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Popliteal Artery Entrapment Syndrome

Winnipeg Vascular and Endovascular Symposium

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Disclosures

I, Marie-Lyne Bourque, have no current relationships with commercial entities.

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Introduction

Entrapment (piège) Chronic compression by adjacent structures

Popliteal Artery Entrapment Syndrome (PAES) Abnormal relationship between the popliteal artery *(vein)* and nearby myofascial structures causing a compression of the popliteal artery *(vein)*

- Anatomical entrapment
- Functional entrapment

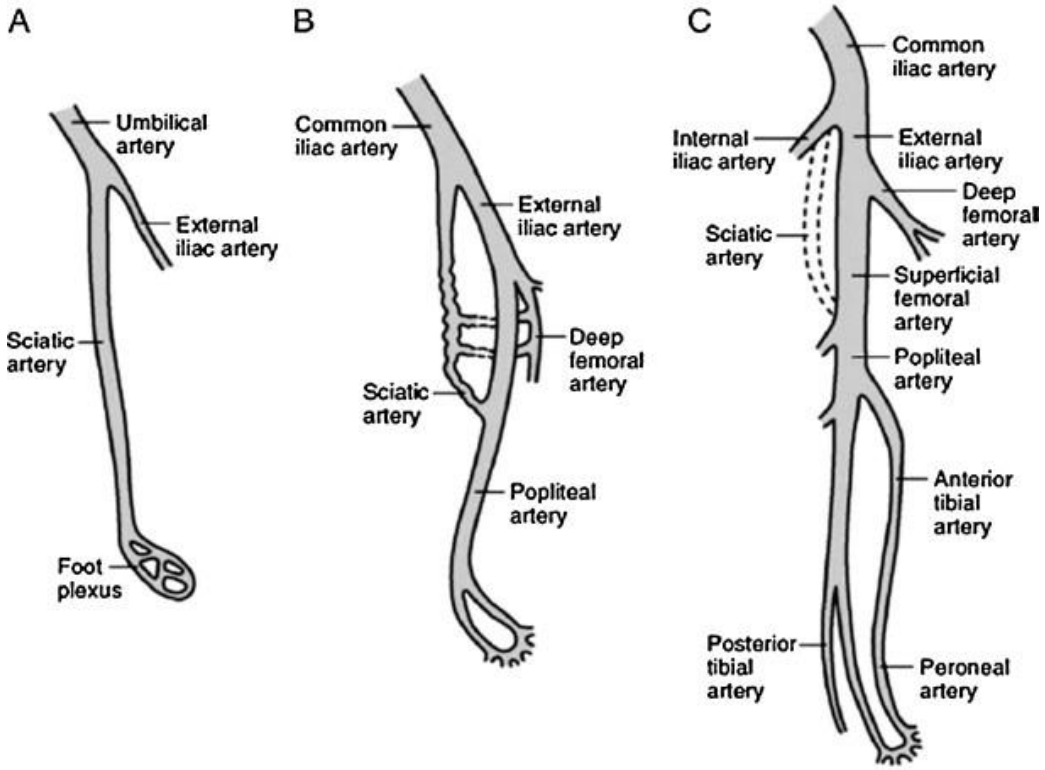
Epidemiology

- In post-mortem studies, present in 3.5% of individuals
  - Up to 60% of young patients with claudication

- Typical patients – Men (80%), 30 to 40 years
- Bilateral symptoms in 30%
  - Bilateral anatomical abnormalities in 2/3

Introduction

Embryology – Normal development of the arteries of the lower limb



- Forms from two embryonic arteries originating from the umbilical artery
  - (1) **Axial/sciatic** artery – first branch to penetrate the leg
  - (2) **External iliac artery** (8 mm embryo, 32 days intrauterine life), giving rise to the femoral arteries (11–12 mm embryo, 38 days intra-uterine life).

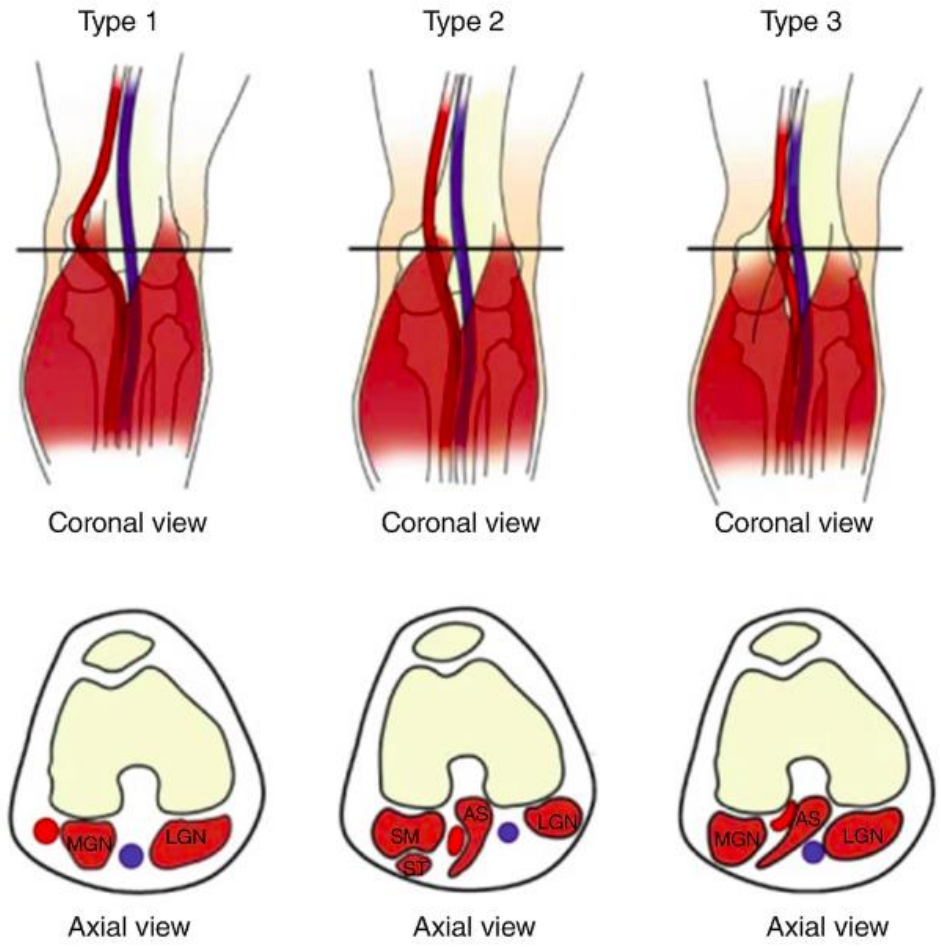
- **The popliteal artery** is formed (12mm embryo, days 39 to 42) from the union of
  - Superficial femoral artery
  - Deep popliteal artery (portion of the sciatic artery running deep to the popliteus muscle)

- **The Gastrocnemius muscle** originates from the posterior aspect of the fibula and lateral tibia
  - Migrates medially across the fossa during limb development
  - Ultimately attaches to the posterior surface of the medial femoral condyle

Introduction

Anatomical Classification

- **Type I** – Medial deviation of the artery, normal insertion of the gastrocnemius muscle (GM)
  - Complete development of the popliteal artery before the migration of the GM
  - During migration, the muscle pushes the artery medially
- **Type II** – Medial deviation of the artery, abnormal femoral insertion of the gastrocnemius muscle
  - Premature formation of the artery arrests the migration of the GM, results in an abnormally attached GM
- **Type III** – Popliteal artery develops within the muscle
  - Abnormal muscle slip/band (either form the lateral or medial condyle)
  - Remnants of the muscle remains posterior

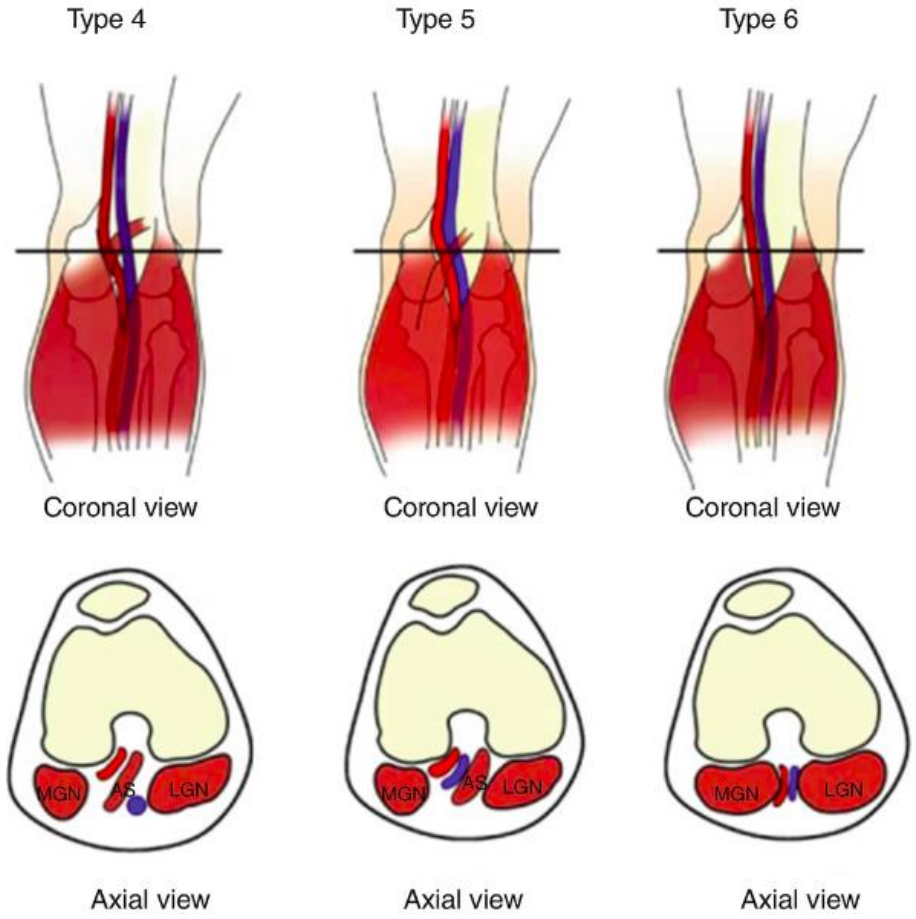


Rothstein, W., Farooq, S., Newton, D.H. (2024).

Introduction

Anatomical Classification

- **Type IV** – Deep to the popliteal muscle
  - Persistance of the sciatic artery as the mature artery keeping its embryologic position
- **Type V** – Involvement of the vein (10 to 15% of cases)
- **Type VI (Type F)** – Functional entrapment
  - Typical feature without anatomical cause
  - Multiple hypothesis, hypertrophied gastrocnemius muscles, lateral courses



Rothstein, W., Farooq, S., Newton, D.H. (2024).

Introduction

Histological Classification

Staging	Histological finding	Clinical significance
Stage 1	Fibrosis confined to the adventitia	Developing fibrosis
Stage 2	Fibrosis involving the media	May lead to post-stenotic dilatation and aneurysm formation (13.5%)
Stage 3	Fibrosis extending into the intima	Luminal surface becomes thrombogenic (occlusion in 24%)

Henry et al., 2004

The staging does not seem to be related to the duration of the compression

Clinical presentation and diagnostic modalities

Clinical Presentation

Clinical Classification and Physical Examination

- Asymptomatic to chronic limb threatning ischemia (CLTI), rarely acute ischemia
- Most common – Claudication in young and active patients
  - May be atypical claudication
  - Coldness, paresthesia, numbness (nerve compression)
- Venous entrapment – Calf cramping, swelling, fullness

Stage 0	Asymptomatic
Stage 1	Pain, paresthesia, cold feet after physical training (in non-professional athletes)
Stage 2	Claudication > 100m
Stage 3	Claudication < 100m
Stage 4	Rest pain
Stage 5	Necrosis

di Marzo, L., & Cavallaro, A. (1997)

Physical Examination

- *Palpable pulses at rest*
- Lost of pulses with maneuvers tensing the gastrocnemius muscle (low sensibility)
  - Passive dorsiflexion
  - Active plantar flexion
- May present with signs of distal embolization or thrombosis

Clinical presentation

Differential Diagnosis

	Population	Clinical pearls	Diagnosis
Iliac artery endofibrosis	Young athletes (cyclists) F = M	Exertional pain, resolves with rest	DUS and DSA with hip flexion - DUS – Increased intimal thickness - DSA – Iliac stenosis
Adventitial cystic disease	40-50 F < H	Exertional, extended recovery time (when compared to PAD) Compression of the arterial lumen by an adventitial cystic lesion	Ishikawa sign – Loss of pedal pulses with sharp knee flexion - CT/MRI for evaluation of the fossa - DSA Scimitar sign
Chronic exertional compartment syndrome	> 40 F = M Athletes	Bilateral, pain over compartments Complete resolution in 10 to 20 minutes	Imaging N Elevated intra-compartment pressures (measured and 1 min/5 min after)

Other vascular causes

- Fibromuscular dysplasia
- Buerger Disease
- Medium and large vessel vasculitis
- PAD, popliteal aneurysm

Musculoskeletal and neurological

- Compression by bone lesion, trauma
- Stress fracture, periostitis
- Spinal stenosis

Diagnostic Evaluation

Noninvasive testing

ABI With stress/treadmill testing

Doppler With provocative maneuvers –

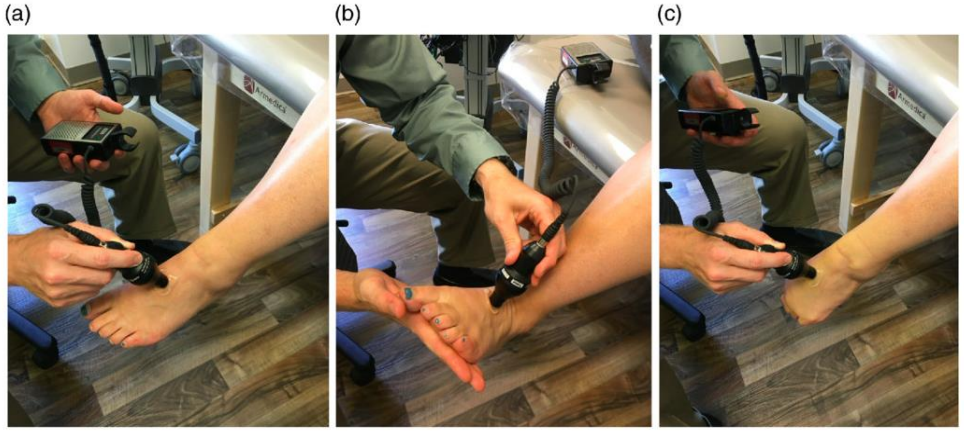
- **Active plantar flexion** and **passive dorsiflexion** while monitoring the posterior tibial artery

Duplex Scanning of the popliteal fossa, at rest and with provocative maneuvers

- Positive test when plantar flexion causes
  - Segmental loss of signal or reduced distal signal (compared to proximal)
  - Significant stenosis (PSV > 200 or double)

Disadvantages

- Operator dependant (up to 72% of false positive)
- Must be repeated



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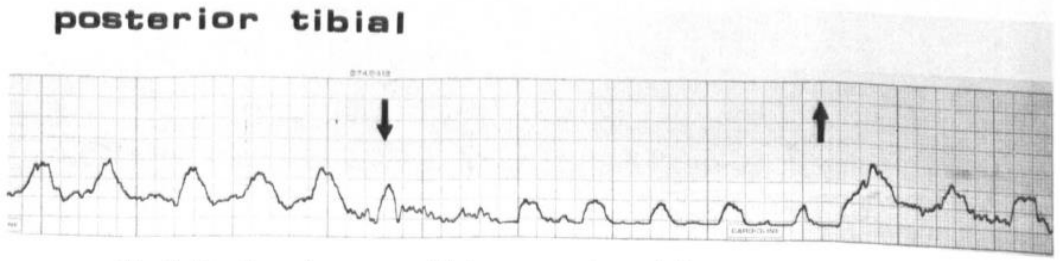


Fig. 3. Doppler tracings at rest and during maneuver (*arrows* indicate the maneuver) (case 2).

di Marzo et al, 1991

Diagnostic Evaluation

Angiography

Advantages

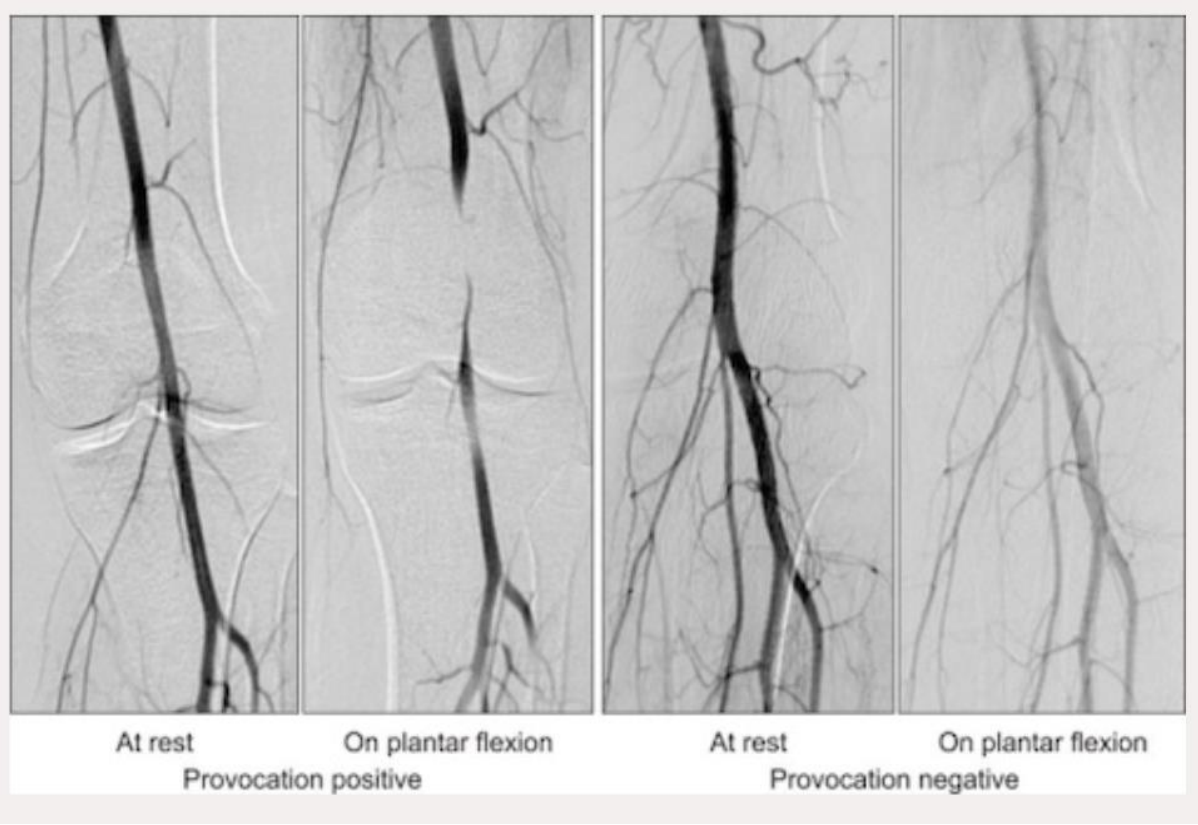
- Excellent sensitivity (ranging from 85% to 100%)
- Evaluation of the tibial anatomy

Diagnostic With at least 2 features

- Medial deviation of the proximal popliteal artery
- Focal occlusion or narrowing (typically of the mid-popliteal artery)
- Post-stenotic dilatation of the distal popliteal artery

Or if flow is patent in neutral position, but absent with provocative maneuvers

Technique In neutral position and with provocative maneuvers (plantar flexion and dorsiflexion)



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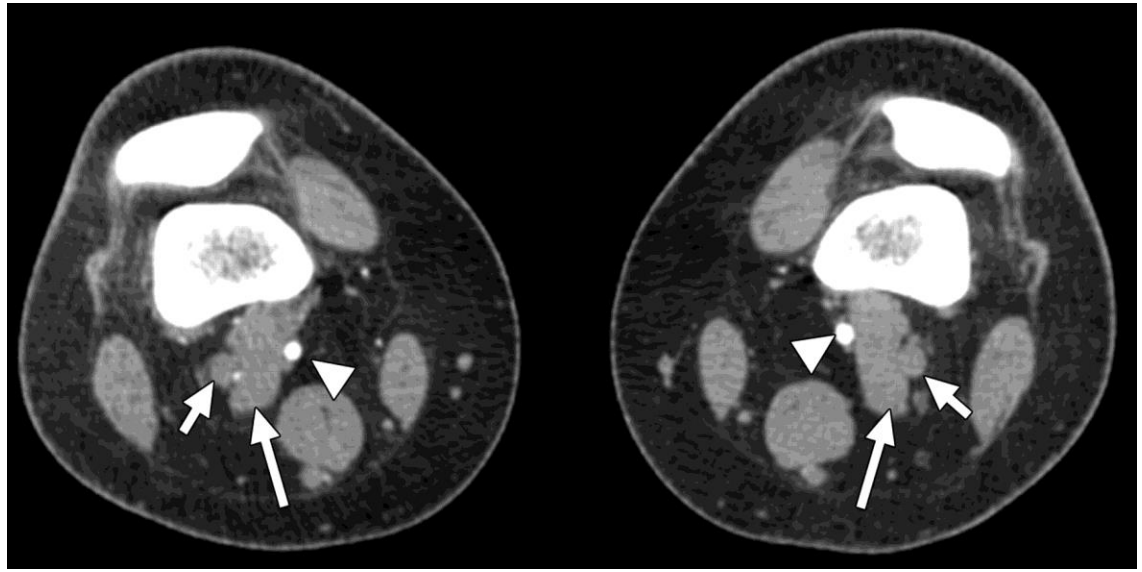
Diagnostic Evaluation

Computed Tomography Angiography

- Shows the relationship between the vascular and musculoskeletal structures
- Allows identification of abnormal muscle insertions, deviation of the artery, etc
  - Allows accurate grading

Advantages

- In modern series – Non-inferior to DSA
  - Useful in cases of advanced PAES with stenosis or occlusion
  - Noninvasive



Role of CT Angiography in the Diagnosis and Treatment of Popliteal Vascular Entrapment Syndrome, https://doi.org/10.2214/AJR.11.6789

19-year-old man with bilateral popliteal vascular entrapment syndrome.

Transverse CT angiographic image shows bilateral type 2 popliteal vascular entrapment syndrome. Long arrows indicate bilateral medial head of gastrocnemius muscles (*long arrows*), which divaricate popliteal artery (*arrowheads*) and vein (*short arrows*).

Diagnostic Evaluation

Computed Tomography

- Shows the relationship between the vascular and musculoskeletal structures
- Allows identification of abnormal muscle insertions, deviation of the artery, etc
  - Allows accurate grading

Magnetic Resonance Imaging

- Allows excellent evaluation of the musculoskeletal relationships
- For some – First choice for further investigations and evaluation of the popliteal fossa

Treatment

Treatment

Natural history with conservative non-surgical management

- High rate of complications without surgical treatment
  - Progression of the fibroses requiring more extensive surgery
  - 18 to 31% of complications with risk of limb loss (thrombosis, embolization from aneurysmal formation)
  - Progression of the atherosclerosis is rare

Surgical indications Types I to V, symptomatic type VI

Treatment

General considerations and principles of treatment

Goals of the treatment

- Restauration of a normal anatomy
- Restauration of normal blood flow
- Prevent arterial degeneration
- Extension of the surgery – based on the extent of the vascular trauma

Surgical options

- Myotomy – adequate alone for entrapment with a normal popliteal artery
- Myotomy with vascular reconstruction
- Endovascular strategies – Limited (unable to treat the muscular compression)

Treatment

MSK release – Technique

Sufficient when the artery is normal

Posterior approach

Through a Z shape incision

- Advantages – Allows better inspection of the fossa and identification of the anatomical abnormalities
- Particularly useful for types III (abnormal muscle slip) and IV (persistence of axial artery)

- **Technique –** Complete division of the medial head of the gastrocnemius muscle or the abnormal musculotendinous slips
  - The popliteal artery might be identified higher in the fossa
  - No functional impact

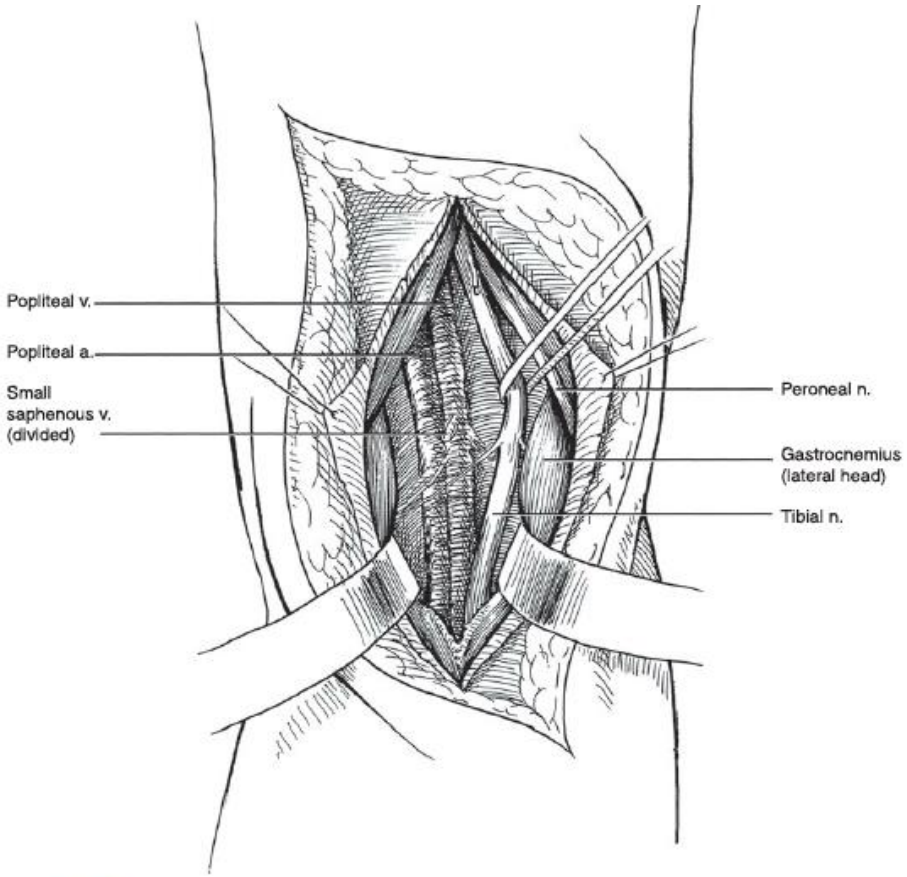


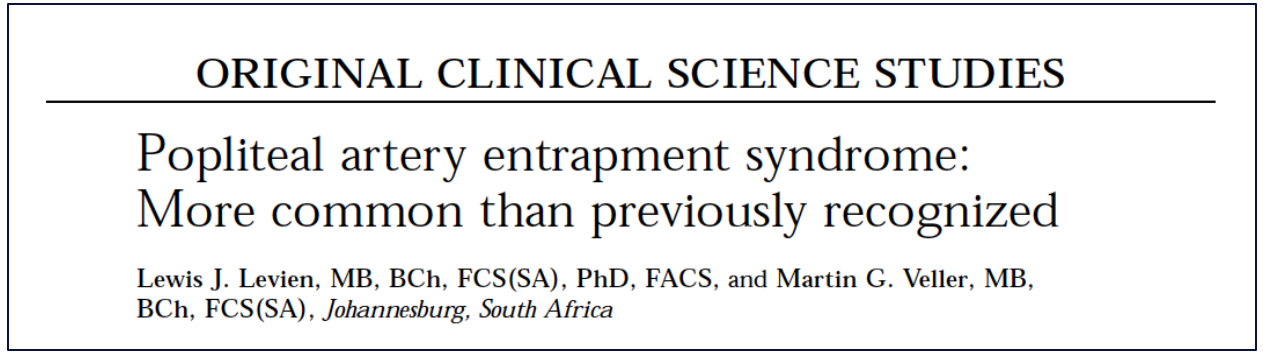
Fig. 17-38 The tibial nerve is the most superficial major midline structure and should be retracted laterally to expose the ensheathed popliteal vessels.

Treatment

MSK release – Technique

Medial approach

- May be well suited for types I and II
- Better for extensive diseased arterial segments
- Quicker recovery and return to normal activities with less incision related morbidity (Levien et Al. 1999)
  - Case series of 66 patients – 58 medial approach vs 8 posterior



ORIGINAL CLINICAL SCIENCE STUDIES

Popliteal artery entrapment syndrome:
More common than previously recognized

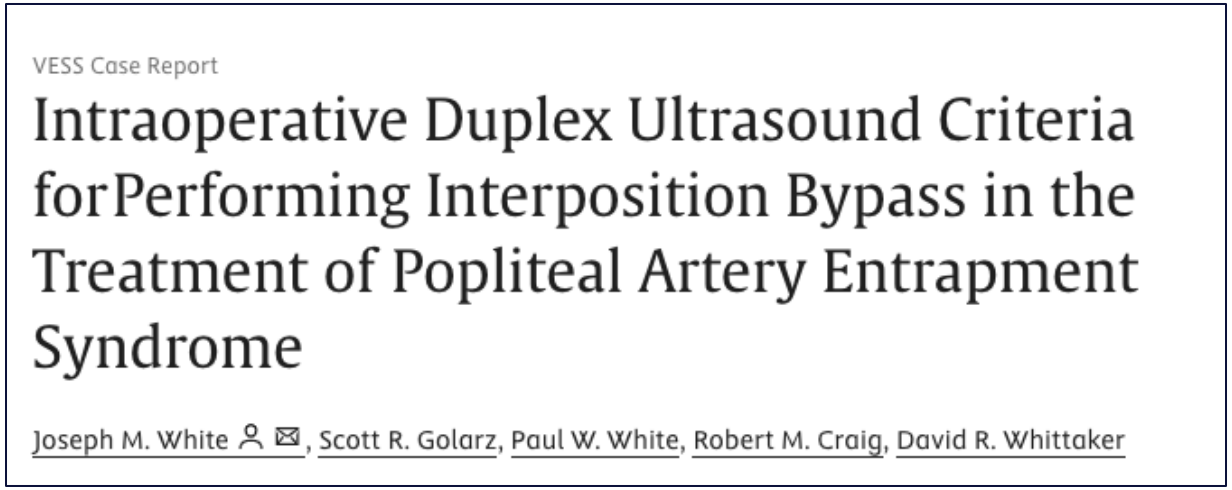
Lewis J. Levien, MB, BCh, FCS(SA), PhD, FACS, and Martin G. Veller, MB, BCh, FCS(SA), *Johannesburg, South Africa*

Treatment

Revascularisation

Indications

- Artery showing chronic damage, even if minimal (thrombosis, degeneration, thrombus formation, fibrosis causing narrowing, or post stenotic dilatation/aneurysm)
- Intra-op duplex indications – PSV > 250-275 cm/s, velocity ratio of >2, occlusion, post-stenotic degeneration


VESS Case Report

Intraoperative Duplex Ultrasound Criteria for Performing Interposition Bypass in the Treatment of Popliteal Artery Entrapment Syndrome

Joseph M. White, Scott R. Golarz, Paul W. White, Robert M. Craig, David R. Whittaker

Technical Pearls

- Muscle entrapment first relieved
- Reconstruction options – Interposition bypass with a vein graft, better results than long bypass
- Medial approach – Better for long proximal and distal extensions

Treatment

Outcomes

Outcomes of myotomy – Excellent, with low rates of complications, return to normal activities and low rates of and re-interventions

Outcomes of bypass with vein graft

- Patency of 65 to 100% at 10 years
- Short interposition – better results

Treatment

Functional Entrapment (Type VI)

Presentation Mostly athletes, exertional pain and paresthesia, lower incidence of complications

Treatment

Asymptomatic Conservative management

Symptomatic

- Botox injection
  - Of the gastrocnemius +/- plantaris muscles, to paralyze the problematic muscle slip leading to muscle atrophy
  - May also relax the arterial smooth muscle, inducing vasodilatation
  - Minimally invasive, may also act as confirmation of the diagnosis
- Surgical decompression with myotomy
- Few revascularization documented for functional PAES

Treatment

A place for endovascular treatments ?

- Limited...
  - Mechanical compression
  - Sub-optimal results for young patients

- Mostly case series with surgical decompression (hybrid procedures)
- Ozkan et al., 2012, case series of five patients
  - Technique – Balloon angioplasty and manual aspiration thrombectomy if required, with surgical decompression
  - Initial success rate – 100%
  - Primary and secondary patency at <8 years – 60%
    Thrombosis with re-intervention in two patients

- Wang et al, 2017, successful results with balloon angioplasty and directed thrombolysis alone

CASE REPORT

Endovascular Treatment of Popliteal Artery Entrapment Syndrome

Technical Aspects and Results of Endovascular Treatment With Surgical Release of Popliteal Artery

Successful endovascular treatment of popliteal artery entrapment syndrome: a case report with 3-years follow-up

Xiaodong Wang[1,2] · Hongkun Zhang[1] · Jin Yan[2] · Ziying Lu[2]

Take home messages

- Rare entity, but common and should be suspected amongst young patients without cardiovascular risk factors presenting with claudication
  - Embryology explains the classification
- Investigations requires specific maneuvers – Often needs to be suspected to be diagnosed
  - Noninvasive testing, plus CTA/MRI/DSA
  - Active plantar flexion, passive dorsiflexion
- Early diagnosis and treatment offer betters outcomes with less extensive surgeries
  - Treatment for all types I to V
  - Treatment for symptomatic Type VI

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