allowing for treatment of the lesion from antegrade. After pre-dilatation with a 6.0 × 120 mm balloon, which could not be properly expanded due to severe calcification (blue arrows in *Figure 3D*), DSA exhibited massive recoil of the recanalized segments (blue arrows in *Figure 3E*). Therefore, two 6.0 × 100 mm and 8.0 × 50mm Viabahn self-expanding coated stents (Gore® Viabahn® VBX Balloon expandable Endoprothesie, Gore Medical) were implanted, which were subsequently aggressively dilated using high pressure 6.0 × 40 mm and 7.0 × 40 mm CONQUEST balloons (Conquest® PTA Dilatation Catheters, BARD) up to 45 bar and then relined using 5.5 × 100 mm and 6.5 × 80 mm Supera self-expanding stents (Supera™, Abbott Vascular), according to the 'pave-and-crack' technique (*Figure 3F and G*). A good bilateral final angiographic result (*Figure 3H*) with acceptable lumen gain and good outflow of the SFA can be appreciated in *Figure 3I* and *J*.

Duplex sonography showed markedly improved flow in the right SFA after endovascular treatment (*Figure 3L*) in comparison to the acquisition before (*Figure 3K*). The patient was set on a high-dose statin treatment and a combination of direct anticoagulant (apixaban) and clopidogrel for 6 months. Ischaemic pain resolved completely, whereas his foot healed completely after 8 weeks. Due to preserved left ventricular function i.v. fluids were given to the patients during and after both endovascular procedures, which required 100 and 180 mL of the contrast agent Visipaque (GE Healthcare Buchler, Braunschweig, Germany), respectively. One week after the second intervention, renal function rather improved, with a creatinine value of 0.9 mg/dL.

Duplex sonography at 3 months showed excellent bilateral flow in both CFA and SFA. In addition, good healing of the wound was already present at the 2 months of follow-up (*Figure 1B*).

Discussion

The occlusion of the distal aorta that extends to both common iliac arteries and to variable degrees to the femoral arteries is defined as Leriche syndrome[1] and is *per se* classified as a TASC D lesion by the Trans-Atlantic Inter-Society Consensus.[2] Depending on the extension of the disease, Leriche is further categorized in Type I involving the distal aorta and the CFA, Type II, the lesions extending to the CFA, and Type III, the lesions extending to the SFA, as in our case.[5] A surgical approach with either placement of aorto-bifemoral bypasses or endarterectomy and graft insertion is considered the standard treatment in such patients.[3] However, with an ageing population exhibiting relevant comorbidities, risks for significantly increased peri-operative morbidity, and mortality exist. Therefore, endovascular approaches may represent an alternative option.

The diagnosis of the Leriche syndrome is suspected clinically after a thorough anamnesis and clinical examination. Duplex ultrasound is a useful first-line tool for the work-up of such patients. In addition, CT- or MR-Angiography may enable more precise assessment of the pelvic arteries. In our patient, the MR-Angiography revealed a complete occlusion of the right CFA extending to the SFA and DFA, but also revealed a patent mid-SFA, which was then used for retrograde access, facilitating wire passage.

Several groups have reported success of endovascular methods for tackling aortoiliac occlusive disease with good mid-term results in small case series.[6,7] In such complex lesions, however, some points need to be considered. A combined retro- and antegrade approach is usually necessary for crossing such long occlusions. Furthermore, especially older patients may present with severely calcified lesions, which prove more challenging to tackle endovascularly, even after successful wire passage. For these cases, balloon dilatation may prove insufficient for this type of lesions and the risk of recoil and restenosis is remarkably high.[8] Furthermore, applying high pressures during balloon angioplasty of pelvic arteries may lead to vessel rupture. In this regard, the 'pave-and-crack' technique proved to be useful for the treatment of severely calcified femoropopliteal lesions.[9] The technique consists of two steps: initially, a coated stent is placed in the severe calcified vessel, which is then aggressively dilated with high-pressure balloons. Then, interwoven nitinol Supera (Supera™, Abbott Vascular) stents are placed, which provide extensive radial pressure to prevent restenosis and re-occlusion. This is mandatory in lesions with such extreme circumferential calcification, which are otherwise prone to recoil, limiting mid- or long-term patency. In

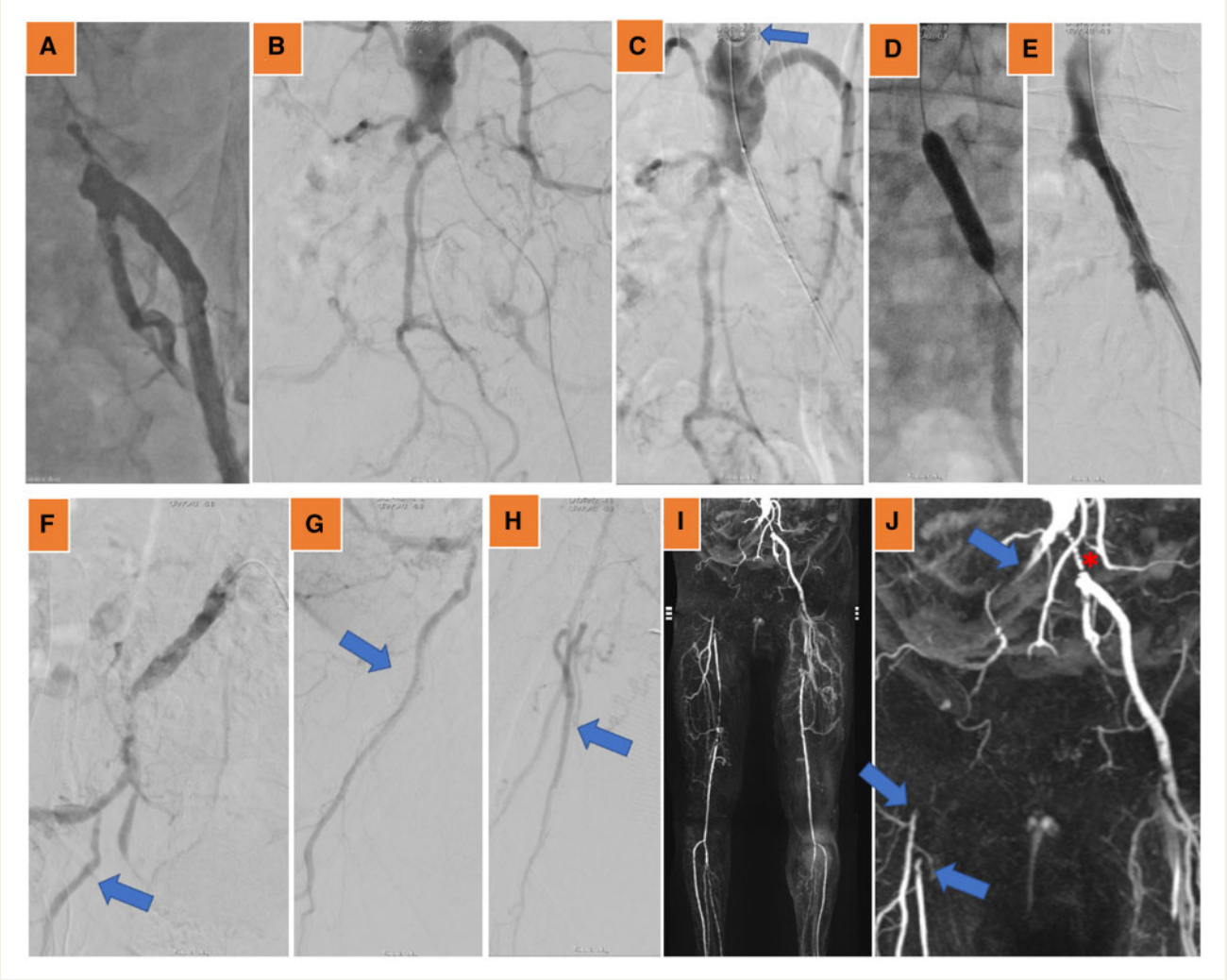

Figure 2 Digital subtraction angiography showed occlusion of the left common iliac artery (*A*). After insertion of an 0.035″ TrailBlazer™ support catheter in the distal aorta, Leriche syndrome is confirmed with occlusion of both common iliac artery (*B*). Implantation of an 8.0 × 39 mm VIABAHN® VBX balloon expandable stent was performed in the left common iliac artery (*C*), with a good angiographic result (*D*, *E*). Selective digital subtraction angiography of the right axis showed high-grade stenosis of the proximal and subtotal occlusion of the distal right common iliac artery (blue arrow in *F*), a very long occlusion of the external iliac and common femoral artery and collateralization of the right deep femoral artery (blue arrow in *H*) by a subtotally occluded right internal iliac artery (*G*). Magnetic resonance angiography confirmed long occlusion of the right CIA, EIA, and common femoral artery and showed occlusion of the proximal deep femoral artery and superficial femoral artery (*I*, magnified in *J*). Good contrast filling was seen in the superficial femoral artery and deep femoral artery by magnetic resonance angiography (blue arrows in *J*). *Note the signal void in the area of the implanted Viabahn prosthesis in *J*.

addition, the interwoven design of the Supera stent allows this device to withstand external forces and stressors thus preventing stent fracture, especially in moving peripheral segments as the popliteal artery. Although endovascular atherectomy is an excellent tool for debulking severe calcified lesions after intraluminal passage,[10] we considered that the risk of perforation after most likely subintimal passage of an occlusion, partially located in the iliac space, would have outweighed potential benefits in our specific case. In addition, atherectomy may not be such effective in large iliac arteries compared with femoropopliteal or below-the-knee vessel segments.

Conclusions

Leriche syndrome is an extreme form of peripheral artery disease. Diagnosis and risk stratification of patients are key elements in the management of such patients and are dependent on anatomical severity, calcification as well as patient's age and comorbidities. After successful treatment, appropriate management of the cardiovascular risk factors is especially important, accompanied by regular clinical follow-up.

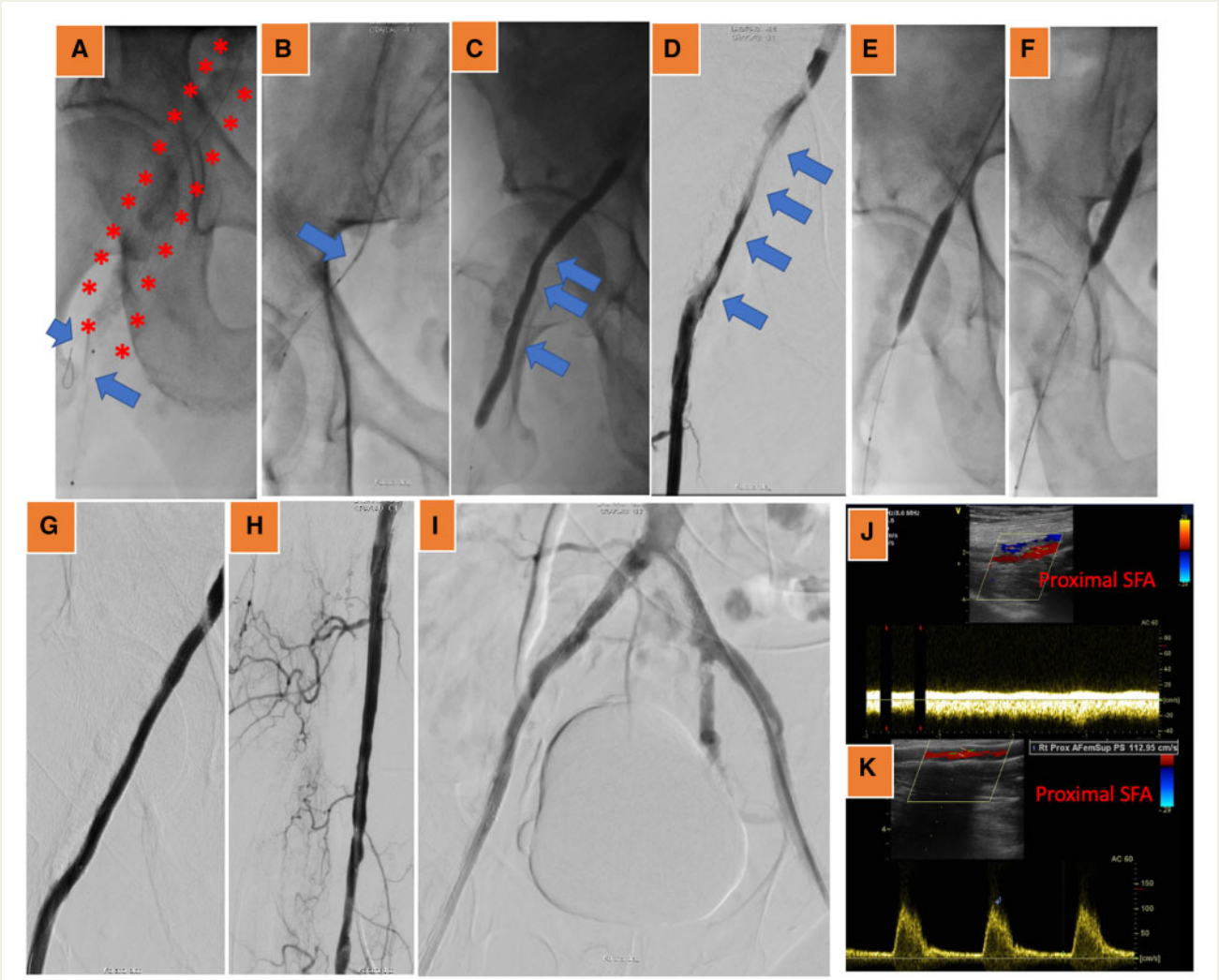

Figure 3 After combined antegrade and retrograde wire access to the right occlusion (blue arrows in *A*, red asterisks showing the extreme bilateral calcification of the right external iliac and common femoral artery, magnified in *B*), wire externalization was performed at the level of the right external iliac (blue arrow in *C*). Pre-dilatation showed inadequate balloon expansion (blue arrows in *D*) and digital subtraction angiography confirmed massive lesional recoil (*E*). Therefore, Viabahn self-expanding coated stents were implanted, which were subsequently aggressively dilated using high-pressure balloons (*F*, *G*) and were then relined using Supera™ self-expanding stents, according to the 'pave-and-crack' technique. A good bilateral final angiographic result with adequate expansion of the prothesis and stents and good outflow of the superficial femoral artery can be appreciated in (*H*, *I*). Duplex sonography showed markedly improved flow in the right superficial femoral artery, comparing duplex findings before (*J*) and after endovascular treatment (*K*).

Lead author biography

Sorin Giusca is a consultant in cardiology with a special focus on peripheral artery interventions.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written informed consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidelines.

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References

1. Leriche R, Morel A. The syndrome of thrombotic obliteration of the aortic bifurcation. *Ann Surg* 1948;**127**:193–206.
2. Norgren L, Hiatt WR, Dormandy JA, Nehler MR, Harris KA, Fowkes FGR. Inter-society consensus for the management of peripheral arterial disease (TASC II). *J Vasc Surg* 2007;**45**:S5–S67.
3. Aboyans V, Ricco J-B, Bartelink M-L, Björck M, Brodmann M, Cohnert T et al. 2017 ESC guidelines on the diagnosis and treatment of peripheral arterial diseases, in collaboration with the European Society for Vascular Surgery (ESVS): document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries. Endorsed by: the European Stroke Organization (ESO). The Task Force for the Diagnosis and Treatment of Peripheral Arterial Diseases of the European Society of Cardiology (ESC) and of the European Society for Vascular Surgery (ESVS). *Eur Heart J* 2018;**39**:763–816.
4. Setacci C, Galzerano G, Setacci F, De Donato G, Sirignano P, Kamargianni V et al. Endovascular approach to Leriche syndrome. *J Cardiovasc Surg (Torino)* 2012; **53**:301–306.
5. Wooten C, Hayat M, Du Plessis M, Cesmebasi A, Koesterer M, Daly KP et al. Anatomical significance in aortoiliac occlusive disease. *Clin Anat* 2014;**27**: 1264–1274.
6. Bracale UM, Giribono AM, Spinelli D, Del Guercio L, Pipitò N, Ferrara D et al. Long-term results of endovascular treatment of TASC C and D aortoiliac occlusive disease with expanded polytetrafluoroethylene stent graft. *Ann Vasc Surg* 2019;**56**:254–260.
7. Goverde PCJM, Grimme F. A B, Verbruggen PJEM, Reijnen MMPJ. Covered endovascular reconstruction of aortic bifurcation (CERAB) technique: a new approach in treating extensive aortoiliac occlusive disease. *J Cardiovasc Surg (Torino)* 2013;**54**:383–387.
8. Scheinert D, Laird JR, Schröder M, Steinkamp H, Balzer JO, Biamino G. Excimer laser-assisted recanalization of long, chronic superficial femoral artery occlusions. *J Endovasc Ther* 2001;**8**:156–166.
9. Dias-Neto M, Matschuck M, Bausback Y, Banning-Eichenseher U, Steiner S, Branzan D et al. Endovascular treatment of severely calcified femoropopliteal lesions using the "pave-and-crack" technique: technical description and 12-month results. *J Endovasc Ther* 2018;**25**:334–342.
10. Giusca S, Lichtenberg M, Schueler M, Heinrich U, Eisenbach C, Andrassy M et al. Safety, effectiveness and mid-term follow-up in 136 consecutive patients with moderate to severely calcified lesions undergoing phoenix atherectomy. *Heart Vessels* 2021;**36**:366–375