

Case Study on the Interdisciplinary Approach to the Management of an Atypical Variant of Popliteal Artery Entrapment Syndrome

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Popliteal Artery Entrapment Syndrome (PAES) is a rare condition involving compression of the popliteal artery, affecting about 0.17% to 3.5% of the population. A young male athlete experienced worsening right foot pain and paleness of the area during exercise, leading to the diagnosis of Type I PAES due to an abnormal tendinous slip of the medial head of the gastrocnemius muscle. After surgical decompression, the athlete recovered smoothly and returned to sports within three months, reporting no symptoms at his one-year follow-up. Diagnosing PAES is challenging owing to non-specific symptoms like exercise-induced leg pain, often confused with common issues. This results in underdiagnosis and misclassification of PAES. Diagnosing PAES can be complex, particularly in young athletes, because its nonspecific symptoms are often overlooked. Enhanced clinical awareness and refined diagnostic strategies are crucial for timely recognition and improved patient outcomes.

Keywords: *Interdisciplinary; Approach; Artery; Entrapment; Provocation; Angiography; Duplex; Athletic; Flexion*

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INTRODUCTION

Popliteal Artery Entrapment Syndrome (PAES) is an uncommon, non-atherosclerotic vascular compression disorder predominantly affecting young, physically active individuals. Despite its relative rarity, PAES is frequently overlooked or misdiagnosed in clinical settings, resulting in delays in the provision of appropriate treatment [1].

The condition is characterized by vascular compression in the popliteal fossa, typically exhibiting a gradual and progressive course. Classic symptoms include exertional calf pain and escalating exercise intolerance, or claudication, which ameliorate with rest. These manifestations, particularly pain and cramping in the calf

during physical activity, can considerably hinder athletic performance and might clinically resemble peripheral arterial occlusive disease (PAOD).

Accurate differential diagnosis often requires targeted and interdisciplinary diagnostic coordination [2].

Pathophysiologically, PAES arises from extrinsic compression of the popliteal artery by adjacent musculotendinous structures, most frequently the medial head of the gastrocnemius muscle, and less commonly the plantaris or popliteus muscle. This mechanical obstruction leads to a hemodynamically significant reduction in perfusion to the lower limb during physical exertion. Chronic compression might lead to structural alterations in the vessel wall, including intimal damage, endothelial injury, thrombus formation, and, in some instances, aneurysmal degeneration [3].

Recent advancements in radiologic imaging have markedly improved the visualization of anatomical structures and enhanced the sensitivity of PAES diagnostics. Magnetic resonance angiography (MRA) is regarded as one of the most precise diagnostic methods for identifying PAES [4].

The treatment of uncomplicated PAES typically necessitates surgical exploration, accompanied by fasciotomy, myotomy, or decompression of the popliteal artery through the transection of fibrotic connective tissue. In

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selected cases, particularly those involving significant vascular damage or persistent symptoms despite decompression, vascular reconstruction might be warranted.

Classification

The currently recognized classification system for PAES differentiates six subtypes (I–VI; Table 1), based on the underlying anatomical or functional deviations:

Types I–V: These subtypes are determined by anatomically identifiable abnormalities in the course of the popliteal artery concerning the surrounding muscular structures. The prevalence of anatomical variants of PAES is estimated to range from 0.62% to 3.5% within the general population.

Type VI (Functional PAES (FPAES)): In contrast to the anatomical subtypes, this variant is characterized by the absence of structural malformations. Initially described by Rignault et al. in 1985 [5].

The functional subtype is attributed to muscular hypertrophy, primarily of the medial head of the gastrocnemius muscle, and dynamic neurovascular irritation during movement [1].

In the following case, we will outline our treatment strategy, emphasizing our cooperative, interdisciplinary approach that encompasses early diagnosis, surgical management, and follow-up care.

This case report was meticulously prepared and documented following the CARE guidelines, ensuring comprehensive adherence to standardized reporting practices for case reports.

CASE PRESENTATION

A 14-year-old male patient presented with a four-month history of exercise-induced pain in the right foot. The patient is an active football player and reported that, following physical activity, the foot exhibited symptoms of pain, pallor, coldness, and cyanosis in the forefoot. These symptoms improved with rest and by extending the leg.

Table 1 Classifications of popliteal artery entrapment syndrome (PAES).

Type I	Normal course of MHGM, popliteal artery medially displaced.
Type II	Laterally displaced MHGM, normal course of popliteal artery.
Type III	Compression of the popliteal artery by an additional slip of the gastrocnemius muscle.
Type IV	Compression of the popliteal artery by the popliteus muscle.
Type V	Compression of the popliteal vein.
Type VI (Functional)	Functional entrapment of the popliteal artery without any anatomical abnormality.

MHGM: medial head of gastrocnemius muscle.

Clinical Examination

Physical examination revealed palpable pedal pulses on the left side; however, they were absent on the right side. Provocation testing, which involved both dorsal and plantar flexion, resulted in the right foot demonstrating lividity and trophic changes during prolonged dorsiflexion.

Vascular Diagnostics

The ankle–brachial index (ABI) measured at 1.0 on the left and 0.6 on the right.

Duplex sonography of the right popliteal artery indicated a bi-triphasic flow pattern with the leg extended, which transitioned to a monophasic signal during foot flexion (Figure 1).

No arterial wall abnormalities or cystic changes were observed along the course of the right popliteal artery.

To further investigate the condition, a 4D MRA (3 Tesla magnetic resonance imaging (MRI)) was performed, revealing a high-grade stenosis approximately 15 mm in length at the distal segment of the superficial femoral artery (SFA) extending into the P1 segment of the popliteal artery during plantarflexion. Conversely, during dorsiflexion, complete occlusion was noted over an extent of approximately 30 mm (Figure 2).

An additional native MRI of the soft tissue in the popliteal fossa confirmed an extrinsic medial course of the popliteal artery, which passed medial to the medial head of the gastrocnemius muscle, corroborating the findings from the angiography (Figure 3).

Interdisciplinary Management and Surgical Findings

After an interdisciplinary consultation involving radiologists and orthopedic surgeons, the decision was made that surgical decompression of the popliteal artery would constitute the most appropriate course of treatment.

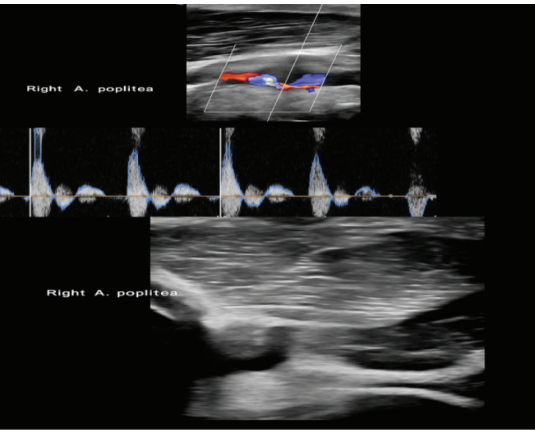


Figure 1 Preoperative duplex findings. Prior to surgery, duplex sonography demonstrated a monophasic flow pattern in the right popliteal artery during dorsiflexion of the foot.

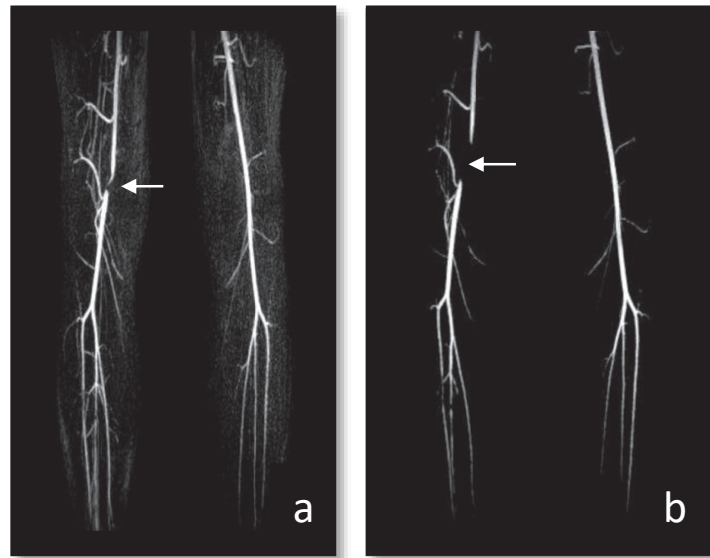


Figure 2 Preoperative magnetic resonance angiography (MRA) findings. (a) 4D MRA demonstrated a high-grade stenosis located at the distal segment of the right superficial femoral artery and extending into the P1 segment of the right popliteal artery during plantarflexion (arrow). (b) Conversely, during dorsiflexion, a complete occlusion was observed (arrow).

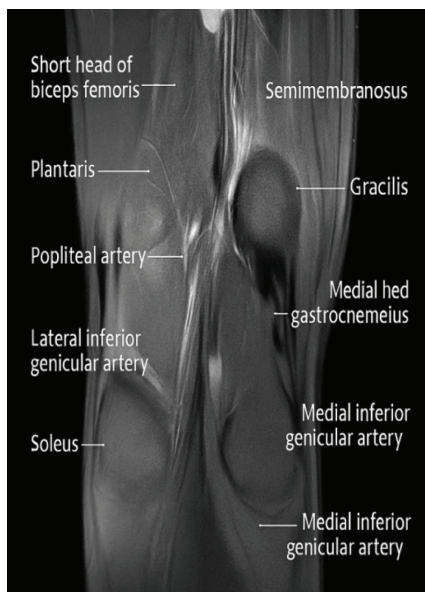


Figure 3 Preoperative duplex findings. Magnetic resonance imaging of the soft tissue within the popliteal fossa indicated an extrinsic medial trajectory of the popliteal artery, resulting from compression by the medial head of the gastrocnemius muscle.

During the surgical procedure, it was determined that the popliteal artery was compressed by an aberrant tendinous slip of the medial head of the gastrocnemius muscle (Figure 4a). The mechanical compression was clearly identified intraoperatively. Under dynamic provocation (both plantar and dorsiflexion), a dense, constrictive tendinous

structure proximal to the femoral condyles was recognized as the source of mechanical narrowing of the artery.

This case illustrated a combined form of PAES in the young patient—a hybrid presentation between Type I and Type III—attributed to the additional muscular slip of the gastrocnemius muscle.

The aberrant anatomical structure was meticulously exposed and surgically divided. Subsequently, the artery was repositioned to ensure complete alleviation of compression within the popliteal fossa (Figure 4b).

In order to prevent recurrent vascular entrapment, the medial head of the gastrocnemius muscle was repositioned and secured with 3-0 Vicryl® suture (Ethicon, Johnson & Johnson) for stabilization.

This surgical intervention facilitated the establishment of a decompressed region surrounding the neurovascular bundle in the popliteal fossa.

Intraoperative duplex sonographical assessment confirmed the establishment of a triphasic signal in the pedal arteries during both plantar and dorsiflexion, thereby verifying the successful decompression of the vessel.

During diagnostic evaluations and intraoperative assessment, the wall of the popliteal artery exhibited no abnormalities. Consequently, in light of the significant improvement in perfusion, vascular reconstruction was deemed unnecessary.

The postoperative course was smooth, and the patient was discharged on the third day after surgery. Partial mobilization and physiotherapy were effectively initiated on the ward. The young patient regained full range of motion and resumed full weight-bearing activities,

allowing a return to daily activities with minimal complaints shortly after discharge.

After a period of two weeks, the patient's mobilization had returned to a state comparable to his preoperative condition. By four to six weeks post-surgery, he gradually reintegrated into light athletic activities, and after approximately three months, he was once again fully engaged in his preferred hobby (playing football) without the recurrence of previous foot symptoms.

A one-year follow-up was conducted, during which the patient expressed high levels of satisfaction with

the outcome and reported freedom from any symptoms during physical activity or exertion. Duplex sonographic examination indicated a normal triphasic flow pattern in both the right popliteal artery and the pedal arteries, with a palpable foot pulse (Figure 5).

In addition, a psychosocial evaluation was conducted utilizing the German version of the SF-36 questionnaire [6].

To assess postoperative outcomes, this evaluation was performed one year post-surgery, empowering the examination of long-term effects and providing a comprehensive insight into the patient's overall health status. The results are summarized as follows:

- (1) The young patient exhibited remarkable recovery as indicated by the questionnaire results.
- (2) He reported no restrictions in activities of daily living or athletic pursuits due to pain, signifying a complete restoration of functional capacity.
- (3) His emotional well-being remained stable, characterized by frequent experiences of energy and happiness, with no reported instances of anxiety or depressive symptoms.
- (4) Social functioning was intact, and he self-assessed his overall health status as satisfactory.
- (5) The patient successfully resumed participation in football without any complaints, demonstrating both physical and psychological aspects of comprehensive recovery.

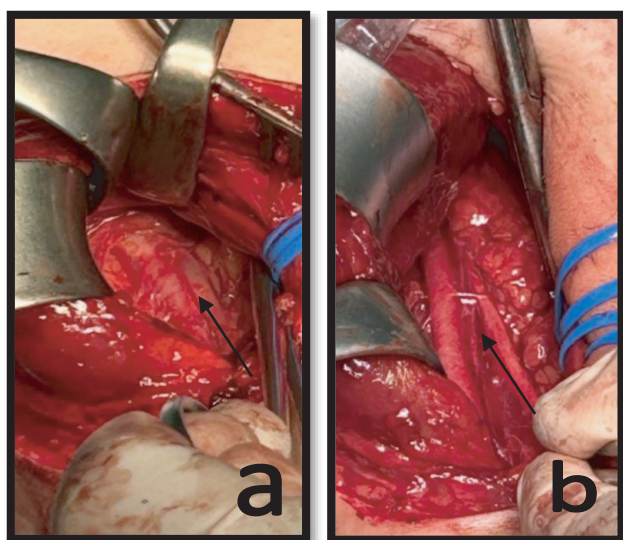


Figure 4 Intraoperative findings. (a) As shown in the image on the left, the arrow points to an abnormal tendinous slip of the medial head of the gastrocnemius muscle, which compresses the popliteal artery. (b) The image on the right illustrates, as indicated by the arrow, that the tendinous slip has been divided, resulting in the complete alleviation of compression on the artery.

Ethical Approval and Informed Consent

Informed consent was not required. According to the German law and in written agreement with the rules of the Medical Ethical Board of the Ärztekammer Niedersachsen in Hannover Germany, no ethical approval was needed for this study (exemption because of study type and content).

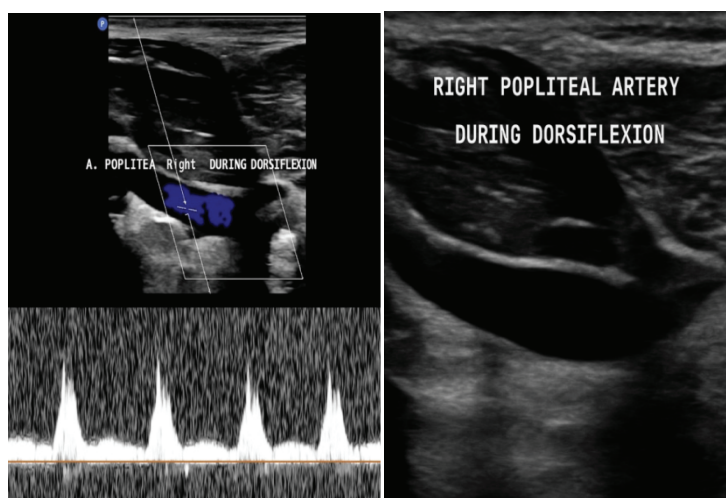


Figure 5 Postoperative duplex findings. A duplex sonographic follow-up conducted one year post surgery revealed an unobstructed course of the right popliteal artery, with a triphasic flow signal observed during foot dorsiflexion.

DISCUSSION

PAES is a rare but important differential diagnosis in young, physically active patients presenting with exertional ischemic symptoms of the lower extremities, particularly in the absence of classic risk factors for atherosclerotic vascular disease [7,8].

This case highlights the importance of a systematic diagnostic approach in evaluating suspected PAES. The diagnostic process commenced with clinical suspicion, followed by a dynamic duplex ultrasound conducted by an outpatient vascular surgeon. Subsequently, the patient was referred to the vascular surgery department of a hospital for further evaluation and treatment.

Functional duplex sonography during plantarflexion and dorsiflexion serves as an established first-line investigation for identifying dynamic alterations in arterial blood flow and has exhibited high sensitivity in suspected PAES cases. In the presented case, the examination revealed notable changes in blood flow contingent upon joint position, thereby reinforcing the clinical suspicion.

Following an interdisciplinary consultation with the radiology department, a targeted dynamic MRA was conducted [9].

The utilization of 4D MRA emerged as a crucial diagnostic modality for evaluating vascular anatomy and dynamic arterial compression. Prior studies have demonstrated that this technique facilitates the reliable identification of both functional stenoses and complete occlusions during provocation maneuvers. Consequently, dynamic magnetic resonance under provocation is now regarded as the gold standard in imaging for diagnosing PAES [10].

Furthermore, MRI of the soft tissue and muscular structures within the popliteal fossa enables the differentiation of various anatomical PAES subtypes, thereby supporting precise classification [11].

Upon confirmation of the suspected diagnosis through radiological findings, an interdisciplinary case discussion was convened with the orthopedic department.

A subsequent surgical intervention was collaboratively planned and executed by both vascular and orthopedic surgeons.

This case exemplifies the essential role of interdisciplinary collaboration in the diagnosis and management of PAES. Effective treatment necessitates an integrated approach that amalgamates the expertise of vascular surgery, radiology, and orthopedics to formulate a tailored surgical strategy based on the patient's unique anatomical presentation.

By leveraging specialized competencies, a comprehensive treatment plan can be formulated that not only optimizes surgical outcomes but also facilitates postoperative recovery and rehabilitation. This interdisciplinary model ensures optimal patient care throughout the entire treatment continuum, encompassing preoperative

planning, surgical intervention, rehabilitation, and long-term follow-up.

CONCLUSION

Diagnosing PAES can be complex, particularly in young athletes, because its nonspecific symptoms are often overlooked. Enhanced clinical awareness and refined diagnostic strategies are crucial for timely recognition and improved patient outcomes.

Ethics Statement

- (1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
- (2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All authors contributed to the conception, data collection, analysis, and manuscript preparation. All authors reviewed and approved the final version of the manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of the Use of Generative AI in the Writing Process

No generative AI or AI-assisted tools were used in the writing or editing of this manuscript.

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