Long-term follow-up of patients with popliteal artery entrapment syndrome treated by endoluminal revascularization

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Abstract

The popliteal artery entrapment syndrome (PAES), a rare cause for leg ischemia, is usually treated by surgical removal of the compressing structure and either venous bypass or interposition graft. However, endovascular revascularization followed by surgery to release the artery has been reported as a feasible alternative. So far long-term results of this approach are not known. We report the follow-up of three patients with PAES and thrombotic occlusion of the popliteal and calf arteries treated by local lysis, percutaneous thrombembolectomy and angioplasty followed by musculotendinous dissection. One patient had an uneventful follow-up of 11 years while the second patient developed a popliteal aneurysm four months after the index procedure. In the third patient, angioplasty of a stenosis of the popliteal artery was performed after two years. However, occlusion of the artery occurred two years later due to a small popliteal aneurysm. Endovascular revascularization followed by surgical release of the artery may be a viable alternative in the treatment of PAES especially in cases with distal embolization. However, careful follow-up by duplex ultrasound is mandatory because of the high risk of reocclusion or development of a popliteal aneurysm.
Long-term follow-up of patients with popliteal artery entrapment syndrome treated by endoluminal revascularization

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Summary
The popliteal artery entrapment syndrome (PAES), a rare cause for leg ischemia, is usually treated by surgical removal of the compressing structure and either venous bypass or interposition graft. However, endovascular revascularization followed by surgery to release the artery has been reported as a feasible alternative. So far long-term results of this approach are not known. We report the follow-up of three patients with PAES and thrombotic occlusion of the popliteal and calf arteries treated by local lysis, percutaneous thrombectomy and angioplasty followed by musculotendinous section. One patient had an uneventful follow-up of 11 years while the second patient developed a popliteal aneurysm four months after the index procedure. In the third patient, angioplasty of a stenosis of the popliteal artery was performed after two years, however occlusion of the artery occurred two years later due to a small popliteal aneurysm. Endovascular revascularization followed by surgical release of the artery may be a viable alternative in the treatment of PAES especially in cases with distal embolization. However, careful follow-up by duplex ultrasound is mandatory because of the high risk of reocclusion or development of a popliteal aneurysm.

Key words: popliteal artery entrapment syndrome, musculotendinous section, thrombotic occlusion of the popliteal artery, popliteal aneurysm, angioplasty, thrombectomy, thrombolytic therapy

Introduction
The popliteal artery entrapment syndrome (PAES) is defined as a compression syndrome of the popliteal artery caused by muscular or ligamentary structures in the popliteal fossa [16, 19]. Various anatomic forms are related either to an anomalous course of the popliteal artery, to an anomalous development of the medial head of gastrocnemius muscle, or to an accessory ligament [3, 18]. The functional form represents a lateral displacement of the entire neurovascular bundle against the lateral angle of the soleal sling and the lateral condyle of the tibia, e.g. in cases of muscle hypertrophy [1, 20, 28]. The incidence of PAES is low and usually affects young, typically male patients [22, 32]. Slowly progressive intermittent claudication or intermittent acute ischemia of the calf or foot are the leading clinical signs in 90% of the cases [15, 18]. Complications of PAES include fixed arterial stenosis caused by fibrosis and premature arteriosclerosis, popliteal aneurysm, local thrombosis or embolization of thrombotic material in calf arteries, which may lead to critical ischemia [25]. These complications are consequences of repetitive microtraumas of the arterial wall due to intermittent compression [14]. The treatment principles of PAES consist of release of the arterial
compression and restoration of arterial blood flow to the limb. In the absence of arterial damage, musculotendinous section (MTS) is the chosen treatment to release the entrapment and to restore the normal anatomy. In the presence of occlusion or stenosis, revascularization of the popliteal artery in addition to MTS is required [8, 13, 25, 32]. Conventionally, the revascularization is performed by thrombendarterectomy, bypass or venous patch graft. In cases of a thrombotic occlusion of the popliteal and crural arteries, catheter guided, endoluminal procedures including a combination of intraarterial local thrombolysis (IAT), percutaneous transluminal thrombendarterectomy (PTEA) and percutaneous transluminal angioplasty (PTA) have been described as effective [23].

We describe the long-term results of the combined treatment, consisting of endoluminal revascularization and MTS, in three patients with PAES and thrombotic occlusion of the popliteal artery.

Patients

Case 1
A 17-year-old football player complained of a 2-week history of coldness, numbness and cramps in the right foot and calf after a few steps. Physical examination revealed the absence of arterial pulses in the right foot. The ankle-brachial pressure index (ABI) was 0.8 on the right and 1.1 on the left side. Angiography revealed an occlusion of the popliteal artery and proximal segments of all three crural arteries. Magnetic resonance imaging (MRI) documented an anomalous course of the medial head of the gastrocnemius muscle with disinfection of the otherwise normal popliteal artery to the medial side. PTEA with a 7F aspiration catheter and IAT with 20,000 IU urokinase through a 4 mm microhole catheter was successfully performed. At the first postinterventional day the ABI was 0.96 and the popliteal, peroneal and posterior tibial arteries were patent in the control angiography. The patient received 15,000 IU heparin intravenously daily for two days and 100 mg acetylsalicylic acid per day indefinitely. One month after the catheter treatment, myotomy of the medial gastrocnemius muscle-head was performed. Oral anticoagulation with phenprocoumon for three months had been initiated postoperatively. Two years later claudication recurred and PTA of a popliteal artery stenosis was successfully performed. Four years after MTS a small aneurysm of the popliteal artery with a maximal diameter of 1.1 cm was detected by duplex sonography at a routine control. A conservative approach was chosen.

![Image](image-url)  

Figure 1: Angiogram of the left popliteo-crural arteries of patient 2. On the left side the angiogram demonstrates medial deviation and occlusion of the popliteal artery. The angiogram on the right side shows the recanalized popliteal and anterior tibial artery after local thrombolysis and percutaneous transluminal thrombendarterectomy had been performed.
and the patient was treated by oral anticoagulation with phenprocoumon. One year later a femoropopliteal bypass with the long saphenous vein was required due to reocclusion of the aneurysmatic popliteal artery. The further follow-up of five years was unremarkable, the patient remained asymptomatic and ABI was 1.0 bilaterally.

Case 2

For one year a 17-year-old patient had been complaining of increasing claudication of the left foot and calf during physical exercise, especially when playing basketball and volleyball the previous month. Arterial pulses in the left foot were absent; the ABI was 0.6 on the left and 1.2 on the right side. Duplex sonography revealed an occlusion of the popliteal artery, an aneurysm had been excluded. Angiography showed the presence of large collaterals and distally occluded crural arteries (Fig 1). The popliteal artery was recanalized by ETL with 200000 IU urokinase, PTEE and PTA. 20000 IU heparin per day were given intravenously for three days and oral anticoagulation withacenocoumarol was initiated. After recanalization, duplex sonography showed complete compression of the popliteal artery during maximal plantar flexion of the foot. CT-angiography demonstrated an anomalous insertion of the medial head of the gastrocnemius muscle at the lateral femoral condyle (Fig 2). One week later de-looping surgery was performed (Fig 3a and 3b). Oral anticoagulation with acenocoumarol was continued for six months. At the 11 year follow-up visit the patient was still asymptomatic. ABI was 1.0 on both sides and duplex ultrasound revealed a patent popliteal artery with a diameter of 5 mm.

Case 3

A 51-year-old clerk with a history of arterial hypertension, hypercholesterolemia and obesity was referred to our outpatient clinic because of acute onset of severe claudication of the left calf. Duplex sonography and angiography revealed thrombotic occlusions of the popliteal artery and the tibioperoneal trunk without signs of arteriosclerosis. The popliteal artery was ecstatic with a maximal diameter of 7 mm. The popliteal artery and tibioperoneal trunk occlusion was treated by ETL with 300000 IU urokinase over some minutes applied by a microbore catheter and PTEE with a 10F aspiration catheter and PTA. Postinterventionally 20000 IU heparin daily were given intravenously for two days and a therapy with 100 mg acetylsalicylic acid per day was started. ABI on the right leg increased from 0.7 to 1.0. PAES was confirmed angiographically after the intervention by the typical complete compression of the popliteal artery during plantar flexion of the right foot. With MRI of the popliteal fossa an additional muscle at the lateral head of the gastrocnemius, crossing the popliteal vessels was detected. One month after revascularization MTS was performed and oral anticoagulation established. Duplex sonography two months after the operation revealed a popliteal aneurysm of 15 mm, which was treated by interposition of a venous graft. Over the following twelve years leg perfusion has remained stable and the venous graft patent.

After the first event all three patients had been seen in our outpatient clinic for duplex ultrasound and ABI measurements. The first control visit was scheduled one day after the intervention, follow-up visits were done after 3, 6, 12 months and then once a year.

Discussion

The incidence of PAES is low and accounts for approximately 1% of all patients with popliteal artery occlusive disease. Therefore long-term follow-up studies of patients with PAES treated interventionaly for thrombotic occlusion are scarce and the results differ. Six studies on patients treated by surgical revascularization and decompression have been pub-

Figure 2: CT-angiogram reveals a left occluded popliteal artery with medially deviated but normal diameter.
Figure 3 (a): The intraoperative photograph shows the popliteal fossa before the musculotendinous section.

Figure 3 (b): The intraoperative photograph shows the popliteal fossa after desinsertion of the medial head of the gastrocnemius muscle.

lished so far. In 1991 di Marzo et al. reported a 58% primary patency rate of the popliteal artery in 12 patients with arterial reconstruction (11 vein grafts, 1 prostatic graft) with a follow-up of 1–100 months [6]. The reported results of the same group six years later were similar with a patency rate of 66% after a mean follow-up of 107 ± 8 months in 13 patients treated with surgical revascularization (9 interposition grafts, 4 bypass grafts, 4 autologous veins, 1 PTFE) [5]. Holting et al. found in their series of 19 patients that venous interposition grafts had the lowest long-term complication rate (16.6%) compared with other surgical techniques such as local thrombendarterectomy with or without venous patch in which reocclusion occurred in 43% after a mean follow-up of 9.3 years [9]. In 1995 Zünd and Brunner presented their experience in PAES-management; their follow-up period extended from 6 months to 22 years. In 24 treated patients (MTS in all cases, 12 short autologous veins interponats, 11 open endarterectomies, 2 autologous femoro-popliteal bypasses, 1 aneurysm resection) five reoperations were necessary [32]; no reasons for these reoperations were given. In the report of Levien et al., 15 limbs with severe ischemia due to popliteal artery thrombosis were treated by venous bypass grafting. All grafts remained open during a mean follow-up period of 4.3 years (range 1–10 years), however, one reocclusion occurred after thrombectomy and venous patch plastic [15]. Ohara et al. published the long-term follow-up (3.2 to 18.6 years) of ten patients with PAES treated surgically. One reocclusion was reported in the follow-up. The limitations of this study are that duplex ultrasound had been performed only during the first two years and that only five patients had initially been diagnosed with an occluded popliteal artery [17].

Regarding this varying failure rate of surgical treatment of PAES, the combined treatment by endovascular revascularization followed by MTS could be a viable alternative. However, there is only limited data available of long-term results after the endovascular approach. Up to
2009 there had been only three publications available reporting a total of seven patients treated with endovascular revascularization followed by MTS. The follow-up period was less than one year. Steurer et al. reported the follow-up of three patients treated by PTEE, EBL and PTA in which angiographically patent arteries had been demonstrated after a follow-up of 4, 8 and 12 months respectively [26]. Ring et al. described the results of preoperative intraarterial thrombolysis (pulse spray and infusion) in three patients with popliteal artery thrombosis due to PAES [21]. The authors emphasized that although the thrombolytic therapy of the popliteal artery thrombus was incomplete, it improved the distal runoff, resulting in a less extensive surgical reconstruction. Bernheimer et al. reported in 2001 that the three month follow-up of a seven year-old boy with an acute lower extremity ischemia due to a PAES treated by intraarterial thrombolysis followed by elective MTS and resection of popliteal aneurysm was uneventful [2]. The authors concluded that in a pediatric population the potential for inducing vasospasm and the small size of the arteries make open mechanical thrombectomy difficult and therefore the endovascular approach is probably superior.

To our knowledge our case series is the first published report of a long-term follow-up over 10 years of patients with PAES and occluded popliteal artery treated with endoluminal revascularization followed by surgical release of the entrapment.

In all three patients the antegrade approach was chosen to recanalize the popliteal and calf arteries by a combination of PTEE through a 6.8 or 10F aspiration catheter followed by local intraarterial thrombolysis with urokinase and PTA of apparent stenosis without stent placement. After the intervention heparin 10000–20000 IU per day was given intravenously for two days. Surgical decompression had been performed once to 16 weeks after successful catheter revascularization. All patients received either 100 mg acetylsalicylic acid per day or coumarin. In the long-term follow-up of our three patients one (case 2) had an event-free follow-up of 11 years. At the last control, the ankle-brachial pressure index was 1.0 and there was no indication of a recurrence of the entrapment. In two patients a popliteal aneurysm was diagnosed two months and four years after catheter therapy. All our cases presented with thrombotic occlusion of the popliteal artery and the proximal tibial arteries. It is crucial to exclude the presence of a concomitant popliteal aneurysm before endovascular treatment. However, in cases with severe acute ischemia successful revascularization with thrombus aspiration, local lysis and placement of a stent graft may be faster and therefore the treatment of choice even in the presence of an aneurysm, especially when calf arteries are occluded as well [7, 10, 11, 12, 24, 30, 31]. The immediate success rate of endovascular treatment of thrombotic occlusions of popliteal and infrapopliteal arteries without PEAS is high and has been reported to be in the range of 90–96% [4]. Of course, the endovascular approach has to be followed electively by surgical decompression and in cases with a popliteal aneurysm by venous bypass grafting, which is the most successful procedure [8]. In contrast to the favorable short term result of endovascular treatment of PAES, surveillance with duplex ultrasound is mandatory to detect restenosis or aneurysm formation of the popliteal artery despite surgical decompression. This may be caused by entrapment injury to the arterial wall with subsequent fibrosis and thickening. Interestingly, di Mauro reported good long-term results after MTS alone in 29 patients in whom the diagnosis of PAES had been made at an early stage and vascular reconstruction had not been necessary [5]. However, two patients needed angioplasty due to stenosis and in one case the artery occluded 28 months after the operation. The development of an acute occlusion due to PAES points to a more advanced degeneration of the vessel and therefore further complications like reocclusion or aneurysm formation after endovascular revascularization have to be anticipated. Complications may occur several years after the first event indicating that long-term follow-up not only by measuring the ABI but also by duplex ultrasonography is mandatory. Whether oral anticoagulation for three months followed by 250 mg acetylsalicylic acid per day, as Steurer et al. recommended, or low dose acetylsalicylic acid alone are sufficient after MTS [21, 26], has not been studied so far. It may depend upon the distal run-off as well as co-morbidities.

Conclusions

Endovascular revascularization followed by musculotendinous section is a feasible treatment modality in patients with thrombotic occlusion of the popliteal and calf arteries due to PEAS [27, 29]. However, follow-up with duplex ultrasound is mandatory to detect restenosis or aneurysm formation of the popliteal artery.

Conflicts of interest

There are no conflicts of interest existing.
References


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