

# Popliteal artery entrapment syndrome needs an interdisciplinary approach

*Popliteal arter tuzak sendromu disiplinlerarası bir yaklaşım gerektirir*

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## ABSTRACT

**Background:** In this study, we report our long-term experiences of popliteal artery entrapment syndrome and to highlight the importance of an interdisciplinary approach.

**Methods:** Between January 1994 and December 2014, popliteal artery entrapment syndrome was diagnosed in a total of 23 limbs of 21 patients (17 males, 4 females; mean age 26.14 years; range 17 to 35 years). All patients underwent surgical decompression of the popliteal artery. Interposition vein graft from the saphenous vein was performed on the patients with type 1 and 2 popliteal artery entrapment syndrome. Interpositional vein grafting after musculotendinous resection of the medial head of gastrocnemius muscle was carried out in the patients with type 3, 4, and 6 popliteal artery entrapment syndrome.

**Results:** The mean follow-up was 120.5±59.0 (range, 38 to 218) months. Re-exploration was required in two limbs. Overall primary graft patency rates at one and five years were 91.3% and 82.6%, respectively. Initially, the vast majority of the patients were admitted to cardiovascular surgery outpatient clinics; however, eight patients applied to the other outpatient clinics and were subsequently consulted.

**Conclusion:** Early and accurate diagnosis should be settled for the patients with popliteal artery entrapment syndrome to ensure an appropriate management as soon as possible. Therefore, the referral of the patients with lower extremity claudication to various outpatient clinics from different specialties should alert the treating physician for popliteal artery entrapment syndrome, even in unusual presentations.

**Keywords:** Lower extremity claudication; popliteal artery entrapment syndrome; vein interposition.

## ÖZ

**Amaç:** Bu çalışmada popliteal arter tuzak sendromuna ilişkin uzun dönem deneyimlerimiz bildirildi ve disiplinlerarası yaklaşımın önemi vurgulandı.

**Çalışma planı:** Ocak 1994 - Aralık 2014 tarihleri arasında 21 hastanın (17 erkek, 4 kadın; ort. yaş 26.14 yıl; dağılım 17-35 yıl) toplam 23 ekstremitesine popliteal arter tuzak sendromu tanısı konuldu. Tüm hastalara popliteal arterin cerrahi dekompresyonu uygulandı. Tip 1 ve 2 popliteal arter tuzak sendromlu hastalara safen ven ile ven greft interpozisyonu yapıldı. Tip 3, 4 ve 6 popliteal arter tuzak sendromlu hastalara gastrocnemius kası medial başının kas ve tendon rezeksiyonundan sonra ven greft interpozisyonu uygulandı.

**Bulgular:** Ortalama takip süresi 120.5±59.0 (dağılım 38-218) ay idi. İki ekstremiteye yeniden girişim uygulanması gerekti. Genel greft açıklık oranları birinci ve beşinci yılda sırasıyla %91.3 ve %82.6 idi. Hastaların büyük bir çoğunluğu başlangıçta kalp damar cerrahisi kliniğine başvurdu; ancak sekiz hasta diğer polikliniklere başvurdu ve takiben konsülte edildi.

**Sonuç:** Popliteal arter tuzak sendromlu hastalara uygun tedavinin kısa sürede sağlanabilmesi için erken ve doğru tanı konulmalıdır. Bu nedenle, farklı branşların çeşitli polikliniklerine alt ekstremitte kladikasyonu ile başvuran hastaları tedavi eden hekim, olağandışı klinik seyir olsa dahi, popliteal arter tuzak sendromu açısından dikkatli olmalıdır.

**Anahtar sözcükler:** Alt ekstremitte kladikasyonu; popliteal arter tuzak sendromu; ven interpozisyonu.



Available online at  
www.tgkdc.dergisi.org  
doi: 10.5606/tgkdc.dergisi.2016.12020  
QR (Quick Response) Code

Received: May 31, 2015 Accepted: August 12, 2015

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Popliteal artery entrapment syndrome (PAES) is a compression syndrome of the popliteal artery (PA) by surrounding musculotendinous structures in the popliteal fossa which was first described by Stuart in 1879.<sup>[1]</sup> Popliteal artery may be compressed in the popliteal fossa by various reasons such as anomalous course of the artery, abnormal development of the gastrocnemius muscle (mainly the medial head of the muscle) or the presence of an accessory ligament. These facts may cause functional impairment or arterial compression leading to ischemia and vascular claudication.<sup>[2,3]</sup> Although intermittent claudication is a manifestation of atherosclerotic peripheral vascular disease in older patients, younger patients may present with similar symptoms, which may complicate the differential diagnosis.

Regardless of the cause, standard treatment of PAES is decompression of popliteal artery from the surrounding structures to ensure a permanent arterial flow.<sup>[3]</sup> However, patients with lower extremity symptoms such as limb ischemia, claudication, and pain apply to various outpatient clinics such as orthopedics, plastic surgery, occupational therapy, emergency, cardiovascular surgery, general surgery, and even general practice. The practitioners out of cardiovascular surgery may not always be aware of the possibility of PAES in a patient with lower extremity claudication. Herein, we aimed to report our long-term experiences of PAES, a serious and a rare lower extremity condition, and to remind it to the physicians interacting in multiple disciplines.

## PATIENTS AND METHODS

The study protocol was approved by the local ethics committee. Between January 1994 and December 2014, a total of 23 limbs in 21 patients (17 males, 4 females; mean age 26.1±5.2 years; range 17 to 35 years) with PAES were treated surgically. All the medical records of these patients were retrospectively reviewed. Demographic and clinical characteristics, diagnostic images, type of revascularization procedures, and postoperative results were recorded. In addition, initial referral clinic of the patients were noted. However, the entire of the lower extremity procedures were carried out at the department of cardiovascular surgery with the participation of plastic surgery/microsurgery, if necessary.

The patients suffering from chronic lower extremity ischemia were categorized according to the Rich classification.<sup>[4]</sup> In type 1, the medial head of gastrocnemius muscle is normal and the popliteal artery is deviated medially and has an aberrant

course. Type 2 is comprised of the entrapment of popliteal artery with laterally located medial head of gastrocnemius muscle. In type 3, the popliteal artery is entrapped by the abnormal muscle bundle from medial head of the gastrocnemius muscle. Type 4 is the entrapment of the deeply located popliteal artery by the popliteus muscle or a fibrous band. In type 5, popliteal vein is entrapped. In type 6, the normally positioned popliteal artery is entrapped by a normally positioned and hypertrophied gastrocnemius muscle.

The diagnosis of PAES was made by duplex ultrasonography, conventional angiography, three-dimensional computed tomography angiography (CTA) or magnetic resonance imaging (MRI). All patients presenting with clinical PAES were examined with Doppler ultrasonography (DUS) and plantar flexion test. If DUS suggested PAES, a CTA was performed in resting position and during active plantar flexion (Figures 1a, b).

The location of the extrinsic compression was confirmed and the surgical procedure was performed via a posterior incision in the popliteal fossa to restore the arterial flow. For minimal arterial damage, myotomy of the gastrocnemius muscle or resection of any abnormal musculotendinous units were performed. In the presence of occlusion or stenosis, revascularization of the affected popliteal artery with a reversed saphenous vein graft was carried out in addition to the musculotendinous resection.

Interposition vein graft from the saphenous vein (v. saphena parva) to PA was the method for the patients with type 1 and 2 PAES. Interpositional vein grafting after musculotendinous resection of the medial head of gastrocnemius muscle was carried out in the patients with type 3, 4 and 6 PAES.

Long-term follow-up data were collected to assess the symptoms and the patency rates. The graft patency was recorded once every six months during the first year and annually, thereafter, through interviews, physical examination or duplex ultrasonography. When non-invasive tests showed abnormal findings, CTA or digital subtraction angiography (DSA) was performed to further evaluate the graft patency.

## Statistical analysis

A commercial statistical software package SPSS for Windows, version 16.0 (SPSS, Inc, Chicago, IL, USA) was used for data analysis. The data were given as frequencies and means with standard deviations (SDs) as appropriate.



**Figure 1.** (a) Conventional peripheral angiography in neutral and (b) during forced plantar flexion demonstrating a sharp occlusion of the popliteal artery.

## RESULTS

Demographic characteristics of the patients are shown in Table 1.

The mean follow-up was  $120.5 \pm 59.0$  (range, 38 to 218) months. In the postoperative period, palpable pulses were found in 16 of 21 limbs.

Regarding the initial referral, two patients with acute occlusion presented to emergency department. Another patient with acute occlusion applied to cardiovascular surgery outpatient clinic. Twelve patients with chronic claudication were admitted to cardiovascular surgery, whereas three patients applied to orthopedics and one patient to plastic surgery. Two patients, one in each, also applied to the outpatient clinics of general practice and physical therapy and rehabilitation (Table 2).

Two male patients had bilateral involvement in which one-side was affected. We found that claudication intermittens with strenuous exercise (i.e., running or cycling) was the most frequent symptom, while chronic critical limb ischemia was uncommon. According to the Rich classification, 10 patients presented with type 2, five patients with type 3, four patients with type 4, and one patient with type 6 PAES with the main complaint of claudication. Three patients presented with acute ischemic leg pain due to acute occlusion of the popliteal artery. None of the patients were diagnosed with type 5 PAES (popliteal vein entrapment).

Digital subtraction angiography, CTA, and MRI were performed in 10 patients, seven patients, and four patients, respectively.

Thromboendarterectomy was performed in three cases with occluded PA in addition to the original procedure. Based on radiological and operative findings, surgical procedures for each subtype of PAES are summarized in Table 1.

**Table 1. Demographics of the patients**

Patient	Age/Gender	Location	Classification	Duration of symptoms (years)
1	35/M	R	4	4
2	32/M	R	4	5
3	27/M	L	2	2
4	28/M	L	3	3
5	24/F	R	2	1/2
6	17/M	R	2	1
7	20/M	L	4	3
8	29/M	R	4	5
9	19/M	L	2	3
10	28/F	L	3	3
11	33/M	Bilateral	3	4
12	29/M	R	2	3
13	19/F	R	2	1
14	32/M	L	6	4
15	26/M	L	2	2
16	24/M	R	3	5
17	23/F	R	2	3
18	31/M	R	3	4
19	22/M	L	2	3
20	30/M	Bilateral	4	5
21	21/M	L	2	1

L: Left; R: Right.

**Table 2. Initial referral and diagnostic modalities of the patients**

Patient	Referral	Initial referral clinic	Diagnostic modality	Management
1	Acute occlusion	Emergency department	CTA + DUS	Vein interposition, thromboendarterectomy, musculotendinous resection
2	Claudication	CVS	Arteriography	Musculotendinous resection
3	Claudication	Orthopedics	CTA + DUS	Vein interposition, musculotendinous resection
4	Claudication	CVS	Arteriography	Vein interposition, musculotendinous resection
5	Claudication	CVS	CTA + MRI + DUS	Vein interposition, musculotendinous resection
6	Claudication	PTR	Arteriography	Musculotendinous resection
7	Acute occlusion	CVS	CTA + DUS	Vein interposition, thromboendarterectomy, musculotendinous resection
8	Claudication	Plastic surgery	DUS + Arteriography	Vein interposition
9	Claudication	CVS	CTA + DUS	Musculotendinous resection
10	Claudication	CVS	DUS + Arteriography	Vein interposition, musculotendinous resection
11	Claudication	CVS	DUS + Arteriography	Vein interposition
12	Claudication	GP	CTA + DUS	Vein interposition
13	Claudication	CVS	MRI + DUS	Vein interposition, musculotendinous resection
14	Claudication	Ortopedics	MRI + DUS	Vein interposition, musculotendinous resection
15	Claudication	CVS	DUS + Arteriography	Vein interposition, musculotendinous resection
16	Acute occlusion	Emergency department	CTA + DUS	Vein interposition, thromboendarterectomy, musculotendinous resection
17	Claudication	CVS	MRI + DUS	Vein interposition, musculotendinous resection
18	Claudication	Orthopedics	Arteriography	Vein interposition
19	Claudication	CVS	DUS + Arteriography	Musculotendinous resection
20	Claudication	CVS	DUS + Arteriography	Musculotendinous resection
21	Claudication	CVS	CTA + DUS	Vein interposition, musculotendinous resection

CTA: Computed tomography angiography; DUS: Doppler ultrasound; CVS: Cardiovascular surgery; MRI: Magnetic resonance imaging; PTR: Physical therapy and rehabilitation; GP: General practice.

No complications were seen after surgery. All patients were under antiplatelet therapy with low-dose aspirin (100 mg once daily). Overall primary graft patency rates at one and five years were 91.3% and 82.6%, respectively. During the follow-up, two limbs required re-exploration. Both patients underwent a femoropopliteal bypass surgery. Thrombolysis was performed in one limb. The other limb showed an occluded and interposed graft at 84 months after

surgery. The occlusion was treated via bypass surgery with autogenous vein grafting between the superficial femoral artery and popliteal artery.

## DISCUSSION

Superficial femoral artery is continued by the popliteal artery which is located in the popliteal fossa, posteriorly. Lower extremity claudication is a common symptom in elderly, which is mainly caused

by atherosclerotic diseases. Young and healthy adults with lower extremity claudication are the candidates for the diseases originating from the muscle-fascia, bone-periosteum, nerve or vascular structures.<sup>[5,6]</sup> Since PAES is mostly found in patients with well-developed muscles, the military surgeons have a great interest on this disorder.<sup>[7]</sup>

The symptoms of this syndrome may vary individually. The typical signs and symptoms include leg swelling, aching pain, pain at rest, and cramping of the calf. In early stages, the patient may have only a feeling of coldness or transitory cramps; however, in later stages, it may progress to acute ischemia and total occlusion of the artery.<sup>[7]</sup> External arterial compression may cause chronic arterial micro-injuries and the extremity becomes prone to arteriosclerosis and thrombus formation. Clinical evidences suggest that it is associated with an increased risk of lower extremity ischemia.<sup>[8]</sup> In this study, 18 patients were in class 2 or 3 with the main complaint of claudication, and three patients presented with acute ischemic leg pain due to acute occlusion of the popliteal artery.

The impingement of popliteal artery in popliteal fossa causes PAES and the classification of PAES is based on the association of the vessel with musculoskeletal structures in the neighborhood.<sup>[4]</sup> Love and Whelan<sup>[9]</sup> developed a useful PAES scheme in 1965. In 1970, Insua<sup>[10]</sup> also classified the most common variations of PAES as four types. Type 1 includes the attachment of medial head of gastrocnemius muscle on the medial condyle of the femur; however the tract of the popliteal artery is abnormal on the medial direction around the muscle belly. In type 2, there is an impingement of the popliteal artery by the aberrant medial head of the gastrocnemius muscle which originates laterally than its natural position. In type 3, the popliteal artery is also entrapped by the aberrant slips of the muscle like in type 2; however, the artery and the muscle are in their natural anatomic positions. Type 4 is comprised of the entrapment of the popliteal artery by the fibrous bands of the popliteus muscle. In 1979, Rich et al.<sup>[4]</sup> modified the PAES scheme and categorized into six types which has been widely accepted. Of note, if there is any type of impingement of the popliteal vein, it is defined as type 5.<sup>[4]</sup>

The functional entrapment syndrome is defined as the entrapment caused by the hypertrophic gastrocnemius muscle.<sup>[12]</sup> Rignault described the functional popliteal impingement as a normal physiological variant of PAES without any musculotendinous anomaly.<sup>[12]</sup> Rutherford classification was based on the symptoms and clinical presentation at the time of surgery.<sup>[4]</sup> There is an also

classification based on radiological and intraoperative findings developed by Delaney.<sup>[13]</sup>

The incidence of PAES has not been clearly delineated in the literature. As it is extremely rare, few studies reported that the incidence varied between 0.17% and 3.5%.<sup>[14,15]</sup>

Although color DUS is the primary imaging tool for the diagnosis of PAES, it lacks to reveal the popliteal fossa anatomy.<sup>[16]</sup> Conventional angiography and DSA give superior results on arterial anatomy compared to DUS.<sup>[17,18]</sup> Computed tomography and MRI can show arterial stenosis, poststenotic dilatation, and popliteal fossa anatomy, as well.<sup>[16]</sup> In our study, conventional angiography was performed in 10 patients. After adapting three-dimensional reconstruction technique, CTA became the main modality diagnostic tool after 2005. In the present study, CTA was performed in eight patients and MRI in four patients.

Furthermore, the management of PAES depends on the disease classification and the extent of the arterial damage. Simple correction of the anatomic abnormality by dividing the appropriate musculotendinous structures may be adequate in patients with type 1 PAES without any irreversible arterial damage. On the other hand, the patients with PAES type 2, 3 and 4 division of any entrapped structure with the combination of vein bypass were performed, as recommended. In two other of type 1 cases, we performed only saphenous vein graft interposition without musculotendinous resection after proper popliteal artery exploration. Management of PAES should be carried out even in asymptomatic patients; thus, preventing serious complications such as aneurysm formation<sup>[19]</sup> and distal embolization are crucial in healthy lower extremity. A simple myotomy to the medial head of the gastrocnemius muscle is able to restore normal arterial flow. However, depending on the degree of arterial injury, revascularization may be required in patients with advanced disease.

Another controversy is on posterior or medial approach. Several studies suggest that the posterior approach may give a better visual anatomy and better cosmesis and an access to the lesser saphenous vein for graft harvesting in short occlusions.<sup>[7]</sup> For longer occlusions necessitating longer bypass grafts, the medial approach is often recommended.<sup>[7,20-23]</sup>

The long-term postoperative care after infrainguinal vein bypass surgery deserves a special interest, as the patient population is mostly young. All patients should be on antiplatelet therapy with low-dose aspirin. However, what remains controversial is still the use of anticoagulants after infrainguinal vein bypass surgery.

The Veterans Affairs Cooperative Trial concludes that vein bypass graft patency did not increase by the addition of coumadin to aspirin; however, there was a significant increase in hemorrhagic complications.<sup>[24]</sup> Therefore, many surgeons use anticoagulation selectively after vein bypass surgery in patients having poor conduit or poor arterial run-off.<sup>[25]</sup>

Moreover, PAES is a challenging condition not only for the patient, but also for the treating physician. The physician should have a thorough anatomical knowledge to choose the definite diagnosis in the management of the patient. Symptomatic PAES may eventually progress to the intimal injuries and thrombosis formation, and total occlusion, eventually.<sup>[7,11]</sup> The patients may apply or may be referred to multiple different disciplines. Of note, time consumption can exacerbate the limb ischemia and the limb loss may even be inevitable over time. Obtaining a long-term patency of the popliteal artery with surgery is critical in young population, particularly. As reported in a study, the pediatrician should look for the presentation of claudication which is a key symptom of PAES.<sup>[16]</sup> Therefore, it seems to be important not only for the cardiovascular surgeons, but also for the all practitioners to be aware of the lower extremity claudication in patients admitted with various complaints. In our current study, cardiovascular surgeons were the primary treating physicians, whereas the other specialties were confined to the awareness of claudication, which subsequently referred the patients to the cardiovascular surgery clinic.

In conclusion, early suspicion of the disease is solely available with a thorough communication among the physicians. Therefore, an interdisciplinary approach may give these patients improved limb survival with long-standing comfort. We believe that it is critical for the practitioners from different subspecialties to be aware of manifestations of lower extremity claudication, which is a major diagnosis criterion for popliteal artery entrapment syndrome, and refer these patients to the disciplines, where they can receive an appropriate treatment.

#### **Declaration of conflicting interests**

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

#### **Funding**

The authors received no financial support for the research and/or authorship of this article.

## **REFERENCES**

1. Stuart TP. Note on a Variation in the Course of the Popliteal Artery. *J Anat Physiol* 1879;13:162.
2. McAree BJ, O'Donnell ME, Davison GW, Boyd C, Lee B, Soong CV. Bilateral popliteal artery occlusion in a competitive bike rider: case report and clinical review. *Vasc Endovascular Surg* 2008;42:380-5.
3. Tercan F, Oğuzkurt L, Kizilkiliç O, Yeniocak A, Gülcan O. Popliteal artery entrapment syndrome. *Diagn Interv Radiol* 2005;11:222-4.
4. Rich NM, Collins GJ Jr, McDonald PT, Kozloff L, Clagett GP, Collins JT. Popliteal vascular entrapment. Its increasing interest. *Arch Surg* 1979;114:1377-84.
5. Hai Z, Guangrui S, Yuan Z, Zhuodong X, Cheng L, Jingmin L, et al. CT angiography and MRI in patients with popliteal artery entrapment syndrome. *AJR Am J Roentgenol* 2008;191:1760-6.
6. Gokkus K, Sagtas E, Bakalim T, Taskaya E, Aydin AT. Popliteal entrapment syndrome. A systematic review of the literature and case presentation. *Muscles Ligaments Tendons J* 2014;4:141-8.
7. Gourgiotis S, Aggelakas J, Salemis N, Elias C, Georgiou C. Diagnosis and surgical approach of popliteal artery entrapment syndrome: a retrospective study. *Vasc Health Risk Manag* 2008;4:83-8.
8. Ozkan U, Oğuzkurt L, Tercan F, Pourbagher A. MRI and DSA findings in popliteal artery entrapment syndrome. *Diagn Interv Radiol* 2008;14:106-10.
9. Love JW, Whelan TJ. Popliteal artery entrapment syndrome. *Am J Surg* 1965;109:620-4.
10. Insua JA, Young JR, Humphries AW. Popliteal artery entrapment syndrome. *Arch Surg* 1970;101:771-5.
11. Aslım E, Akay HT, Korun O, Akgün RC. Type 2 popliteal artery entrapment syndrome: a case report. *Turk Gogus Kalp Dama* 2012;20:910-2.
12. Rignault DP, Pailler JL, Lunel F. The "functional" popliteal entrapment syndrome. *Int Angiol* 1985;4:341-3.
13. Delaney TA, Gonzalez LL. Occlusion of popliteal artery due to muscular entrapment. *Surgery* 1971;69:97-101.
14. Bouhoutsos J. Popliteal artery entrapment syndrome: report of 29 cases. *Vasc Surg* 1980;14:365-74.
15. Gibson MH, Mills JG, Johnson GE, Downs AR. Popliteal entrapment syndrome. *Ann Surg* 1977;185:341-8.
16. Tekbaş G, Gümüş H, Ekici F, Keleşçi S, Yavuz C, Bilici A. A rare cause of intermittent claudication: recurrence of popliteal artery entrapment syndrome in a 16-years-old boy. *Turk Gogus Kalp Dama* 2013;2:503-5.
17. Elias DA, White LM, Rubenstein JD, Christakis M, Merchant N. Clinical evaluation and MR imaging features of popliteal artery entrapment and cystic adventitial disease. *AJR Am J Roentgenol* 2003;180:627-32.
18. Papaioannou S, Tsitouridis K, Giataganas G, Rodokalakis G, Kyriakou V, Papastergiou Ch, et al. Evaluation of popliteal arteries with CT angiography in popliteal artery entrapment syndrome. *Hippokratia* 2009;13:32-7.
19. López Garcia D, Arranz MA, Tagarro S, Camarero SR, Gonzalez ME, Gimeno MG. Bilateral popliteal aneurysm as

- a result of vascular type IV entrapment in a young patient: a report of an exceptional case. *J Vasc Surg* 2007;46:1047-50.
20. Igari K, Sugano N, Kudo T, Toyofuku T, Jibiki M, Inoue Y, et al. Surgical treatment for popliteal artery entrapment syndrome. *Ann Vasc Dis* 2014;7:28-33.
  21. Levien LJ, Veller MG. Popliteal artery entrapment syndrome: more common than previously recognized. *J Vasc Surg* 1999;30:587-98.
  22. Hoelting T, Schuermann G, Allenberg JR. Entrapment of the popliteal artery and its surgical management in a 20-year period. *Br J Surg* 1997;84:338-41.
  23. Andrilopoulos V, Papcharalambous G. The popliteal artery entrapment syndrome. *Vasc Endovasc Surg* 1999;33:357-65.
  24. Johnson WC, Williford WO. Benefits, morbidity, and mortality associated with long-term administration of oral anticoagulant therapy to patients with peripheral arterial bypass procedures: a prospective randomized study. *J Vasc Surg* 2002;35:413-21.
  25. Sarac TP, Huber TS, Back MR, Ozaki CK, Carlton LM, Flynn TC, et al. Warfarin improves the outcome of infrainguinal vein bypass grafting at high risk for failure. *J Vasc Surg* 1998;28:446-57.