

Popliteal entrapment syndrome

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Introduction: Popliteal entrapment syndrome (PES) is a rare but important cause of intermittent claudication in young people. Controversy exists about optimal strategies for diagnosis and management, particularly for variants such as functional popliteal entrapment. The aim of this review was to systematically catalog the published English-language literature on PES and to determine if evidence-based guidelines for management could be formulated.

Methods: An electronic search using the MEDLINE, EMBASE, Cochrane Library, AMED, and CINAHL databases was performed to identify articles about PES published from 1947 to December 2010. The systematic review conformed to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement standards. Prospective studies and retrospective case series with more than five patients with arterial, venous, nerve, and combined neurovascular entrapment were analyzed on a study-by-study narrative basis.

Results: The search identified 291 articles, and 44 were included. Of these, 30 studies were on popliteal artery entrapment syndrome (PAES). No relationship was found between duration of symptoms and the presence of irreversible arterial injury. Each study used a median of three diagnostic tests (range, 1-6). Arteriography was used in 28 of 30 studies to diagnose PAES, with an estimated mean sensitivity of 97% (range, 85%-100%). Twenty-three studies described arterial reconstructive procedures, with a median failure rate of 27.5% (range, 0%-83%). The proportion of patients asymptomatic after surgery was reported in only 12 of 30 studies, with a median value of 77% (range, 70%-100%).

Conclusions: A large volume of predominantly retrospective clinical data exists on PES. A subset of studies describe a significant failure rate after surgery, but study quality is insufficient to derive robust conclusions allowing recommendation of any one particular diagnostic modality or operative procedure over another. Improvements in management of this condition are unlikely to result from publication of further retrospective case series, and clinicians should concentrate on prospectively collected data with predefined inclusion criteria, outcome measures, follow-up protocols, and transparent standardized reporting criteria. (*J Vasc Surg* 2012;55:252-62.)

Intermittent claudication (IC), as a manifestation of atherosclerotic peripheral vascular disease (PVD) in older patients, is a frequently encountered symptom in vascular surgical practice. However, IC may also be described by a younger subset of patients without any risk factors for PVD and can present a diagnostic challenge.¹ Popliteal entrapment syndrome (PES) describes a group of conditions in which compression of the popliteal artery, popliteal vein, and tibial nerve (singly or in combination) in the popliteal fossa by surrounding musculoskeletal structures occurs to a degree sufficient to cause vascular and neurogenic symptoms.² Popliteal artery entrapment syndrome (PAES) is believed to be responsible for a significant proportion of IC in young patients and should not be considered benign, because

progressive injury to the popliteal artery with subsequent limb loss has been described.^{3,4}

Although the anatomic basis for entrapment of the popliteal artery was first described in 1879, the clinical condition associated with such anatomic abnormalities was not described until 1958.³ Knowledge of the syndrome—and of variations in the underlying anatomic abnormalities—was subsequently advanced through sporadic publication of case reports and small case series.³ The formation of the Popliteal Vascular Entrapment Forum in 1998 was an attempt to gain some consensus on the anatomic classification of the different types of PES (Fig 1), but it was acknowledged that the quality of available studies on which to base management guidelines was poor, and attempts at evidence synthesis have previously been through narrative commentary rather than systematic review.^{3,5}

PES can be difficult to differentiate from other causes of exertional lower leg pain in young patients, and proposed management algorithms are complex or based on guidelines for atherosclerotic PVD, with particular inconsistencies in the diagnosis of functional popliteal entrapment.^{5,6} Furthermore, although open surgery was traditionally recommended as the treatment of choice for PES, the development of endoluminal revascularization (catheter-directed thrombolysis) and endovascular techniques has fueled interest in complementary treatment strategies.^{7,8} As a consequence, there remains a lack of consensus regarding the most effective strategy for diagnosis and treatment of PES. The

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Competition of interest: none.

Additional material for this article may be found online at www.jvascsurg.org.
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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a competition of interest.

0741-5214/\$36.00

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doi:10.1016/j.jvs.2011.08.050

Type I	Popliteal artery running medial to the medialhead of gastrocnemius
Type II	Medial head of gastrocnemiuslaterally attached
Type II	Accessory slip of gastrocnemius/fibrous bands arising from medial head of gastrocnemius
Type IV	Popliteal artery passing below popliteus muscle/fibrous bands arising from popliteus
Type V	Primarily venous entrapment
Type VI	Other variants
Type F	Functional entrapment

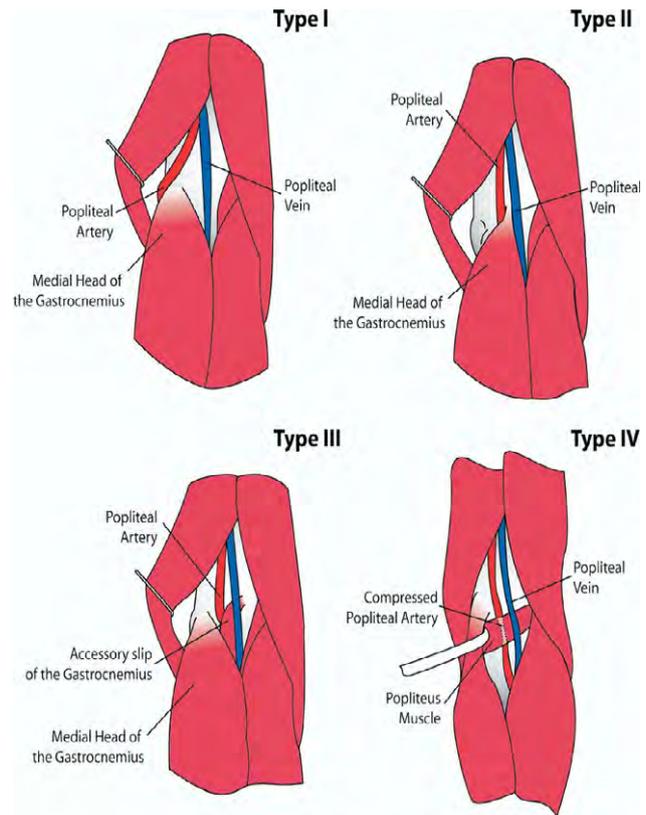


Fig 1. Popliteal Vascular Entrapment Forum classification for popliteal entrapment syndrome (adapted from Di Marzo and Cavallaro,⁵ figures reproduced from Pillai et al² with permission).

objective of this study was to systematically categorize the published English-language literature on PES, collate the evidence, and determine if evidence-based guidelines for management could be formulated.

METHODS

A systematic review of PES was performed by electronically searching the medical literature published from 1947 to December 2010 using EMBASE Classic, EMBASE, Ovid-MEDLINE, Ovid-MEDLINE in-process and other nonindexed citations, AMED, CINAHL, the Cochrane Database of Systematic Reviews, the Cochrane Database of Controlled Trials, and Elsevier's ScienceDirect catalog. The search strategy was limited to English-language articles and used the following terms: "popliteal" adj/adj2/adj3 "entrapment" and "popliteal" adj/adj2/adj3 "compression" in titles and abstract fields for all databases. In addition for EMBASE and MEDLINE, the exploded term "popliteal" was combined with the keywords "entrapment" and "compression".

Inclusion criteria for articles were prospective studies and retrospective case series with more than five patients. We excluded case reports, case series with fewer than five patients, letters, review articles, and commentaries. The electronic search results were manually reviewed to retrieve

relevant titles and complemented by hand searches of reference lists of the included articles. The literature review conformed to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement standards.⁹

Articles that met the inclusion criteria were further classified according to the pathology described (ie, entrapment of artery, vein, and/or nerve), and two authors (S.S., R.H.) independently abstracted the data. Data were collected on patient demographics (age, sex), disease presentation (symptoms, laterality), diagnostic adjuncts, type of treatment, duration of follow-up, and outcome measures and summarized in evidence tables as a study-by-study narrative. Outcome measures of interest were mortality rates, complication rates (eg, graft failure and amputations), successful relief of symptoms in operated-on symptomatic limbs, successful prevention of symptoms in operated-on asymptomatic limbs, and results for conservatively managed limbs.

Study quality was assessed by examining risk of bias using validated Cochrane methodology.¹⁰ The quality of the study was based on the risks of bias and was translated into a level of evidence according to the Scottish Intercollegiate Guidelines Network (SIGN) instrument.¹¹

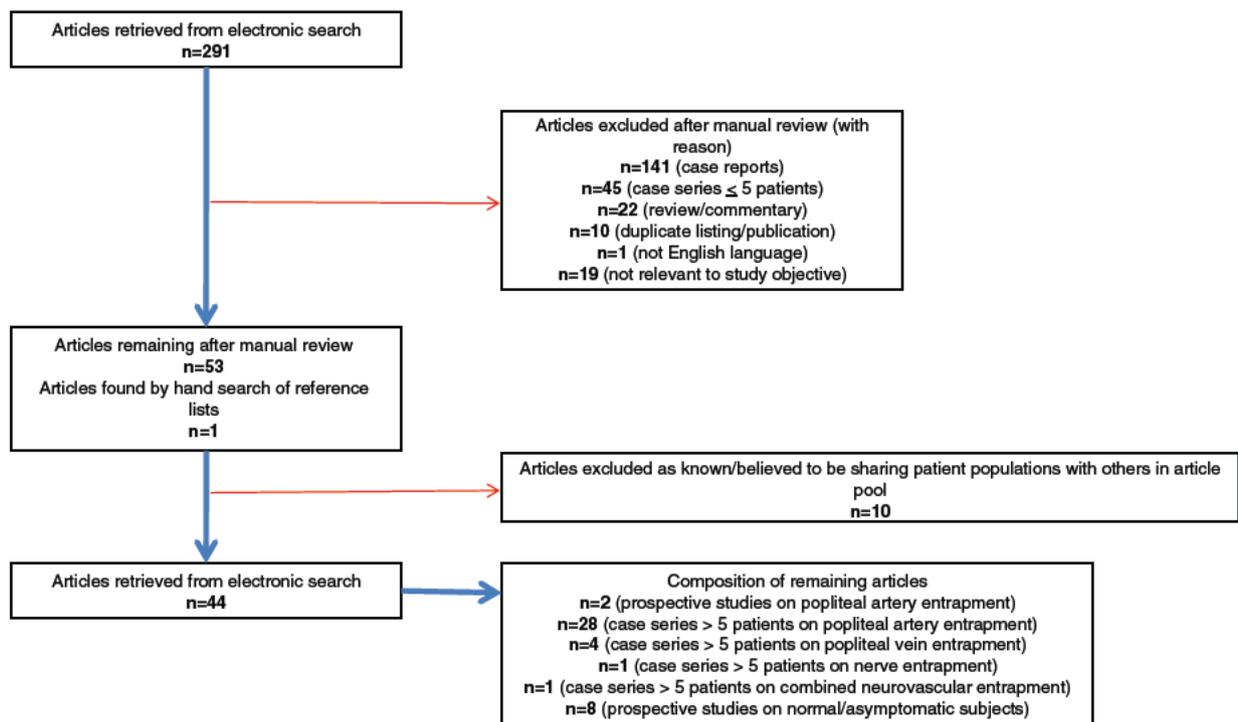


Fig 2. Flow chart shows systematic search results.

Owing to the inconsistency of reporting and heterogeneity of study interventions, follow-up, and outcomes—particularly at the patient level—results were not pooled. Statistical analysis was performed using StatsDirect 2.7.8 software (StatsDirect, Cheshire, UK). The Mann-Whitney two-sided *U* test was used to compare means, with $P < .05$ considered significant.

RESULTS

The initial systematic search retrieved 291 articles (Fig 2). Manual review of the retrieved articles deemed 53 were suitable for inclusion, and the hand search of reference lists added a further article. The 54 articles comprised two prospective studies on PAES, 37 retrospective case series on PAES, four on popliteal vein entrapment PVES, one tibial nerve entrapment in the popliteal fossa, two on combined neurovascular entrapment, and eight prospective studies assessing prevalence of popliteal vascular compression or occlusion in asymptomatic individuals.

We excluded nine of the 37 case series on PAES and one of the two case series on combined neurovascular entrapment because more recent studies included in the article pool potentially shared a proportion of the patient populations.¹²⁻²¹ This was confirmed by personal communication with the lead authors for six of the 10 articles.¹²⁻¹⁷ Thus, 44 articles remained and were included in the final analysis (Appendices 1-7, online only).²²⁻⁶⁵

Overview of studies. All 44 studies were noted to be at risk of bias in the domains assessed and were graded at SIGN evidence level 2 to 3 (Table I).

Patient demographics and disease presentation. Of the 30 studies on PAES, 27 reported the mean age of patients, giving a value of 32 years (range, 20.7-41 years), and 29 studies reported sex distribution, with a median male proportion of 83% (range, 22%-100%). The number of limbs diagnosed with PAES was reported in 28 studies, with a median of 15.5 limbs (range, 7-88 limbs).

IC was the most common presenting symptom in 22 studies, although the definitions used were variably reported. Eleven studies described a median proportion of 11% of limbs (range, 5%-67%) presenting with acute ischemia.^{24,26,27,30,33,36,37,41,42,45,49} A median proportion of 38.25% of patients (range, 0%-100%) diagnosed with bilateral PAES was described in 26 studies. In 12 of 30 studies, a median proportion of 17.5% of limbs (range, 6%-31%) diagnosed with PAES were asymptomatic, whereas this proportion was unclear in seven studies. In the remaining 11 studies, no asymptomatic limbs were diagnosed with PAES.^{22,23,26,32,37,39,43,44,46,48,50}

Three of the four studies on PVES reported median age of 28 years (range, 27.6-43.6 years). Three of the studies that reported sex differentiation indicated a median 73% female predominance (range, 53%-100%).

Three of the four studies reported a median of 14 limbs (range, 11-49 limbs) diagnosed with PVES. The most common presenting symptom was limb swelling. In three of the four studies, the number of asymptomatic limbs diagnosed with PVES was unclear.^{52,53,55} Three studies described a median of 27% of patients (range, 0%-34%) diagnosed with bilateral PVES. Foot numbness or pares-

Table I. Summary characteristics/results of the studies included in the systematic review

<i>Study (year)</i>	<i>Pathology</i>	<i>Study type</i>	<i>Patients (No.)</i>	<i>Limbs (No.)</i>	<i>Diagnostic tests used</i>	<i>Operated (%)</i>	<i>Asymptomatic (%)</i>	<i>SIGN level^a</i>
Di Cesare (1994) ²²	PAES	Prospective	6	10	Doppler US/ABPI, MRI, DSA	20	NS/UC	2-
Forster (1997) ²³	PAES	Prospective	9	17	Doppler US/ABPI, MRA, DSA	100	NS/UC	2-
Greenwood (1986) ²⁴	PAES	Retrospective	7	12	ETT, PVR, DSA	67	NS/UC	3
Kim (2006) ²⁵	PAES	Retrospective	12	23	Doppler US/ABPI, MRI, MRA, CT, CTA, DSA	NS/UC	NS/UC	3
Ozkan (2008) ²⁶	PAES	Retrospective	6	7	MRI, DSA	83	NS/UC	3
Hai (2008) ²⁷	PAES	Retrospective	8	11	CTA, MRI, DSA	100	NS/UC	3
Papaioannou (2009) ²⁸	PAES	Retrospective	16	NS/UC	CTA	NS/UC	NS/UC	3
Anil (2010) ²⁹	PAES	Retrospective	8	13	CTA	100	NS/UC	3
Zhong (2010) ³⁰	PAES	Retrospective	9	13	CTA, DSA	100	NS/UC	3
Rich (1979) ³¹	PAES	Retrospective	9	14	ETT, Doppler US/ABPI, PVR, DSA	100	NS/UC	3
Ferrero (1980) ³²	PAES	Retrospective	7	7	DSA	100	NS/UC	3
Collins (1989) ³³	PAES	Retrospective	12	20	ETT, DSA	90	73	3
Gyftokostas 1991 ³⁴	PAES	Retrospective	NS/UC	74	Doppler US/ABPI, DSA	10	NS/UC	3
Zund (1995) ³⁵	PAES	Retrospective	20	26	Doppler US/ABPI, DSA, CT	92	NS/UC	3
Rosset (1995) ³⁶	PAES	Retrospective	11	15	DSA, CT, MRI	100	NS/UC	3
Porcellini (1997) ³⁷	PAES	Retrospective	9	11	Doppler US/ABPI, ETT, DUS, CTA, MRI, DSA	100	91	3
Hoelting 1997 ³⁸	PAES	Retrospective	19	23	Doppler US/ABPI, DSA	100	70	3
Di Marzo (1997) ³⁹	PAES	Retrospective	30	45	Doppler US/ABPI, DUS, DSA	100	76	3
Deshpande (1998) ⁴⁰	PAES	Retrospective	8	16	Duplex US, DSA	100	75	3
Lambert (1998) ⁴¹	PAES	Retrospective	17	21	PFR, DUS, MRI, DSA	81	70	3
Davidovich (1999) ⁴²	PAES	Retrospective	8	9	Doppler US/ABPI, DSA	100	89	3
Levien (1999) ⁴³	PAES	Retrospective	48	88	Doppler US/ABPI, DUS, DSA	93	NS/UC	3
Ring Jr (1999) ⁴⁴	PAES	Retrospective	8	16	DSA	81	NS/UC	3
Andrikopoulos (1999) ⁴⁵	PAES	Retrospective	14	18	Doppler US/ABPI, DUS, MRI, CT, DSA	100	78	3
Ohara (2001) ⁴⁶	PAES	Retrospective	10	11	Doppler US/ABPI, CT, DSA	100	91	3
Ruppert (2004) ⁴⁷	PAES	Retrospective	23	32	Doppler US/ABPI, DSA	100	NS/UC	3
Goh (2005) ⁴⁸	PAES	Retrospective	6	8	Doppler US/ABPI, DUS, CTA, MRI, DSA	100	87.5	3
Bustabad 2006 ⁴⁹	PAES	Retrospective	8	12	Doppler US/ABPI, DUS, MRI/MRA, DSA	83	70	3
Gourgiotis (2008) ⁵⁰	PAES	Retrospective	38	49	Doppler US/ABPI, DUS, CT, CTA, DSA	100	100	3
Turnipseed (2009) ⁵¹	PAES	Retrospective	57	NS/UC	Doppler US/ABPI, PVR, DUS, MRA/MRI, DSA	100	NS/UC	3
Raju 2000 ⁵²	PVES	Retrospective	30	NS/UC	PVR, DUS, venography	100	48	3
Hirokawa 2002 ⁵³	PVES	Retrospective	11	14	Doppler US, DUS, venography, CT	100	57	3
Milleret (2007) ⁵⁴	PVES	Retrospective	11	11	Doppler US, DUS, venography	100	82	3
Lane (2009) ⁵⁵	PVES	Retrospective	NS/UC	49	Duplex US, venography	61	NS/UC	3
Mastaglia (2000) ⁵⁶	NEPF	Retrospective	9	9	Nerve conduction studies, electromyography	67	100	3
Psathakis (1991) ⁵⁷	CNVE	Retrospective	49	66	Doppler US/ABPI, venography	62	98	3
Pailler (1988) ⁵⁸	Healthy subjects	Prospective	107	NS/UC	Doppler US/ABPI	N/A	N/A	2-
Leon (1992) ⁵⁹	Healthy subjects	Prospective	100	200	Duplex US, PVR	N/A	N/A	2-
Erdoes (1994) ⁶⁰	Healthy subjects	Prospective	36	72	Duplex US, MRI, MRA	N/A	N/A	2-
Chernoff (1995) ⁶¹	Healthy subjects	Prospective	13	13	Doppler US/ABPI, MRI/MRA	N/A	N/A	2-
Akkersdijk (1995) ⁶²	Healthy subjects	Prospective	16	32	Duplex US	N/A	N/A	2-

Table I. Continued

Study (year)	Pathology	Study type	Patients (No.)	Limbs (No.)	Diagnostic tests used	Operated (%)	Asymptomatic (%)	SIGN level ^a
Hoffman (1997) ⁶³	Healthy subjects	Prospective	42	84	Duplex US, MRI	N/A	N/A	2-
De Almeida (2004) ⁶⁴	Healthy subjects	Prospective	42	84	Doppler US/ABPI, DUS	N/A	N/A	2-
Pillai (2008) ⁶⁵	Healthy subjects	Prospective	88	176	Doppler US/ABPI, DUS, MRI	N/A	N/A	2-

ABPI, Ankle-brachial pressure index; CNVE, combined neurovascular entrapment; CT, computed tomography; CTA, computed tomography angiography; DSA, digital subtraction arteriography; DUS, duplex ultrasound; ETT, exercise treadmill test; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; N/A, not applicable; NEPF, nerve entrapment in the popliteal fossa; NS/UC, not stated/unclear; PAES, popliteal artery entrapment syndrome; PFR, plain film radiography; PVES, popliteal vein entrapment syndrome; PVR, pulse-volume recording; SIGN, Scottish Intercollegiate Guidelines Network; US, ultrasound.

^aA risk of bias was present in all studies.

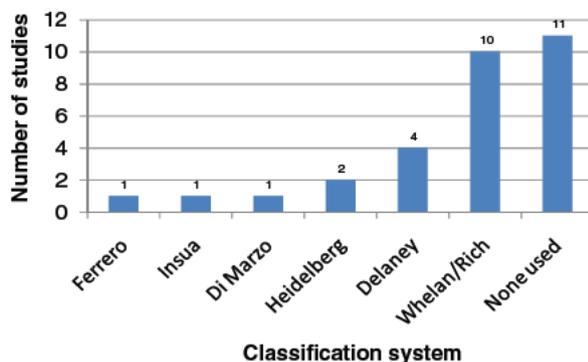


Fig 3. Study level use of classification systems on popliteal artery entrapment syndrome (n = 30).

thetia was reported in all patients in the series on tibial nerve entrapment.⁵⁶

Anatomic variations and functional popliteal artery entrapment. There was considerable variability in the use of anatomic classification systems among the 30 studies on PAES (Fig 3). Functional popliteal artery entrapment was reported by nine of 30 studies, and this subset comprised a median 23% of entrapments (range, 6.25%-87.5%).^{22,25,29,40,43,44,47,49,51} Of the remaining 21 studies, 14 provided sufficient detail about anatomic types to conclude that functional entrapment was not present in any of the reported patients. Although the most commonly used definition of functional popliteal entrapment was that proposed by Rignault et al⁶⁶ (compression due to muscular hypertrophy), two other interpretations of functional popliteal entrapment were encountered.^{51,65} No evidence was found to suggest differing symptoms or clinical characteristics for functional entrapment in studies that used the Rignault et al⁶⁶ definition. However, one study that defined functional entrapment at the level of the soleal sling described a different patient demographic (greater proportion of women), atypical symptoms (deep soleal cramping with foot paresthesia), an indolent clinical course (absence of vascular complications), and clinical overlap with chronic compartment syndrome.⁵¹

Diagnostic modalities. Frequency of use and results of diagnostic tests at the patient level were inconsistently

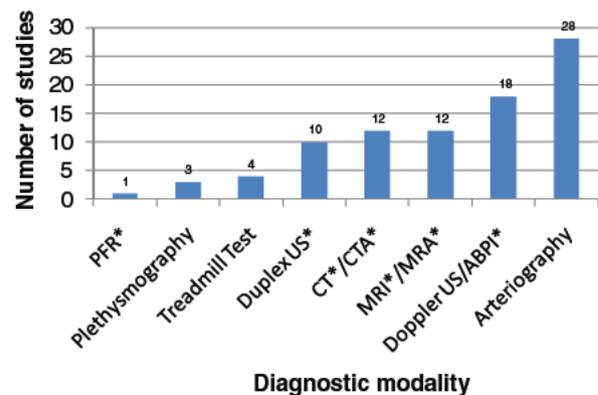


Fig 4. Study level use of diagnostic adjuncts for popliteal artery entrapment syndrome (n = 30). ABPI, ankle-brachial pressure index; CT, computed tomography; CTA, computed tomography angiography; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; PFR, plain film radiography; US, ultrasound.

reported. Each study described a median number of three investigations (range, 1-6). Arteriography (provocation and static) was used in 28 of 30 studies for assessing PAES (Fig 4). Four studies used postexercise (treadmill) test Doppler ultrasound (US) imaging/ankle-brachial pressure index (ABPI) as part of the investigative pathway for PAES.^{24,31,33,37} The use of provocation maneuvers were described in 27 of 30 studies for at least one diagnostic modality. Duplex US imaging and provocation venography were used in the four PVES studies.⁵²⁻⁵⁵

By using surgical confirmation of pathology as the reference standard and provocation catheter arteriography as the index test, 13 of 21 studies provided sufficient information to yield a mean estimate of sensitivity for provocation arteriography of 97% (median, 100%; range, 85%-100%).^{22-24,27,30,33,36,37,39,40,42-44} Similar estimates for other diagnostic modalities are given in Table II. One prospective study and five of seven retrospective case series on PAES recommended the use of cross-sectional magnetic resonance (MR) imaging (MRI)/MR angiography (MRA) or computed tomography (CT)/CT angiography in diagnosis because it allowed visualization of the common vas-

Table II. Estimate of diagnostic sensitivities for different tests used to assess popliteal artery entrapment syndrome

Diagnostic modality	Studies describing use of test		Studies allowing estimate of sensitivity		Estimate of sensitivity, %	
	No.	Ref	No.	Ref	Mean	Median (range)
Provocation arteriography	21/30	22-25, 27, 30, 31, 33, 34, 36-40, 42-45, 47, 48, 51	13/21	22-24, 27, 30, 33, 36, 37, 39, 40, 42-44	97	100 (85-100)
Static (or not further described) arteriography	7/30	26, 32, 35, 41, 46, 49, 50	4/7	26, 32, 46, 50	100	100 (NA)
Provocation DUS	10/30	37, 39-41, 43, 45, 48-51	3/10	39, 40, 45	83	100 (50-100)
Provocation Doppler US/ABPI	18/30	22, 23, 25, 31, 34, 35, 37-39, 42, 43, 45-51	6/18	22, 39, 42, 45, 50, 51	90	100 (50-100)
MRI/MRA (provocation and static)	12/30	22, 23, 25-27, 36, 37, 41, 45, 48, 49, 51	4/12	22, 23, 26, 51	94	100 (76.5-100)
CT/CTA (provocation and static)	12/30	25, 27, 28, 29, 30, 35-37, 45, 46, 48, 50	3/12	29, 30, 46	100	100 (NA)
Exercise (treadmill) testing	4/30	24, 31, 33, 37	1/4	33	100	100 (NA)
Plethysmography/PVR	3/30	24, 31, 51	1/3	51	100	100 (NA)

ABPI, Ankle-brachial pressure index; CT, computed tomography; CTA, computed tomography angiography; DUS, duplex ultrasound; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; NA, not applicable; PVR, pulse-volume recording; US, ultrasound.

cular (arterial stenosis, occlusion, aneurysmal change, and deviated course) and extravascular (abnormal muscle attachments and muscular hypertrophy) anatomic abnormalities implicated in arterial entrapment.^{22,25-29} However, only three studies suggested that cross-sectional imaging—one supporting MRI/MRA and two supporting CT/CTA—could replace arteriography as a diagnostic test.^{26,28,29} No studies directly compared MRI/MRA with CT/CTA for diagnosis of PAES.

Imaging in healthy (asymptomatic) individuals.

Popliteal artery occlusion on provocation was demonstrated in a significant proportion of asymptomatic individuals using different diagnostic modalities. Four studies used duplex US imaging to demonstrate popliteal artery occlusion on provocation in a median of 56% of asymptomatic individuals (range, 7.1%-80%).^{60,62-64} One study demonstrated popliteal artery occlusion on provocation in 69% of asymptomatic individuals using Doppler US (ABPI) and MRA.⁶¹ No significant differences in the prevalence of popliteal artery compression were found between “athletic” and “nonathletic” asymptomatic individuals, although it is noteworthy that definitions of “athleticism” were based on unclear, subjective, or self-reported criteria.^{58,60,62-64}

Two studies reported differing prevalences of popliteal vein compression in the asymptomatic population detected by duplex US imaging on provocation (20.5% and 100%).^{59,60} The two prospective studies that used provocation MRI/MRA to compare asymptomatic with symptomatic patients found high prevalences of significant popliteal artery (25%) and vein (37.5%) compression in asymptomatic individuals.^{22,23}

Disease progression. For all modes of presentation (acute and chronic), 24 of the 30 studies on PAES de-

scribed a median 24% prevalence (range, 6%-86%) of popliteal artery occlusion, and 15 of 30 studies reported a median 13.5% prevalence (range, 4%-36%) of poststenotic dilatation or aneurysm formation in the popliteal artery. The duration of symptoms before diagnosis was reported in 10 of 30 PAES studies and was a median of 12 months (range, 4 hours-120 months).^{24,29,30,33,35,37,39,44,48,50} No relationship between duration of symptoms and presence of irreversible arterial damage (occlusion, poststenotic dilatation, or aneurysm formation) was found in the three studies that reported sufficient patient-level detail to carry out this analysis ($P = .55$, $P = .17$, and $P = .64$, two-sided Mann-Whitney U test).^{24,30,48}

Surgical treatments. Surgical treatment for PAES was described in 28 of 30 studies. The two studies that did not describe whether surgery was performed were both retrospective case series with a focus on diagnostics.^{25,28} An exclusively posterior approach to the popliteal fossa was used in five studies.^{31,33,34,37,46} Three studies described using the medial approach more frequently than the posterior approach.^{40,43,51} Studies that advocated both approaches tended to acknowledge the superiority of the posterior approach for exposing popliteal fossa anatomy and reported use of the medial approach only when an arterial bypass procedure was anticipated, although there were no descriptions of protocolized care pathways. After musculotendinous division to release the entrapment, only one study described reattachment of the gastrocnemius muscle compared with eight studies that did not reattach it.^{31,33,34,37,39,40,46,49,50} Of the 30 studies on PAES, 23 described arterial reconstructive procedures (Fig 5). The four PVES case series described decompressive surgery (fasciotomy with or without musculotendinous section),

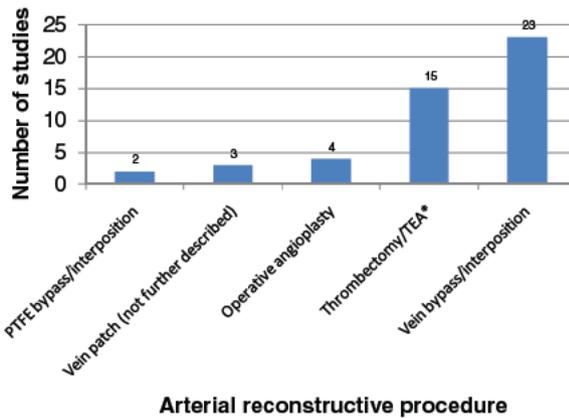


Fig 5. Study level distribution of arterial reconstructive procedures for popliteal artery entrapment syndrome. TEA, Thromboendarterectomy, with and without polytetrafluoroethylene or vein patching.

and two of the four described popliteal vein reconstruction.^{52,53}

Nonoperative and complementary treatments. Nine of the 30 PAES studies contained limbs diagnosed with PAES that did not undergo surgery (median proportion, 17%; range 8%-80%).^{22,24,26,33,35,41,43,44,49} Although patient refusal was the most common stated reason for not performing surgery, the reason for not operating in five studies was unclear for at least one patient.^{22,24,41,44,49} The conservatively managed cohort of five of the nine studies contained symptomatic limbs only.^{22,26,43,44,49} In one study, the nonoperated-on cohort comprised 75% symptomatic limbs and 25% asymptomatic limbs.²⁴ It was not possible to determine the proportions of symptomatic and asymptomatic limbs in the remaining three nonoperated-on cohorts.^{33,35,41} Only three of the nine studies described outcomes for the conservatively managed cohorts^{26,43,49}:

The first study reported a patient with an anatomic entrapment who refused decompressive surgery after catheter-directed thrombolysis. Recurrent thrombosis 2 months later required bypass grafting.²⁶

The second study contained two conservatively managed limbs with anatomic entrapments. Symptoms resolved in one limb and persisted in the other limb.⁴⁹

The third study described six limbs that did not undergo initial decompressive surgery, and four of the six limbs were diagnosed with functional entrapment. The authors reported "progressive and total resolution of symptoms" after cessation of "extreme physical activity." Of the remaining two limbs with anatomic entrapments, one eventually required amputation for advanced ischemia (a woman who presented late after preceding unsuccessful thrombolysis and subsequently was found to have a thrombophilic syndrome), and revascularization was not possible in the other due to poor run-off; however, specific outcomes for this limb were not stated.⁴³

In the combined neurovascular entrapment case series, 38% did not undergo surgery, but no outcomes were presented for this subgroup.⁵⁷

Five retrospective case series on PAES described endoluminal revascularization using catheter-directed thrombolysis.^{24,26,41,44,49} Four studies described initial thrombolytic therapy in seven patients with PAES.^{24,41,44,49} Thrombolysis was considered to have improved distal run-off in four, but did not obviate the need for surgery in any of the patients. One study described catheter-directed thrombolysis, followed by percutaneous transluminal angioplasty, for two of six patients diagnosed with PAES, both of whom eventually required surgery.²⁶ No studies described the use of endovascular stenting for treating PAES, one study described the use of postoperative antiplatelet agents for PAES patients, and no studies reported use of postoperative anticoagulation for PVES patients.⁴⁹

There were no reports of noninterventional rehabilitative therapy for arterial or venous entrapment, but the single case series on tibial nerve entrapment described a time-limited restriction of physical activity for three of nine patients, all three of whom experienced "improvement" in symptoms and did not require surgery.⁵⁶

Asymptomatic limbs diagnosed with entrapment. Of the 12 studies on PAES containing asymptomatic limbs, surgery was performed for all asymptomatic limbs in eight studies.^{27,29,30,40,42,44,45,49} In one series, no surgery was performed in the single described asymptomatic limb.²⁴ In three studies, it was not possible to determine the proportion of asymptomatic limbs that underwent surgery.^{25,33,41} Outcomes were not clearly reported in nine of the 12 studies. The remaining three studies reported no new symptoms in asymptomatic limbs that underwent surgery.^{40,42,45}

Outcome measures. Successful resolution of symptoms after surgery for PAES was reported clearly in only 12 of 30 studies, with a median value of 77% (range, 70%-100%)^{33,37-42,45,46,48-50} (Fig 6). Three of 30 studies used entirely subjective descriptions for outcomes, such as "good" or "excellent," and 15 of 30 studies did not clearly describe symptom resolution after surgery. No deaths were reported in any studies.

Complications related to arterial reconstruction were described in 14 of 30 studies, with a median failure rate of 27.5% (range, 0%-83%) but were reported too heterogeneously to yield meaningful comparisons between types of reconstruction (ie, interposition/bypass graft vs thromboendarterectomy).^{33,35,37-39,41-46,48-50} Amputation ("minor" in one, above knee in one, and level not specified in two) as a result of failed treatment was reported in four case series (one patient in each series).^{38,43,45,48} Other complications described wound infection or hematoma in four studies (median frequency, 3%), wound seroma in one study (frequency, 4.6%), and deep vein thrombosis in one study (frequency, 11%).

Two of four case series on PVES reported resolution of symptoms in 48% and 57% of patients after surgery.^{52,53} One PVES study reported symptom "improvement" in

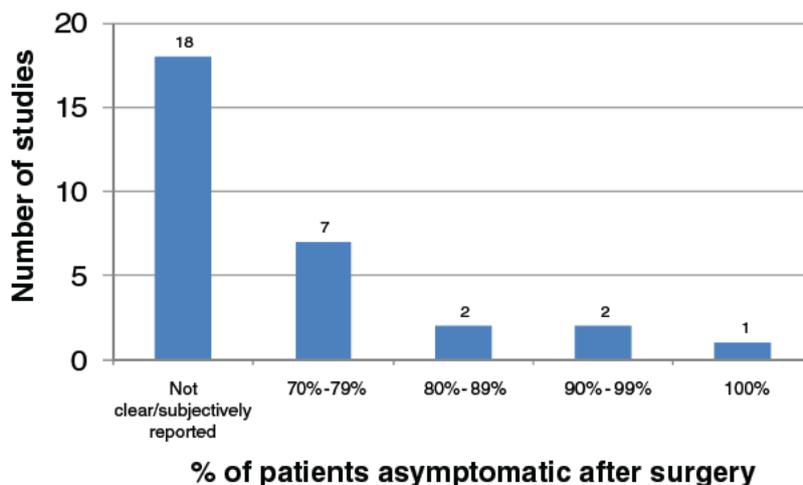


Fig 6. Percentage of patients asymptomatic after surgery for popliteal artery entrapment syndrome by study (n = 30).

nine of 11 patients (82%) after surgery but used a validated questionnaire for only five patients.⁵⁴ Another study used a published venous disease clinical scoring system to assess improvement after surgery.⁵⁵ The case series on nerve entrapment reported symptom “improvement” in the six patients who underwent surgery as well as in the three patients who did not.⁵⁶ The case series on combined neurovascular entrapment reported simply that 98% of patients were asymptomatic after surgery, with no further qualifying statements.⁵⁷

Follow-up data were variably reported. The follow-up period was not reported or unclear in 16 of 30 studies on PAES, and loss to follow-up was not reported or unclear in 20 studies. In the studies that did report the follow-up period, median duration was 51 months (range, 1-264 months). Follow-up investigations for patients with PAES were reported in 14 of 30 studies, with duplex US imaging being most commonly used (nine studies). Only two studies used exercise testing as part of follow-up investigations.^{33,39} Follow-up duration and loss to follow-up was specified in three and two of the four PVES case series, respectively, with duration of follow-up ranging from 2 to 120 months.

DISCUSSION

Diagnosis and appropriate management of PES is complicated by several factors: first, although its true prevalence is unknown, the condition is rare.

Second, dynamic occlusion of the popliteal vessels can be demonstrated in a significant proportion of asymptomatic individuals and, indeed, has been described as a “physiological phenomenon”.⁶² The reported prevalence of popliteal artery occlusion in asymptomatic individuals detected with duplex US imaging varied between studies from 7.1% to 80%. This may be a result of differences in measurement techniques, because flow dynamics under provocation differ depending on which part of the popliteal artery record-

ings are taken from.⁶² Given the incidence of occlusion in healthy individuals, reliance solely on radiologic demonstration of vascular occlusion for diagnosis of PAES in symptomatic patients is likely to yield a significant number of false-positive results. Imaging modalities that delineate anatomic abnormalities known to cause entrapment and also demonstrate vascular occlusion might be expected to increase diagnostic specificity, but use of cross-sectional imaging appears to lag behind the use of Doppler US imaging and arteriography.

Third, despite attempts at consensus, considerable variation remains in the use of anatomic classification systems and in the definition of variants such as functional entrapment. This review identified the use of six different classification systems, with only one study using the consensus classification system proposed by the Popliteal Vascular Entrapment Forum. It is noteworthy that even the consensus classification system contains a type labeled “variants”, with little guidance on exactly what should be placed in this group. Some researchers have classed entrapment from the soleal sling in the “variants” category, whereas others consider this to be the cause of functional entrapment.^{39,51} The true prevalence of functional entrapment is unknown, and this likely reflects the differing definitions of the underlying pathology.

The Rignault et al⁶⁶ original description of functional entrapment was based on one case report with subjectively defined outcomes, and even among reports that subscribe to the Rignault et al⁶⁶ definition of functional entrapment, variations exist in the interpretation of the mechanism of entrapment and in the type of operation used to treat it.^{40,44,47,66} Other authors have proposed entirely different mechanisms of functional entrapment, such as subtle variations in the attachment of the medial head of gastrocnemius.⁶⁵ Only one study, which described functional entrapment at the soleal sling, acknowledged clinical overlap with chronic compartment syndrome.⁵¹ Although this study

described a 0% reoperation rate for functional entrapment, it also reported that >50% of patients undergoing surgery for functional entrapment required precedent or subsequent fasciectomy for chronic compartment syndrome.⁵¹

This systematic review has revealed that although a significant volume of material on PES has been published, the quality of available evidence on which to base guidelines is poor. Included studies were noted to be at risk of bias, and significant variability was found in the reporting of key outcome measures. Most of the included studies were on PAES and PVES, and although venous entrapment can coexist with arterial entrapment, the case series on PVES described a predominantly female patient cohort compared with the studies on PAES. Tibial nerve entrapment was described in one case series that reported equivalent results in both surgically treated and conservatively managed patients.⁵⁶ A separate series on combined neurovascular entrapment was described by one author and termed popliteal “pseudoentrapment” syndrome.⁵⁷ We think it noteworthy that no other researchers have since described this condition and that key features of the “pseudoentrapment” syndrome, such as associated entrapment of the tibial nerve, have been described as variants of PAES.³¹

Although estimates of sensitivity were gleaned for some diagnostic tests, clinicians should interpret these with care given the inconsistent reporting of numbers of limbs screened, inconsistent reporting of test results and operative confirmation at patient level, and the lack of a universally accepted reference standard for diagnosis. In particular, there was a dearth of data on negative surgical explorations preventing calculation of specificity for diagnostic tests. Our unit currently investigates all patients bilaterally with APBIs before and after exercise testing and noninvasive compartment pressure measurements, static MRI/MRA, and provocation arteriography, with results discussed at a specialized vascular multidisciplinary team meeting.

Insufficient evidence was gathered to demonstrate superiority of any one operative treatment over another, although alternative treatments for PAES, such as catheter-directed thrombolysis, did not seem to obviate the need for subsequent surgery. However, challenging the traditional dogma that symptomatic PAES should always be managed surgically, this review has found that a subset of studies describe a significant rate of failure (both arterial surgical reconstruction failure and failure to cure symptoms), which underscores the need for protocolized management pathways based on the best available evidence.

Outcomes for nonoperative management of symptomatic PAES were reported for only eight limbs, with spontaneous symptom resolution noted in five limbs (one limb with anatomic entrapment and four limbs with functional entrapment). Robust recommendations on conservative management strategies for anatomic or functional symptomatic entrapments cannot be made, however, because one of the eight limbs with an anatomic entrapment presented later with advanced ischemia requiring amputation, while the same study which described symptom resolution

in the four limbs with functional entrapment also described arterial occlusion in three other limbs with functional entrapment. Evidence to guide the management of asymptomatic limbs diagnosed with entrapment is also lacking. Outcomes are only available for six asymptomatic limbs that underwent surgery, with no report of new symptoms in the treated limbs.

Only one study described a conservatively managed asymptomatic limb but did not present outcomes for it. Our unit does not currently carry out popliteal fossa decompression on asymptomatic limbs diagnosed with entrapment or on symptomatic limbs without concurrent objective (ie, postexercise test ABPI drop) or radiologic evidence of concurrent arterial compression. Such patients enter a graded physical rehabilitation program and are assessed using the same follow-up protocol as surgically treated patients.

Publication of further retrospective case series on PES is unlikely to result in improvements in management and outcome. Given the rarity of the condition and the difficulty in accumulating significant numbers of cases, patients with suspected PES should be referred to large vascular centers for management to allow build-up of expertise and greater coherence in data collection. Future attempts at data collection should be done prospectively with predefined inclusion and exclusion parameters, outcome measures, follow-up protocols, and standardized reporting criteria to maximize their value.⁶⁷

The deficiencies in reporting identified by this systematic review have directed our unit to focus on a number of parameters. We now maintain a prospective database that clearly records the number of patients screened. Both lower limbs are assessed in patients who enter the investigative pathway. Symptoms, results of investigations, and operative results are reported by limb and not by patient, with the reasons for not operating on a limb clearly recorded. Results of all surgical explorations (positive and negative) are entered into the database.

Our postoperative follow-up protocol is defined a priori and consists of a graded physical rehabilitation program, a postprocedure exercise test at 6 weeks, and a telephone consultation at 3, 6, and 12 months, with deviations from protocol (eg, readmissions due to recurrent symptoms) prospectively recorded. Our primary outcome measures are patient oriented (numbers asymptomatic after surgery or returning to presymptom level of activities or both) and are supplemented with validated preoperative and postoperative quality-of-life questionnaire scores (Short Form 36-Item Health Survey and Walking Impairment Questionnaire).⁶⁸ We believe that objective and pragmatic evidence of effectiveness is critical (such as postsurgery exercise testing) rather than surrogate clinical end points (such as graft patency rates). Although surgical complications are notoriously variably reported, we support the use of published classification systems to improve comparability and generalizability of data.⁶⁹

Units should aim to collect complete outcome data for all four groups: symptomatic surgically treated limbs, con-

servatively managed symptomatic limbs, asymptomatic surgically treated limbs, and asymptomatic conservatively managed limbs. Given the differing definitions of functional entrapment and differing opinions about the nature of progression of the condition, particular efforts are needed to gather data for this subgroup. It is unreasonable to expect international consensus on controversial areas such as the definition of functional entrapment, but it is crucial that studies clearly report the definitions and classification systems that they do use. Eventual consensus on definition may only be possible in the future after comparison of outcomes between different studies, but this will only be feasible if data are reported in a transparent and standardized manner.

This systematic review is at risk of bias given that search strategies were limited to English-language articles. Owing to a lack of prospective and randomized trials, the review included a large proportion of retrospective case series, and it has been demonstrated that observational studies, such as case series, are more susceptible to publication bias than randomized trials.⁷⁰ The review excluded retrospective case series with five or fewer patients, which is arguably unjustified because sample size of case series has not been shown to influence outcome.⁷¹ The rationale for excluding these smaller series was to collate the experiences of centers that have treated several patients rather than those with only isolated experiences, and the threshold of more than five patients allowed retention of an acceptable number of studies. Lowering the threshold to include case series with five patients would have resulted in the addition of only five more articles (all on PAES).

CONCLUSIONS

This systematic review has catalogued a large volume of primarily retrospective clinical data on PES. Although a subset of studies suggests a significant failure rate after surgery, there is insufficient evidence to clearly recommend one diagnostic modality or operative procedure over another. Clinicians should henceforth concentrate on prospectively collected data with predefined inclusion criteria, outcome measures, and follow-up protocols, as well as transparent standardized reporting criteria.

AUTHOR CONTRIBUTIONS

Conception and design: RH, JH, IL, SS

Analysis and interpretation: SS, RH, JH

Data collection: SS, RH

Writing the article: SS

Critical revision of the article: RH, JH, IL, MT, PH

Final approval of the article: RH, IL, MT, PH, JH

Statistical analysis: SS

Obtained funding: Not applicable

Overall responsibility: RH

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Submitted May 4, 2011; accepted Aug 21, 2011.

Additional material for this article may be found online at www.jvascsurg.org.

Appendix I (online only). Included prospective studies on popliteal vein entrapment

<i>Reference</i>	<i>Patient characteristics</i>	<i>Diagnostic adjuncts</i>	<i>Classification of pathology</i>	<i>Intervention</i>	<i>Outcomes + follow-up</i>	<i>Risk of bias/SIGN level</i>
Di Cesare (1994) ²²	8 asymptomatic subjects (16 limbs)	Asymptomatic subjects: provocation MRI used in 8/8 subjects (16 limbs)	Asymptomatic subjects' MRI findings: no anatomic abnormalities found but PV compression on provocation = 37.5%	Surgery 2/10 (those with positive Doppler US, MRI, and arteriography), no surgery 8/10 (reasons unclear)	Outcomes measures NS	Free from risk of bias?
Case-control study	Mean age 29.1 (range, 21-34) yrs, 4M:4F	Symptomatic patients: provocation Doppler US used in 6/6 patients (unclear if all patients assessed bilaterally, 9 limbs positive)	Symptomatic patients' MRI findings: type I = 10%, type II = 10%, functional = 40%, variants = 20%, no anatomic abnormalities found but PV compression on provocation = 20%	Surgical approach NS	Follow-up duration: NS	Baseline imbalance: no
Evaluating provocation MRI for diagnosis of PAES	6 patients (10 limbs) with PAES	Provocation MRI used in 6/6 patients (unclear if all patients assessed bilaterally, 8 limbs positive)	Heidelberg classification	Muscle/band section 2/2 (100%)	Loss to follow-up: NS	Blinding of assessors: no
Single-center (Italy)	Mean age 37.3 (range, 22-50) yrs, 3M:3F	Provocation arteriography used for 2/6 patients (unclear if patients assessed bilaterally, 2 limbs positive)			Follow-up tests: NS	Partial verification: no
Study period: NS	4/6 (67%) patients symptomatic bilaterally Duration of symptoms: NS PVD risk factors in 0/14 patients	Provocation maneuvers: plantar flexion				Differential verification: no Incomplete outcome data: no Selective outcome reporting: no Source of funding: unclear Academic: yes SIGN level of evidence: 2-
Forster (1997) ²³	8 asymptomatic subjects (16 limbs)	Asymptomatic subjects: provocation MRA used in 8/8 (16 limbs)	Asymptomatic subjects' MRA findings: no stenosis (75%), 1%-50% stenosis (25%)	Surgery 17/17	Outcome measures: NS	Free from risk of bias?

Appendix I (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Case-control study	Mean age 33.4 (range, 25-37) yrs, 4M:4F	Symptomatic patients: ABPI and Doppler US (frequency of use and accuracy unclear)	Symptomatic patients' MRA findings: 1%-50% stenosis (23.5%), 51%-75% stenosis (23.5%), 76%-99% stenosis (23.5%), >99% stenosis (29%)	Surgical approach NS	Follow-up duration: NS	Baseline imbalance: no
Evaluating provocation MRA vs DSA for diagnosis of PAES	9 patients (17 limbs) with PAES	Provocation DSA used in 9/9 patients (17/18 limbs assessed)	Symptomatic patients' DSA findings: 51%-75% stenosis (12%), 76%-99% stenosis (23.5%), >99% stenosis (65%)	Muscle/band section 17/17 (100%)	Loss to follow-up: NS	Blinding of assessors: yes
Single center (Canada)	Mean age 20.7 (range, 14-34) yrs, 2M:7F	Provocation MRA used in 9/9 patients (17/18 limbs assessed)	Anatomic types described		Follow-up tests: NS	Partial verification: no
Study period: 9-mo recruitment	8/9 (89%) of patients symptomatic bilaterally Duration of symptoms: NS PVD risk factors: NS	41% agreement between MRA and DSA Provocation maneuvers: plantar flexion	Classification system NS			Differential verification: no Incomplete outcome data: unclear Selective outcome reporting: yes Source of funding: unclear Academic: yes SIGN level of evidence: 2-

DSA, Digital subtraction arteriography; MRA, magnetic resonance angiography; PAES, popliteal artery entrapment syndrome; SIGN, Scottish Intercollegiate Guidelines Network; MRI, magnetic resonance imaging; NS, not stated or not specified; PV, popliteal vein; US, ultrasound.

Appendix II (online only). Included retrospective case-series on popliteal artery entrapment syndrome with a focus on diagnostics

<i>Reference</i>	<i>Patient characteristics</i>	<i>Diagnostic adjuncts</i>	<i>Classification of pathology</i>	<i>Intervention</i>	<i>Outcomes + Follow-Up</i>	<i>Risk of bias/SIGN level</i>
Greenwood (1986) ²⁴	7 patients, 12 limbs	Bilateral post-treadmill test ABPI used in 7/7 patients (11/14 limbs positive)	Types described anatomically but classification system NS	1/7 (14%) of patients had initial thrombolysis (still required surgery)	Outcome measures: NS	Free from risk of bias?
Single center (USA)	5/7 (71%) of patients diagnosed with bilateral PAES	Provocation PVR used in 4/7 patients (7/8 limbs positive)	Occluded artery in 1/12 (8%)	Surgery 8/12 (67%), no surgery 4/12 (33%) [reasons unclear]	Outcome for asymptomatic limb unclear	Incomplete outcome data: no
Study period: 1980-1985	4/5 symptomatic bilaterally	Provocation arteriography used in 7/7 patients (13 limbs, 12/13 limbs positive)	No relationship to duration of symptoms	Surgical approach NS	Follow-up duration: NS	Selective outcome reporting: no
	Mean age 30.6 (range, 22-56) yrs, 6M:1F	Provocation maneuvers: plantar flexion		Surgical procedures NS	Loss to follow-up: NS	Source of funding: unclear
	Presenting symptoms by limb: IC 9/12 (75%), acute ischemia 2/12 (17%)				Follow-up tests: NS	Academic: yes
	Duration of symptoms 5 days-120 mos					SIGN level of evidence: 3
	1/12 (8%) of limbs asymptomatic (not operated)					
	PVD risk factors NS					
Kim (2006) ²⁵	12 patients, 23 limbs	ABPI and provocation Doppler US used in all patients (accuracy unclear)	Type II = 26%, type III = 22%, type V = 4%, functional = 9%, variants = 34%, no abnormality = 4%	No. operated unclear	Outcome measures: NS	Free from risk of bias?
Single center (S. Korea)	11/12 (92%) of patients diagnosed with bilateral PAES	MRI used in 12/12 patients (21 limbs, 20/21 limbs positive)	8 coexisting venous entrapments	Surgical approach NS	Outcome for asymptomatic limbs unclear	Incomplete outcome data: no
Study period: 1995-2005	7/11 symptomatic bilaterally	CT used in 5/12 patients (10 limbs, 10/10 limbs positive)	Whelan-Rich classification	Surgical procedures unclear	Follow-up duration: NS	Selective outcome reporting: unclear
	Mean age 25 (range, 18-54) yrs, 12M:0F	Bilateral provocation MRA used in 4/12 patients (8 limbs, 4/8 limbs positive)	Occluded artery in 5/23 (22%)		Loss to follow-up: NS	Source of funding: unclear
	Presenting symptoms by limb: NS	Bilateral provocation CTA used in 5/12 patients (10 limbs, 8/10 limbs positive)			Follow-up tests: NS	Academic: yes

Appendix II (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + Follow-Up	Risk of bias/SIGN level
Ozkan (2008) ²⁶	Presenting symptoms by patient: IC 12/12 (100%)	Bilateral provocation DSA used in 5/12 patients (10 limbs, 8/10 limbs positive)				SIGN level of evidence: 3
	Duration of symptoms NS	Provocation maneuvers: plantar flexion and dorsiflexion				
	4/23 (17%) of limbs asymptomatic (number operated unclear) PVD risk factors NS 6 patients, 7 limbs	MRI used in 6/6 patients (NS if dynamic scan, unclear if all patients assessed bilaterally) -7 limbs positive	Type II = 43%, type III = 57%	2/6 (33%) of patients had initial thrombolysis and PTA (1/2 then had muscle/band section, 1/2 refused decompressive surgery)	Outcome measures: NS	Free from risk of bias?
Single center (Turkey)	1/6 (17%) of patients diagnosed with bilateral PAES	DSA used in 6/6 patients (NS if dynamic test, unclear if all patients assessed bilaterally): 7 limbs positive	Whelan-Rich classification	Surgery 5/6 (83%), no surgery 1/6 (17%) [patient refusal]	Recurrent thrombosis requiring bypass surgery in 1/7 limbs initially treated with thrombolysis (and initial decompressive surgery refused by patient)	Incomplete outcome data: unclear
Study period: NS	1/1 symptomatic bilaterally	NB-MRI considered diagnostic in 7/7 limbs, DSA considered diagnostic in 2/7 limbs	Occluded artery in 4/7 (57%)	Surgical approach NS	Follow-up duration: unclear	Selective outcome reporting: unclear
	Mean age 36 (range, 17-50) yrs, 5M:1F		PSD/aneurysm in 2/7 (29%)	Bypass surgery (not described further) 4/6 (67%), muscle/band Section 1/6 (17%)	Loss to follow-up: unclear	Source of funding: unclear
	Presenting symptoms by limb: IC 6/7 (86%), acute ischemia 1/7 (14%) Duration of symptoms NS PVD risk factors NS				Follow-up tests: NS	Academic: yes SIGN level of evidence: 3

Appendix II (online only). Continued

<i>Reference</i>	<i>Patient characteristics</i>	<i>Diagnostic adjuncts</i>	<i>Classification of pathology</i>	<i>Intervention</i>	<i>Outcomes + Follow-Up</i>	<i>Risk of bias/SIGN level</i>
Hai (2008) ²⁷	8 patients, 11 limbs	Static CTA used in 7/8 patients (unclear if all patients assessed bilaterally): 10 limbs positive	Type I = 36%, type II = 45%, type III = 18%	All operated (11/11)	Outcome measures: NS	Free from risk of bias?
Single center (China)	3/8 (37.5%) of patients diagnosed with bilateral PAES	Static MRI used in 3/8 patients (unclear if all patients assessed bilaterally) – 4 limbs positive	Whelan-Rich classification	Surgical approach NS	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 2003-2007	1/3 symptomatic bilaterally Mean age 32 (range, 16-64) yrs, 6M:2F Presenting symptoms by limb: IC 5/11 (45%), rest pain 1/11 (9%), calf swelling 2/11 (18%), acute ischemia 1/11 (9%) Duration of symptoms NS 2/11 (18%) of limbs asymptomatic (all operated) PVD risk factors NS	Bilateral biplanar provocation DSA used in 8/8 patients (16 limbs, 10/16 limbs positive) Provocation maneuvers: plantar flexion and dorsiflexion	Occluded artery in 5/11 (45%) PSD/aneurysm in 2/11 (18%)	Surgical procedures NS	Follow-up duration: NS Loss to follow-up: NS Follow-up tests: NS	Selective outcome reporting: no Source of funding: unclear Academic: no SIGN level of evidence: 3
Papaoannou (2009) ²⁸	16 patients, number of limbs unclear	Provocation CTA used in 16/16 patients (unclear if all patients assessed bilaterally, 13/16 patients showed evidence of vascular compression)	Types NS	No. operated NS	Outcome measures: NS	Free from risk of bias?
Single center (Greece) Study period: 2002-2007	Incidence of bilateral cases unclear Mean age 26 (range, 18-72) yrs, 9M:7F Presenting symptoms by limb or patient: unclear	Provocation maneuvers: knee hyperextension	1 coexistent venous entrapment Classification system NS Occluded artery in 1 limb (denominator unclear)	Surgical approach NS Surgical procedures NS	Follow-up duration: NS Loss to follow-up: NS Follow-up tests: NS	Incomplete outcome data: no Selective outcome reporting: no Source of funding: unclear

Appendix II (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + Follow-Up	Risk of bias/SIGN level
	Duration of symptoms NS PVD risk factors NS					Academic: yes SIGN level of evidence: 3
Anil (2010) ²⁹	8 patients, 13 limbs	Bilateral provocation CTA used in 8/8 patients (16 limbs, 13/16 limbs positive)	Type I = 15%, type II = 8%, type III = 38%, functional = 23%, variants = 15%	All operated (13/13)	Outcome measures: NS	Free from risk of bias?
No. of centers unclear (Singapore)	5/8 (62.5%) of patients diagnosed with bilateral PAES	NB-CTA considered diagnostic in 13/13 limbs	Whelan-Rich classification	Surgical approach NS	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 2002-2009	2/5 symptomatic bilaterally	Provocation maneuvers: plantar flexion	Occluded artery in 4/13 (31%)	Muscle/band section only 10/13 (77%), bypass graft 2/13 (15%), "microvascular graft" + muscle/band section 1/13 (8%)	Follow-up duration: NS	Selective outcome reporting: no
	Mean age 31 (range, 22-46) yrs, 7M:1F Presenting symptoms by limb: IC 8/13 (61%), atypical pain 1/13 (8%), rest pain 1/13 (8%) Duration of symptoms 3-60 mos 3/13 (23%) of limbs asymptomatic (all operated) PVD risk factors unclear		Relationship to duration of symptoms unclear		Loss to follow-up: NS Follow-up tests: NS	Source of funding: yes Academic: unclear SIGN level of evidence: 3
Zhong (2010) ³⁰	9 patients, 13 limbs	Static CTA used in 9/9 patients (unclear if all patients assessed bilaterally): 13 limbs positive	Type I = 46%, type II = 38%, type III = 15%	All operated (13/13)	Outcome measures: NS	Free from risk of bias?
Single center (China)	4/9 (44%) of patients diagnosed with bilateral PAES	Bilateral biplanar provocation DSA used in 9/9 patients (18 limbs, 11/18 limbs positive)	Whelan-Rich classification	Surgical approach NS	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: no

Appendix II (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + Follow-Up	Risk of bias/SIGN level
Study period: 2007-2009	1/4 symptomatic bilaterally	NB-CTA considered superior in 13/13 limbs	Occluded artery in 3/13 (23%)	Muscle/band section only 6/13 (46%), endarterectomy + muscle/band section 3/13 (23%), bypass graft + muscle/band section 2/13 (15%), angioplasty (not described further) + muscle/band section 2/13 (15%)	Follow-up duration: NS	Selective outcome reporting: no
	Mean age 30 (range, 9-58) yrs, 7M:2F	Provocation maneuvers: plantar flexion and dorsiflexion	PSD/aneurysm in 2/13 (15%)		Loss to follow-up: NS	Source of funding: unclear
	Presenting symptoms by limb: IC 5/13 (38%), rest pain 1/13 (7%), cold foot/calf swelling 2/13 (15%), atypical pain 1/13 (7%), acute ischemia 1/13 (7%)		No relationship to duration of symptoms		Follow-up tests: NS	Academic: no
	Duration of symptoms: 4 h-12 mos					SIGN level of evidence: 3
	3/13 (23%) of limbs asymptomatic (all operated)					
	PVD risk factors in 3/9 patients					

ABPI, Ankle-brachial pressure index; CTA, computed tomography angiogram; DSA, digital subtraction arteriography; IC, intermittent claudication; MRI, magnetic resonance imaging; NS, not specified or not stated; PAES, popliteal artery entrapment syndrome; PSD, poststenotic dilatation; PTA, percutaneous transluminal angioplasty; PVD, peripheral vascular disease; PVR, pulse volume recording; SIGN, Scottish Intercollegiate Guidelines Network.

Appendix III (online only). Included retrospective case-series on PAES with a focus on treatment

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Rich (1979) ³¹	9 patients, 14 limbs	Exercise testing, Doppler US, provocation Doppler US and plethysmography (frequency of use NS)	Type I = 43%, type II = 7%, type III = 14%, type IV = 28%, type I + III = 7%	All operated (14/14)	Outcomes measures NS (results described as "good to excellent")	Free from risk of bias?
Single center (USA)	5/9 (55%) of patients diagnosed with bilateral PAES	Arteriography used in 14 limbs (accuracy unclear)	1 coexisting venous entrapment	Posterior approach in 14/14 (100%)	Follow-up duration: NS	Incomplete outcome data: unclear
Study period: 1966-1979	Mean age 41 (range, 21-59) yrs, 9M:0F	Provocation biplanar arteriography used in 8/14 limbs (accuracy unclear)	1 coexisting tibial nerve branch entrapment	Vein bypass graft 4/14 (29%), TEA + vein patch 2/14 (14%), muscle/band section only 8/14 (57%)	Loss to follow-up: unclear	Selective outcome reporting: no
	Presenting symptoms by limb: unclear	Unclear if all patients assessed bilaterally	Whelan-Rich classification	Muscle not reattached	Follow-up tests: NS	Source of funding: unclear
	Presenting symptoms by patient: IC 9/9 (100%)	Provocation maneuvers: plantar flexion and dorsiflexion	Occluded artery in 3/14 (21%)			Academic: yes
	Duration of symptoms NS		PSD/aneurysm in 3/14 (21%)			SIGN level of evidence: 3
	No. of asymptomatic limbs unclear					
Ferrero (1980) ³²	PVD risk factors NS 7 patients, 7 limbs	Arteriography (not described further) used in 7 limbs (7 limbs positive)	Type IV = 57%, type VI = 14%, unclear = 28%	All operated (7/7)	Outcomes measures NS	Free from risk of bias?
Single center (Italy)	0% of patients diagnosed with bilateral PAES		Ferrero classification	Surgical approach NS	Follow-up duration: NS	Incomplete outcome data: unclear
Study period: unclear	Mean age 38 (range, 19-52) yrs, 7M:0F		Occluded artery in 6/7 (86%)	Thrombectomy + patch 1/7 (14%), vein bypass/interposition graft + muscle/band section 5/7 (71%), muscle/band section only 1/7 (14%)	Loss to follow-up: NS	Selective outcome reporting: no
	Presenting symptoms by limb: IC 5/7 (71%), paresthesia 1/7 (14%), incidental finding during SFA thrombectomy 1/7 (14%)				Follow-up tests: NS	Source of funding: unclear
	Duration of symptoms NS					Academic: yes
	PVD risk factors NS					SIGN level of evidence: 3

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Collins (1989) ³³	12 patients, 20 limbs	Post-treadmill test ABPI used in 12/12 patients (20/24 limbs positive)	Type I = 5%, type II = 32%, type III = 26%, type IV = 37%	Surgery 18/20 (90%), no surgery 2/20 (10%) [patient refusal]	Asymptomatic after surgery 8/11 patients (73%), late vein graft/patch failure 2/4 (50%) [with 'mild' recurrent symptoms, unclear if reoperated], reoperation 1/11 patients (9%) [missed type IV lesion]	Free from risk of bias?
Single center (USA)	8/12 (67%) of patients diagnosed with bilateral PAES	Bilateral biplanar provocation arteriography used in 12/12 patients (20/24 limbs positive)	Whelan-Rich classification	Posterior approach in 18/18 (100%)	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 1977-1988	3/8 symptomatic bilaterally	Provocation maneuvers: plantar flexion and dorsiflexion	Occluded artery in 4/20 (20%)	SV bypass graft + muscle/band section 2/18 (11%), TEA, vein patch + muscle/band section 2/18 (11%), muscle/band section only 14/18 (78%)	Follow-up duration: unclear (range, 1 month: 'long-term')	Selective outcome reporting: no
	Mean age 27 (range, 19-53) yrs, 10M:2F Presenting symptoms by limb: IC 14/20 (70%), IC + acute ischemia 1/20 (5%) Duration of symptoms: mean 13 (range, 2-36) mos 5/20 (25%) of limbs asymptomatic (no. operated unclear) PVD risk factors NS		Relationship to duration of symptoms unclear	Muscle not reattached	Loss to follow-up: unclear Follow-up tests: post-treadmill test ABPI	Source of funding: unclear Academic: yes SIGN level of evidence: 3
Gyftokostas (1991) ³⁴	No. of patients NS, 74 limbs	Provocation ABPI used for all cases (accuracy NS, "only useful for patent vessels")	Some types described anatomically but classification system NS	All operated (74/74)	Outcomes measures NS (results described as "excellent")	Free from risk of bias?
Single center (Greece)	Incidence of bilateral cases unclear	Bilateral provocation arteriography used for all patients (accuracy NS)	Occluded artery in 23/74 (31%)	Posterior approach in 74/74 (100%)	Follow-up duration: mean 96 mos (no further details given)	Incomplete outcome data: no
Study period: 1974-1990	Mean age 25 (range, 21-30) yrs, "all but 1 male" Presenting symptoms by limb or patient NS Duration of symptoms NS No. asymptomatic limbs unclear PVD risk factors NS	Provocation maneuvers: plantar flexion	PSD/aneurysm in 10/74 (13.5%)	Muscle/band section 74/74 (100%), vein graft number NS Muscle not reattached	Loss to follow-up: NS Follow-up tests: NS	Selective outcome reporting: no Source of funding: unclear Academic: no SIGN level of evidence: 3

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Zund (1995) ³⁵	20 patients, 26 limbs	Provocation ABPI used in 18/20 patients (unclear if all patients assessed bilaterally, accuracy unclear)	Type I = 71%, type II 29%	Surgery 24/26 (92%), no surgery 2/26 (8%) [patient refusal]	Symptom relief after surgery NS, endarterectomy failure 11/11 (100%) [six reoperated], interposition graft failure 8/12 (67%) [none reoperated]	Free from risk of bias?
Single center (Switzerland)	6/20 (30%) of patients diagnosed with bilateral PAES	Static arteriography used in 6/20 patients (unclear if bilateral studies performed, accuracy unclear)	Insua classification	Surgical approach NS	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 1967-1993	Mean age 38.5 (range, 15-72) yrs, 17M:3F	CT used in 20/20 patients (bilateral assessment, 40 limbs, unclear if dynamic scan); accuracy NS	PSD/aneurysm in 1/26 (4%)	Muscle/band section 24/24 (100%), endarterectomy +/- vein patch 11/24 (46%), vein interposition graft 12/24 (50%), vein bypass graft 2/24 (8%), aneurysm resection + vein patch 1/24 (4%), operative angioplasty 1/24 (4%)	Follow-up duration: mean 86 (range, 6-264) mos	Selective outcome reporting: no
	Presenting symptoms by limb or patient NS	Provocation maneuvers: plantar flexion and dorsiflexion	Relationship to duration of symptoms unclear		Loss to follow-up: unclear	Source of funding: unclear
	Duration of symptoms: mean 60 mos				Follow-up tests: NS	Academic: yes
	No. of asymptomatic limbs unclear					SIGN level of evidence: 3
	PVD risk factors NS					
Rosset (1995) ³⁶	11 patients, 15 limbs	Provocation arteriography in 11/11 patients (unclear if bilateral studies performed, 15 limbs positive)	Types described anatomically but classification system NS	All operated (15/15)	Outcome measures: NS (results described as "excellent")	Free from risk of bias?
Single center (France)	4/11 (36%) of patients diagnosed with bilateral PAES	Venography in 1/11 patients	1 coexisting venous entrapment	Posterior approach (frequency unclear)	Follow-up duration: unclear	Incomplete outcome data: unclear
Study period: 1984-1994	Mean age 28 (range, 19-48) yrs, 10M:1F	CT used "3 times" (unclear if dynamic scan)	Occluded artery in 2/15 (13%)	Medial approach (frequency unclear)	Loss to follow-up 0%	Selective outcome reporting: no
	Presenting symptoms by limbs: unclear	MRI used "4 times" (unclear if dynamic scan)		Muscle/band section only, 12/15 (80%), SV bypass graft 3/15 (20%)	Follow-up tests: DUS	Source of funding: unclear
	Presenting symptoms by patient: IC 9/11 (82%), acute ischemia 1/11 (9%), atypical pain 1/11 (9%)	Provocation maneuvers: not described				Academic: yes
	Duration of symptoms NS					SIGN level of evidence: 3

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Porcellini (1997) ³⁷	No. of asymptomatic limbs unclear PVD risk factors NS 9 patients, 11 limbs	Provocation Doppler US (PST) (frequency of use unclear, 6 limbs positive)	Types NS	All operated (11/11)	Asymptomatic after surgery 10/11 limbs (91%), late vein graft failure 1/5 (20%) [not reoperated]	Free from risk of bias?
Single center (Italy)	2/9 (22%) of patients diagnosed with bilateral PAES	Treadmill test (frequency of use unclear, 6 limbs positive)	Classification system not specified	Posterior approach in 11/11 (100%)	Follow-up duration: mean 54 (range, 7-93) mos	Incomplete outcome data: unclear
Study period: 1983-1995	2/2 symptomatic bilaterally	Provocation DUS (frequency of use unclear)	Occluded artery in 4/11 (36%)	Vein bypass/interposition graft + muscle/band section 5/11 (45%), muscle/band section only 6/11 (55%)	Loss to follow-up: unclear	Selective outcome reporting: unclear
	Mean age 23 (range, 16-58) yrs, 9M:0F	CTA used in 4/9 patients (unclear if dynamic scan)	Aneurysm in 1/11 (9%)	Muscle not reattached	Follow-up tests: ABPI	Source of funding: unclear
	Presenting symptoms by limb: IC 3/11 (27%), cold/numb foot after exercise 5/11 (45%), acute ischemia 2/11 (18%), painful popliteal artery aneurysm 1/9 (9%)	MRI used in 2/9 patients (unclear if dynamic scan)	Relationship to duration of symptoms unclear			Academic: yes
	Duration of symptoms: 3 days -48 mos	Provocation arteriography used in 9/9 patients (unclear if bilateral studies performed, 11 limbs positive)				SIGN level of evidence: 3
	PVD risk factors in 0/9 patients	Unclear if all patients assessed bilaterally Provocation maneuvers: plantar flexion and dorsiflexion				
Hoelting (1997) ³⁸	19 patients, 23 limbs	Provocation ABPI used in 19/19 patients (accuracy unclear)	Type I = 22%, type II = 26%, type III = 52%	All operated (23/23)	Asymptomatic after surgery 16/23 limbs (70%), early vein graft failure 2/18 (11%) [1/2 required thrombectomy, 1/2 required thrombolysis], 1/23 (4%) hematoma [required reoperation], late vein graft failure 2/18 (11%) [causing critical ischemia, both reoperated], amputation 1/23 (4%) ("minor", level not specified)	Free from risk of bias?

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Single center (Germany)	4/19 (21%) of patients diagnosed with bilateral PAES	Biplanar provocation arteriography used in 19/19 patients (unclear if bilateral studies performed, accuracy unclear)	Heidelberg classification	Posterior approach (frequency NS)	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 1976-1995	Median age 43 (range, 19-61) yrs, 19M:0F Presenting symptoms by limb: NS Presenting symptoms by patient: IC 19/19 (100%) Duration of symptoms not specified No. of asymptomatic limbs unclear PVD risk factors in 0/19 patients	Provocation maneuvers: knee extension, foot plantar flexion and dorsiflexion	Occluded artery in 19/23 (83%)	Medial approach (frequency NS) TEA + muscle/band section 1/23 (4%), TEA, vein patch + muscle/band section 6/23 (26%), vein interposition graft + muscle/band section 12/23 (52%), muscle/band section only 4/23 (17%)	Follow-up duration: mean 114 (range, 6-240) mos Loss to follow-up: unclear Follow-up tests: ABPI	Selective outcome reporting: no Source of funding: unclear Academic: no SIGN level of evidence: 3
Di Marzo (1997) ³⁹	30 patients (1 bilateral redo case), 45 limbs	Provocation Doppler US used in 30/30 patients (positive in all patients)	Type II = 42%, type III = 31%, type VI = 27%	All operated (45/45)	Asymptomatic after surgery 34/45 (76%), early vein graft failure 3/15 (20%) [2/3 reoperated], 5/45 (11%) wound infection, 1/45 (2%) popliteal artery thrombosis, 2/45 (4%) recurrence of symptoms requiring reoperation, late vein graft failure 2/15 (13%) [unclear if reoperated]	Free from risk of bias?
Single center (Italy)	13/30 (43%) of patients diagnosed with bilateral PAES	Provocation DUS used in 30/30 patients (positive in all patients)	9 coexisting venous entrapments	Posterior approach (frequency NS)	Follow-up duration - mean 95 mos (range, 11-198)	Incomplete outcome data: yes
Study period: 1979-1995	13/13 symptomatic bilaterally	Provocation arteriography used in 30/30 patients (unclear if bilateral studies performed, 43 limbs positive)	Di Marzo classification	Medial approach (frequency NS)	Loss to follow-up - 0%	Selective outcome reporting: unclear

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
	Mean age 35 (range, 14-62) yrs, 23M:7F	Venography used in 2 limbs	Occluded artery in 6/45 (13%)	Muscle/band section only 28/45 (62%), balloon angioplasty + muscle/band section 2/45 (4%), PTFE graft + muscle/band section 1/45 (2%), vein bypass/interposition graft + muscle/band section 14/45 (31%)	Follow-up tests: ABPI, DUS, treadmill testing	Source of funding: unclear
	Presenting symptoms by limb: IC 23/45 (51%), cold/numb/painful foot after exercise 21/45 (47%), tissue loss 1/45 (2%) Duration of symptoms: mean 22 ± 2 mos PVD risk factors not specified	Provocation maneuvers: plantar flexion	PSD/aneurysm in 6/45 (13%) Relationship to duration of symptoms unclear	Muscle not reattached		Academic: no SIGN level of evidence: 3
Deshpande (1998) ⁴⁰	8 patients (1 redo case), 16 limbs	Provocation DUS used in 8/8 patients (16 limbs positive)	Type I = 12.5%, functional = 87.5% (“tethering by bands” classed as functional PAES by authors)	All operated (16/16)	Asymptomatic after surgery 12/16 limbs (75%) [first surgery in re-do case classed as successful by authors], 4/16 recurrent symptoms [2/4 reoperated, 2/4 unclear if reoperated]	Free from risk of bias?
Single center (Australia)	8/8 (100%) of patients diagnosed with bilateral PAES	Bilateral biplanar provocation arteriography used in 8/8 patients (16/16 limbs positive)	Classification system NS	Medial approach in 14/16 (87.5%)	No new symptoms in 1/1 asymptomatic operated limbs	Incomplete outcome data: yes
Study period: 1993-1996	7/8 symptomatic bilaterally	Provocation maneuvers: knee extension, foot plantar flexion	Occluded artery in 1/16 (6%) Relationship to duration of symptoms unclear	Medial + posterior approach in 2/16 (12.5%) [redo case] Muscle/band section only 15/16 (94%), SV bypass graft + muscle/band section 1/16 (6%)	Follow-up duration: “minimum 1 year” (no further details given) Loss to follow-up 0%	Selective outcome reporting: no Source of funding: unclear
	Mean age 22.5 (range, 18-26) yrs, 3M:5F Presenting symptoms by limb: IC 15/16 (94%) Duration of symptoms unclear 5/8 previously misdiagnosed as CPCS and treated with fasciotomies 1/16 (6%) of limbs asymptomatic (operated) PVD risk factors NS			Muscle not reattached	Follow-up tests: DUS and arteriography	Academic: yes SIGN level of evidence: 3

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Lambert (1998) ⁴¹	17 patients, 21 limbs	Plain radiography used in 1/21 limbs	Types NS	2/17 (12%) patients had initial thrombolysis (unsuccessful)	Asymptomatic after surgery 12/17 limbs (70%), interposition/bypass graft failure 2/6 (33%) [both reoperated], amputation (0%), reoperation rate for recurrent symptoms unclear	Free from risk of bias?
10 centers (UK)	4/17 (23%) of patients diagnosed with bilateral PAES	DUS used in 4/21 limbs	Classification system NS	Surgery 17/21 (81%), no surgery 4/21 (19%) [1/4 patient refusal, other cases reason unclear]	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: no
Study period: 1984-1995	1/4 symptomatic bilaterally Median age 29 (range, 14-45) yrs, 15M:2F	MRI used in 1/21 limbs Arteriography (not described further) used in 20/21 limbs		Surgical approach NS Muscle/band section only 4/17 (23.5%), TEA, vein patch + muscle/band section 4/17 (23.5%), TEA + excision of bony exostosis 1/17 (6%), vein patch + muscle/band section 2/17 (12%), interposition graft (type NS) 2/17 (12%), bypass graft (type NS) 4/17 (23.5%)	Outcome for asymptomatic nonoperated limbs unclear Outcome for symptomatic nonoperated limbs unclear	Selective outcome reporting: no Source of funding: unclear
	Presenting symptoms by limb: IC 17/21 (81%), acute ischemia 1/21 (5%) Duration of symptoms NS	Unclear if all patients assessed bilaterally			Follow-up duration: NS Loss to follow-up: unclear Follow-up tests: NS	Academic: no SIGN level of evidence: 3
Davidovich (1999) ⁴²	3/21 (14%) of limbs asymptomatic (number operated unclear) PVD risk factors NS 8 patients, 9 limbs	Bilateral provocation ABPI used in 8/8 patients (12/16 limbs positive)	Type I = 11%, type II = 22%, type III = 44%, type IV = 11%, not classified = 11%	All operated (9/9)	Asymptomatic after surgery 8/9 limbs (89%), early graft failure (0%), late occlusion 1/9 (11%) [thrombectomy case, not reoperated], amputation (0%)	Free from risk of bias?
Single center (Yugoslavia)	1/8 (12.5%) of patients diagnosed with bilateral PAES	Provocation arteriography used in 8/8 patients (10 limbs studied, 9/10 positive)	Delaney classification	Posterior approach in 8/9 (89%)	No new symptoms in 1/1 asymptomatic operated limbs	Incomplete outcome data: no
Study period: 1985-1996	0/1 symptomatic bilaterally	Provocation maneuvers: plantar flexion and dorsiflexion	Occluded artery in 7/9 (78%)	Medial approach in 1/9 (11%)	Follow-up duration: mean 75 (range, 12-144) mos	Selective outcome reporting: no

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Levien (1999) ⁴³	Mean age 34.6 (range, 25-54) yrs, 7M:1F		PSD/aneurysm in 1/9 (11%)	Muscle/band section only 1/9 (11%), thrombectomy + muscle/band section 1/9 (11%), vein interposition graft + muscle/band section 5/9 (55%), vein interposition graft only 1/9 (11%), vein bypass graft 1/9 (11%)	Loss to follow-up 0%	Source of funding: unclear
	Presenting symptoms by limb: acute ischemia 6/9 (67%), chronic ischemia 2/9 (22%) Duration of symptoms NS				Follow-up tests: ABPI	Academic: yes
	1/9 (11%) of limbs asymptomatic (operated) PVD risk factors in 0/8 patients					SIGN level of evidence: 3
	48 patients, 88 limbs	Provocation ABPI (frequency of use and accuracy unclear)	Type I = 5%, type II = 14%, type III = 37.5%, type IV = 9%, functional = 34%	Surgery 82/88 (93%), no surgery 6/88 (7%) [4/6 functional entrapment, 2/6 delayed presentation]	Symptom relief after surgery unclear, late occlusion 1/16 (6%) [thrombectomy case, reoperated], amputation [level NS] 1/82 (1%)	Free from risk of bias?
Single center (South Africa)	40/48 (83%) of patients diagnosed with bilateral PAES	Provocation DUS (frequency of use and accuracy unclear)	10 coexisting venous entrapments	Posterior approach in 8/82 (10%)	Outcome for 5/6 symptomatic nonoperated limbs [four functional entrapments, one anatomical entrapment] stated	Incomplete outcome data: unclear
Study period: 1987-1997	40/40 symptomatic bilaterally	Provocation arteriography (frequency of use unclear, 70/88 limbs positive)	Whelan/modified Rich classification	Medial approach in 74/82 (90%)	Follow-up duration: median 48 (range, 12-120) mos	Selective outcome reporting: no
	Mean age 34.9 (range, 16-55) yrs, 60% male	Unclear if all patients assessed bilaterally	Occluded artery in 18/88 (20%)	Muscle/band section only 66/82 (80%), thrombectomy, vein patch + muscle/band section 1/82 (1%), vein bypass graft + muscle/band section 15/82 (18%)	Loss to follow-up 0%	Source of funding: unclear
	Presenting symptoms by limb: IC 70/88 (80%), critical ischemia 18/88 (20%) Duration of symptoms NS	Provocation maneuvers: plantar flexion and dorsiflexion	PSD/aneurysm in 8/88 (9%)		Follow-up tests: DUS	Academic: no
	No. of asymptomatic limbs unclear PVD risk factors NS					SIGN level of evidence: 3

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Ring Jr (1999) ⁴⁴	8 patients, 16 limbs	Bilateral biplanar provocation arteriography used in 8/8 patients (16/16 limbs positive)	Type I = 6%, type II = 25%, type III = 6%, type IV = 31%, type V = 6%, functional = 12.5%	3/8 (37.5%) of patients had initial thrombolysis (all required surgery)	Symptom relief after surgery NS, amputation (0%), reoperation rate for vein grafts (0%)	Free from risk of bias?
Single center (USA)	8/8 (100%) of patients diagnosed with bilateral PAES	Provocation maneuvers: plantar flexion and dorsiflexion	1 coexisting venous entrapment	Surgery 13/16 (81%), no surgery 3/16 (19%) [2/3 patient refusal, 1/3 reason unclear]	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: no
Study period: 1991-1998	3/8 symptomatic bilaterally Mean age 33.7 (range, 24-56) yrs, 8M:0F		Whelan-Rich classification Occluded artery in 2/16 (12.5%)	Surgical approach NS Muscle/band section only 8/13 (61.5%), thrombectomy + muscle/band section 1/13 (8%), vein interposition/bypass graft 3/13 (23%), fasciotomy 1/13 (8%) [functional entrapment]	Follow-up duration: NS Loss to follow-up 12.5% (prior to surgery)	Selective outcome reporting: no Source of funding: unclear
	Symptoms by limb: IC 10/16 (62.5%), numb foot after exercise 1/16 (6%) Duration of symptoms: 2 days-84 mos 5/16 (31%) of limbs asymptomatic (all operated) PVD risk factors in 5/8 patients		PSD/aneurysm in 2/16 (12.5%) Relationship to duration of symptoms unclear		Follow-up tests: NS	Academic: yes SIGN level of evidence: 3
Andrikopoulos (1999) ⁴⁵	14 patients, 18 limbs	Provocation Doppler and DUS used in 18/18 limbs (unclear if all patients assessed bilaterally, 9 limbs positive)	Some types described anatomically but classification system NS	All operated (18/18)	Asymptomatic after surgery 14/18 limbs (78%), early vein graft failure 1/7 (14%) [reoperated], late vein graft failure 2/7 (28%) [not reoperated], early PTFE graft failure 1/4 (25%), late PTFE graft failure 1/4 (25%) [not reoperated], above-knee amputation 1/18 (5%) [early PTFE graft failure], DVT 2/18 (11%)	Free from risk of bias?
Single center (Greece)	4/14 (29%) of patients diagnosed with bilateral PAES	Bilateral biplanar provocation arteriography used in 13/14 patients (18/26 limbs positive)	2 coexisting venous entrapments	Posterior approach in 17/18 (94%)	No new symptoms in 4/4 asymptomatic operated limbs	Incomplete outcome data: no
Study period: 1986-1996	0/4 symptomatic bilaterally	MRI used for post-op diagnosis in one patient initially misdiagnosed as embolic phenomenon	Occluded artery in 4/18 (22%)	Medial approach in 1/18 (6%) (misdiagnosed as embolic phenomenon)	Follow-up duration: median 24 (range, 5-96) mos	Selective outcome reporting: no

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Ohara (2001) ⁴⁶	Mean age 32 (range, 16-54) yrs; 13M:1F	CT (frequency of use NS, unclear if dynamic scan)	PSD/aneurysm in 2/18 (11%)	Vein graft + muscle/band section 7/18 (39%), PTFE graft + muscle/band section 2/18 (11%), TEA, PTFE patch + muscle/band section 1/18 (5%), muscle/band section only 7/18 (39%), PTFE graft only 1/18 (11%) [misdiagnosed case]	Loss to follow-up 2/14 (14%) after 3 yrs	Source of funding: unclear
	Presenting symptoms by limb: IC 7/18 (39%), acute ischemia 2/18 (11%), atypical pain 3/18 (17%), rest pain 1/18 (5%), rest pain and tissue loss 1/18 (5%) Duration of symptoms NS	Provocation maneuvers: plantar flexion and dorsiflexion			Follow-up tests: unclear	Academic: yes
Single center (Japan)	4/18 (22%) of limbs asymptomatic (all operated) PVD risk factors in 4/14 patients 10 patients, 11 limbs	Provocation Doppler US (PST) used in 5/10 patients (not used if artery occluded)	Type I = 18%, type II = 64%, type III 36%, type IV = 0%	All operated (11/11)	Asymptomatic after surgery 10/11 limbs (91%), late vein patch failure 1/3 (33%) [not reoperated]	Free from risk of bias?
Study period: 1980-1999	1/10 (10%) of patients diagnosed with bilateral PAES	Static (nonprovocation) arteriography used in 10/10 patients (unclear if bilateral studies performed, 11 limbs positive)	Delaney classification	Posterior approach in 11/11 (100%)	Follow-up duration: median 149 (range, 38-223) mos	Incomplete outcome data: yes
	1/1 symptomatic bilaterally	CT used in 10/10 patients ("all showed positive findings", unclear if dynamic scan)	Occluded artery in 5/11 (45%)	TEA, vein patch + muscle/band section 2/11 (18%), vein patch + muscle/band section 1/11 (9%), vein interposition/bypass graft + muscle/band section 7/11 (63%), muscle/band section only 1/11 (9%)	Loss to follow-up 0%	Selective outcome reporting: no
	Median age 34.7 (range, 16-67) yrs, 10M:0F Presenting symptoms by limb: IC 9/11 (82%), cold foot after exercise 2/11 (18%) Duration of symptoms NS PVD risk factors in 5/10 patients	Unclear if all patients assessed bilaterally Provocation maneuvers: plantar flexion and dorsiflexion	PSD/aneurysm in 4/11 (36%)	Muscle not reattached	Follow-up tests: DUS	Source of funding: unclear Academic: yes
						SIGN level of evidence: 3

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Ruppert (2004) ⁴⁷	23 patients, 32 limbs	Provocation ABPI used in 32/32 limbs (accuracy NS)	Most types NS or described (30 “anatomical”, 2 “functional”)	All operated (32/32)	Outcome measures: NS	Free from risk of bias?
Single center (Germany)	9/23 (39%) of patients diagnosed with bilateral PAES	Provocation arteriography used in 32/32 limbs (accuracy unclear)	Classification system not used	Surgical approach NS	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 1986-2000	Mean age 38.3 (range, NS) yrs, 19M:4F	Unclear if all patients assessed bilaterally	Occluded artery in 8/32 (25%)	Muscle/band section only 22/32 (69%), thrombectomy + muscle/band section 1/32 (3%), thrombectomy, vein patch + muscle/band section 3/32 (9%), vein interposition graft + muscle/band section 5/32 (16%), vein bypass graft + muscle/band section 1/32 (9%)	Follow-up duration: unclear	Selective outcome reporting: no
	Presenting symptoms by limb NS	Provocation maneuvers: knee extension, foot plantar flexion and dorsiflexion			Loss to follow-up: unclear	Source of funding: unclear
	Presenting symptoms by patient NS				Follow-up tests: provocation ABPI, DUS, arteriography	Academic: yes
	Duration of symptoms NS					SIGN level of evidence: 3
	No. of asymptomatic limbs unclear					Comment: purpose of study was to assess effectiveness of post-op ABPI in assessing success of surgery for PAES
Goh (2005) ⁴⁸	PVD risk factors NS 6 patients, 8 limbs	Bilateral provocation Doppler US (PST) used in 1/6 patients (1/2 limbs positive)	Type III = 100%	All operated (8/8)	Asymptomatic after surgery 7/8 limbs (87.5%), early graft failure 1/4 (25%), amputation [level NS] 1/8 (12.5%) [after graft failure]	Free from risk of bias?
Single center (Singapore)	2/6 (33%) of patients diagnosed with bilateral PAES	Bilateral provocation DUS used in 4/6 patients (5/8 limbs positive)	Delaney classification	Posterior approach in 5/8 (62.5%)	“No post-op complications”	Incomplete outcome data: yes
Study period: 1995-2004	2/2 symptomatic bilaterally	Bilateral provocation CTA used in 3/6 patients (5/6 limbs positive)	Occluded artery in 3/8 (37.5%)	Medial approach in 3/8 (37.5%)	Follow-up duration: median 15 (range, 1-108) mos	Selective outcome reporting: unclear

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Bustabad (2006) ⁴⁹	Mean age 34 (range, 27-38) yrs, 5M:1F	Bilateral provocation MRI used in 1/6 patients (0/2 limbs positive)	No relationship to duration of symptoms	SV bypass graft + muscle/band section 2/8 (25%), TEA, vein patch + muscle/band section 1/8 (12.5%), vein patch + muscle/band section 1/8 (12.5%), muscle/band section only 4/8 (50%)	Loss to follow-up: unclear	Source of funding: unclear
	Presenting symptoms by limb: IC 7/8 (87.5%), rest pain + critical ischemia 1/8 (12.5%)	Bilateral provocation arteriography used in 3/6 patients (3/6 limbs positive)			Follow-up tests: DUS	Academic: yes
	Duration of symptoms: 2 days-48 mos PVD risk factors in 2/6 patients 8 patients, 12 limbs	Provocation maneuvers: plantar flexion Provocation ABPI used in 8/8 patients (unclear if patients assessed bilaterally)	Type II = 58%, type III = 8%, type V = 8%, functional = 25%	1/8 (12.5%) of patients treated with thrombolysis prior to surgery (bypass graft)	Asymptomatic after surgery 7/10 limbs (70%), early vein graft failure 1/10 (10%) [required graft thrombectomy], late vein graft failure 2/10 (20%) [not reoperated], amputation (0%)	Free from risk of bias?
Single center (Spain)	4/8 (50%) of patients diagnosed with bilateral PAES	Provocation DUS used in 8/8 patients (unclear if patients assessed bilaterally, "not useful with occluded artery")	Whelan-Rich classification	Surgery 10/12 (83%), no surgery 2/12 (16%) [1/2 due to patient refusal, other case reason unclear]	Recurrent symptoms in 2/3 (66%) of functional entrapments (after graft failure, not reoperated)	Incomplete outcome data: unclear
Study period: 1998-2005	2/4 symptomatic bilaterally	MRI/MRA used in 7/8 patients (arteries assessed bilaterally, unclear if dynamic scan, accuracy unclear)	Occluded artery in 6/12 (50%)	Posterior approach in 6/10 (60%)	Resolution of symptoms in 1/2 (50%) of symptomatic nonoperated limbs (both type II)	Selective outcome reporting: no
	Mean age 38 (range, 24-63) yrs, 6M:2F	DSA (unclear if done with provocation maneuvers, frequency of use NS)	Occlusion + PSD/aneurysm in 2/12 (16%)	Medial approach in 4/10 (40%)	Outcome for asymptomatic operated limbs unclear	Source of funding: unclear
	Presenting symptoms by limb: IC 6/12 (50%), acute ischemia 3/12 (25%), incidental finding during surgery for popliteal artery aneurysm 1/12 (8%)	Provocation maneuvers: plantar flexion and dorsiflexion	'Focal injury' in 4/12 (33%)	Vein bypass graft + muscle/band section 9/10 (90%), popliteal angioplasty, vein patch + muscle/band section 1/10 (10%)	Follow-up duration: mean 43 (range, 12-96) mos	Academic: yes
	Duration of symptoms NS 2/12 (16%) of limbs asymptomatic (both operated) PVD risk factors in 3/8 patients			Muscle reattachment only in type II	Loss to follow-up: unclear Follow-up tests: Doppler and DUS	SIGN level of evidence: 3

Appendix III (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of pathology	Intervention	Outcomes + follow-up	Risk of bias/SIGN level
Gourgiotis (2008) ⁵⁰	38 patients, 49 limbs	Bilateral provocation Doppler US (PST) used in 38/38 patients (41/76 limbs positive)	Type I = 18.4%, type II = 67.3%, type III = 14.3%	All operated (49/49)	Asymptomatic after surgery 49/49 limbs (100%), graft failure 0/49 (0%), wound infection or hematoma 8/38 patients (21%) [managed conservatively]	Free from risk of bias?
Single center (Greece)	11/38 (29%) of patients diagnosed with bilateral PAES	DUS used in 43 limbs (criteria for use unclear, 32/43 limbs positive)	Delaney classification	Posterior approach (frequency NS)	Follow-up duration: median 34 (8-42) mos	Incomplete outcome data: yes
Study period: 1995-2002	11/11 symptomatic bilaterally	CT used in 38/38 patients (unclear if dynamic scan, accuracy unclear)	Occluded artery in 4/49 (8%)	Medial approach (frequency NS)	Loss to follow-up 0%	Selective outcome reporting: no
	Mean age 21 (range, 18-29) yrs, 31M:7F	CTA (frequency of use NS)	PSD/aneurysm in 17/49 (35%)	Muscle/band section 33/49 (67%), TEA, vein patch + muscle/band section in 5/49 (10%), SV bypass/interposition graft + muscle/band section in 11/49 (22.5%)	Follow-up tests: DUS	Source of funding: unclear
	Presenting symptoms by limb: IC 43/49 (88%), cold foot after exercise 6/49 (12%)	Arteriography (not described further) positive in 49 limbs (number of limbs screened unclear)	Relationship to duration of symptoms unclear	Muscle not reattached		Academic: unclear
	Duration of symptoms: 8-24 mos	Provocation maneuvers: plantar flexion				SIGN level of evidence 3
	PVD risk factors in 27/38 patients					
Turnipseed (2009) ⁵¹	57 patients, No. of limbs unclear	Provocation ABPI (used for all patients, 57 limbs positive)	Anatomic entrapment 14/57 (24.5%), functional entrapment 43/57 (75.5%)	All operated (57/57)	Symptom relief after surgery unclear, 0% reoperation rate for functional entrapment surgery during "extended" follow-up; wound infection 2%, seroma 4.6%	Free from risk of bias?
Single center (USA)	Incidence of bilateral cases unclear	Provocation PVR (used for all patients, 57 limbs positive)	Anatomic descriptions NS	Medial approach in at least 43/57 (75.5%) (all functional entrapments)	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 1987-2007	Mean age 36 (range, 22-71) yrs, 20M:37F	Provocation DUS (frequency of use unclear)	Classification system NS	Posterior approach (frequency unclear)	Follow-up duration: unclear	Selective outcome reporting: no
	Presenting symptoms by limb: IC 50/57 (88%), paresthesia 19/57 (33%), digital ischemia 6/57 (10.5%), calf swelling 5/57 (9%)	Provocation MRA/MRI (frequency of use unclear, 57 limbs positive)		Muscle/band section for at least 43/57 (75.5%), all functional entrapments	Loss to follow-up: unclear	Source of funding: unclear

Appendix III (online only). Continued

<i>Reference</i>	<i>Patient characteristics</i>	<i>Diagnostic adjuncts</i>	<i>Classification of pathology</i>	<i>Intervention</i>	<i>Outcomes + follow-up</i>	<i>Risk of bias/SIGN level</i>
	Duration of symptoms unclear No. of asymptomatic limbs unclear PVD risk factors NS	Provocation arteriography (frequency of use unclear) Unclear if all patients assessed bilaterally Provocation maneuvers: plantar flexion		Surgical procedures for anatomic entrapments NS	Follow-up tests: provocation ABPI/PVR	Academic: no SIGN level of evidence: 3 Comment: purpose of study was to describe diagnosis and treatment of functional PAES and chronic recurrent exertional compartment syndrome

ABPI, Ankle-brachial pressure index; *CPCS*, chronic posterior compartment syndrome; *CTA*, computed tomography angiogram; *DSA*, digital subtraction arteriography; *DUS*, duplex ultrasound; *IC*, intermittent claudication; *MRA*, magnetic resonance angiogram; *MRI*, magnetic resonance imaging; *NS*, not stated or not specified; *PAES*, popliteal artery entrapment syndrome; *PSD*, poststenotic dilatation; *PST*, positional stress test; *PTFE*, polytetrafluoroethylene *PVR*, pulse volume recording; *SIGN*, Scottish Intercollegiate Guidelines Network; *PVD*, peripheral vascular disease; *TEA*, thromboendarterectomy; *US*, ultrasound.

Appendix IV (online only). Included retrospective case-series on popliteal vein entrapment syndrome (PVES)

Reference	Patient characteristics	Diagnostic adjuncts	Description of pathology	Intervention	Outcomes and follow-up	Risk of bias/SIGN level
Raju (2000) ⁵²	30 patients, No. of limbs unclear	Arm/foot pressure differential used in all 30 patients (accuracy unclear)	Abnormal insertion or origin of gastrocnemius muscle 24/30	Criteria for surgery: "severe disabling symptoms after failed compression treatment with popliteal entrapment observed on venography"	Complete relief of pain after surgery 14/29 (48%), complete relief of swelling after surgery 12/29 (41%), healing of stasis ulcer/dermatitis 9/11 (82%)	Free from risk of bias?
Single center (USA)	34% of patients diagnosed with bilateral PVES	Air plethysmography used in all 30 patients (accuracy unclear)	Entrapment by soleal sling 3/30	Operated cases by limb unclear	Popliteal vein thrombosis 1/30 (3%)	Incomplete outcome data: no
Study period: 1996-1998	Median age 49 (range, 27-73) yrs, 14M: 16F	DUS used in all 30 patients (accuracy unclear)	Perivenous fibrosis 13/30	Operated cases by patient: 30/30 (100%)	Follow-up duration: median 14 (range, 2-36) mos	Selective outcome reporting: no
	Presenting symptoms by limb: unclear	Provocation ascending venography used in all 30 patients (unclear if all patients assessed bilaterally, number of positive results unclear)	Aberrant course of vessels 2/30	Medial approach in 30/30 (100%)	Loss to follow-up: 1/30 (3%)	Source of funding: unclear
	Presenting symptoms by patient: swelling (87%), pain (83%), hyperpigmentation (74%), stasis ulceration (30%), stasis dermatitis (7%), recurrent cellulitis (13%)	Popliteal vein pressure transduction in 9/30 patients (accuracy unclear)	Unknown 1/30	Muscle/band/fascia section (frequency unclear), popliteal valve repair (transcommissural valvuloplasty or axillary vein transfer) 11/30 (37%)	Follow-up tests: unclear	Academic: yes
	Duration of symptoms NS	Toe plethysmography to assess arterial entrapment (frequency of use and accuracy unclear)	8/30 coexisting arterial entrapments			SIGN level of evidence: 3
	No. of asymptomatic limbs unclear	Provocation maneuvers: plantar flexion	Vein sclerosis 13/30 Pre/poststenotic dilatation 5/30 Post-thrombotic changes 2/30			
Hirokawa 2002 ⁵³	11 patients, 14 limbs	Provocation Doppler and DUS (frequency of use unclear, accuracy NS)	Hypertrophy/abnormal head of gastrocnemius muscle 14/14	Criteria for surgery: those with positive venography and CT	Asymptomatic after surgery 8/14 (57%)	Free from risk of bias?

Appendix IV (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Description of pathology	Intervention	Outcomes and follow-up	Risk of bias/SIGN level
Single center (Japan)	3/11 (27%) of patients diagnosed with bilateral PVES	Provocation ascending venography (frequency of use unclear, accuracy NS)	Entrapment by plantaris muscle 1/14	All operated (14/14)	“No complications occurred”	Incomplete outcome data: yes
Study period: 1984-2001	Mean age 27.6 (range, NS) yrs, 0M:11F Presenting symptoms by limb: unclear	CT (frequency of use unclear, accuracy NS) Unclear if all patients assessed bilaterally	Prestenotic dilatation 1/14	Posterior approach in 14/14 (100%) Muscle/band section 14/14 (100%), Dacron reinforcement of popliteal vein 1/14 (7%)	“No re-operations performed” Follow-up duration: 36-120 mos	Selective outcome reporting: yes Source of funding: unclear
	Presenting symptoms by patient: calf ache/swelling (frequency NS) Duration of symptoms NS No. of asymptomatic limbs unclear	Provocation maneuvers: dorsiflexion			Loss to follow-up: unclear	Academic: no
Milleret (2007) ⁵⁴	11 patients, 11 limbs	Provocation Doppler and DUS (frequency of use NS, accuracy unclear)	Hypertrophy or abnormal insertion of gastrocnemius muscle 11/11	Criteria for surgery: unclear	Symptom “improvement” after surgery 9/11 (82%) (SF-12 QOL used for 5/11 patients) Repeat surgery (aponeurectomy) 2/11 (18%)	Free from risk of bias?
Single center (France)	0% of patients diagnosed with bilateral PVES	Biplanar provocation venography (frequency of use NS, accuracy unclear)	Hypertrophy of plantaris/popliteus muscle 4/11	All operated (11/11)	Repeat surgery (aponeurectomy) 2/11 (18%)	Incomplete outcome data: unclear
Study period: 2001-2006	Mean age 28 (range, 19-47) yrs, 3M:11F Presenting symptoms by limb: exertional calf swelling 3/11 (27%), positional calf swelling 2/11 (18%), recurrent varicose veins 4/11 (36%), sural vein thrombosis 2/11 (18%) Duration of symptoms NS	Provocation maneuvers: plantar flexion and dorsiflexion	Perivenous fibrosis 7/11 Fibrous band 6/11	Posterior approach in 8/11 (73%) Medial approach in 3/11 (27%)	Sural vein thrombosis 1/11 (9%) Follow-up duration: unclear	Selective outcome reporting: no Source of funding: unclear
				Muscle/band section + aponeurectomy 11/11 (100%)	Loss to follow-up: unclear Follow-up tests: unclear	Academic: yes SIGN level of evidence: 3

Appendix IV (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Description of pathology	Intervention	Outcomes and follow-up	Risk of bias/SIGN level
Lane (2009) ⁵⁵	No. of patients unclear, 49 limbs	Bilateral provocation DUS (frequency of use unclear, accuracy unclear)	Muscular/fibrous band 2/49	Criteria for surgery: "failed conservative treatment with objective evidence of popliteal vein compression"	Outcome measures: improvement in venous disease clinical score (3.9 ± 1.2 to 1.7 ± 1.7 , $P < .001$), improvement in provocation DUS detected vein diameter (1.0 ± 2.1 to 9.0 ± 1.5 , $P < .001$)	Free from risk of bias?
No. of centers unclear (Australia)	Incidence of bilateral cases unclear	Provocation venography (not further described) used in 2/49 limbs	Hypertrophied soleus/gastrocnemius muscles in "most" cases	Surgery 30/49, no surgery 19/49 [reasons unclear]	Wound infection 2/49 (4%)	Incomplete outcome data: unclear
Study period: unclear	Mean age 43.6 (range, NS) yrs, M/F NS Presenting symptoms by limb or patient: unclear Duration of symptoms NS No. of asymptomatic limbs unclear	Provocation maneuvers: knee extension		Posterior approach in 30/30 (100%) Muscle/band section + popliteal fossa decompression 2/30 (7%), popliteal fossa decompression only 28/30 (93%)	Follow-up duration: mean 16.2 mos Loss to follow-up: 0% Follow-up tests: DUS	Selective outcome reporting: unclear Source of funding: unclear Academic: yes SIGN level of evidence: 3 Comment: study cohort comprised obese patients (mean BMI 34.6 ± 6.2 with a diagnosis of chronic venous hypertension)

BMI, Body mass index, kg/m²; CT, computed tomography; NS, not stated or not specified; QOL, quality of life; SF-12, Short Form 12; SIGN, Scottish Intercollegiate Guidelines Network; US, ultrasound.

Appendix V (online only). Included retrospective case series on nerve entrapments in the popliteal fossa

<i>Reference</i>	<i>Patient characteristics</i>	<i>Diagnostic adjuncts</i>	<i>Classification of pathology</i>	<i>Intervention</i>	<i>Outcomes and follow-Up</i>	<i>Risk of bias/SIGN level</i>
Mastaglia (2000) ⁵⁶	9 patients, 9 limbs	Motor nerve conduction studies used in 9/9 limbs (2 limbs positive)	Entrapment by soleal arch 6/6	Criteria for surgery: "severe pain and disability"	Symptom "improvement" after surgery 6/6 (100%) (not quantified)	Free from risk of bias?
Single center (Australia)	0% of patients diagnosed with bilateral nerve entrapment	Sensory nerve conduction studies used in 4/9 limbs (1 limb positive)	3 coexisting venous abnormalities (1/3 venous entrapment, 1/3 venous thrombosis, 1/3 dilated vein without obvious cause)	Surgery 6/9 (67%), no surgery 3/9 (33%)	Symptom "improvement" in nonoperated cases 3/3 (100%) (not quantified)	Incomplete outcome data: yes
Study period: unclear	Mean age 35.5 (range, 13-70) yrs, 5M:4F Presenting symptoms by limb: popliteal fossa, calf, lower thigh pain 9/9 (100%), foot numbness, paresthesia 9/9 (100%) Duration of symptoms: 1-24 mos	Needle electromyography (frequency of use unclear, 2 limbs positive)	No relationship to duration of symptoms	Surgical approach NS Surgical procedures NS	Follow-up duration: unclear Loss to follow-up: unclear Follow-up tests: unclear	Selective outcome reporting: no Source of funding: unclear Academic: no SIGN level of evidence: 3

NS, Not stated or not specified; SIGN, Scottish Intercollegiate Guidelines Network.

Appendix VI (online only). Included retrospective case-series on popliteal neurovascular entrapment

<i>Reference</i>	<i>Patient characteristics</i>	<i>Diagnostic adjuncts</i>	<i>Classification of pathology</i>	<i>Intervention</i>	<i>Outcomes and follow-Up</i>	<i>Risk of bias/SIGN Level</i>
Psathakis (1991) ⁵⁷	49 patients, 66 limbs	Provocation Doppler US used in 49 patients (unclear if patients assessed bilaterally, accuracy unclear)	Predominantly nerve compression 42/66	Surgery 41/66 (62%), no surgery 25/66 (38%) [reasons NS]	Asymptomatic after surgery 40/41 (98%)	Free from risk of bias?
Single center (Germany)	17/49 (34%) of patients diagnosed with bilateral entrapment	Provocation ascending phlebography used in 3 patients (unclear if patients assessed bilaterally)	Predominantly arterial compression 24/66	Posterior approach (frequency NS)	Outcome for asymptomatic operated limbs unclear	Incomplete outcome data: unclear
Study period: 1985-1990	Mean age NS, 11M: 38F Presenting symptoms by limb: NS Presenting symptoms by patient: calf pain, calf/foot paresthesia, lower limb swelling/discolouration/heaviness (frequencies NS) Duration of symptoms NS No. of asymptomatic limbs unclear	Arteriography considered "invasive and unnecessary" Provocation maneuvers: knee flexion and foot plantar flexion		Muscle/band section (frequency NS)	Outcome for nonoperated limbs unclear Follow-up duration: 48 mos Loss to follow-up: unclear Follow-up tests: Doppler US	Selective outcome reporting: no Source of funding: unclear Academic: no SIGN level of evidence: 3

NS, Not stated or not specified; SIGN, Scottish Intercollegiate Guidelines Network, US, ultrasound.

Appendix VII (online only). Included prospective studies on popliteal vascular compression in asymptomatic subjects

<i>Reference</i>	<i>Patient characteristics</i>	<i>Diagnostic adjuncts</i>	<i>Classification of findings</i>	<i>Conclusions of authors</i>	<i>Risk of bias/SIGN level</i>
Pailler (1988) ⁵⁸	107 subjects (unclear if all assessed bilaterally)	Provocation Doppler US used in all subjects (plantar flexion)	Decrease or cessation of popliteal arterial flow on plantar flexion occurs in 50% of athletes and 30% of nonathletes	Positive Doppler US on plantar flexion is insufficient to diagnose PAES	Free from risk of bias?
Cohort study/nested case-control study	Age NS, 107M:0F				Subject selection: no
No. of centers unclear (France)	53/107 (49.5%) = "top level athletes" (no. of asymptomatic cases unclear), 53/107 (49.5%) = nonathletic control group (all asymptomatic)				Blinding of assessors: no
Study period: NS	1/107 subjects unaccounted for				Incomplete outcome data: no Selective outcome reporting: unclear Source of funding: unclear Academic: no SIGN level of evidence: 2-
Leon (1992) ⁵⁹	100 asymptomatic subjects (200 limbs) with no history of DVT or venous insufficiency	Provocation DUS used in all subjects (subjects seated, knee extension)	By limb (DUS): 50%-100% popliteal vein compression on provocation = 41/200 (20.5%), <50% popliteal compression on provocation = 159/200 (79.5%)	Duplex US can identify significant popliteal vein compression on knee extension in a significant proportion of asymptomatic subjects	Free from risk of bias?
Cohort study	Mean age 30 ± 9 yrs, M/F NS	Air plethysmography used to assess functional venous outflow obstruction in 27 subjects with positive DUS	Bilateral venous compression in 14/27 subjects	Those identified with significant popliteal vein compression on DUS also have evidence of moderate-severe functional venous outflow obstruction on air plethysmography	Subject selection: unclear
Single center (UK)			Moderate-severe functional venous outflow obstruction on knee extension in 27/27		Blinding of assessors: no
Study period: NS					Incomplete outcome data: yes Selective outcome reporting: yes Source of funding: unclear Academic: yes SIGN level of evidence: 2-
Erdoes (1994) ⁶⁰	36 asymptomatic subjects (72 limbs)	Provocation DUS used in all subjects (subjects prone, knee extension, active and passive foot dorsiflexion and plantar flexion)	By limb (DUS): Popliteal artery occlusion on provocation = 38/72 (53%), no occlusion on provocation = 34/72 (47%) (none occluded after exercise)	Popliteal artery occlusion on plantar flexion can be demonstrated in a significant no. of asymptomatic subjects on DUS	Free from risk of bias?
Cohort study/nested case-control study	Mean age 26 (range, 18-42) yrs, 21M:15F	Nonoccluders on provocation DUS exercised to heart-rate of ≥140 beats/min and rescanned	All nonoccluders (34 limbs) showed mean decrease in ABPI of 0.15 on provocation	No significant difference between athletes and nonathletes in prevalence of occlusion	Subject selection: no

Appendix VII (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of findings	Conclusions of authors	Risk of bias/SIGN level
Single center (USA)	16/36 (44%) = athletic ("cross-country runners"), 20/36 (56%) = nonathletic ("normally active")	Provocation MRI and MRA in 14/36 subjects (28 limbs, 15 limbs positive on DUS)	72/72 limbs showed popliteal vein occlusion	MRI can disclose anatomy of the popliteal fossa (and so rule out anatomical entrapment)	Blinding of assessors: no
Study period: NS		Note: muscle fatigue during provocation MRI noted to be a problem	MRI/MRA: popliteal artery occlusion on provocation detected in 9 limbs (60% correlation with DUS), no anatomic abnormalities detected		Incomplete outcome data: yes Selective outcome reporting: yes Source of funding: unclear Academic: yes SIGN level of evidence: 2- Free from risk of bias?
Chernoff (1995) ⁶¹	13 asymptomatic subjects (13 limbs: only right limbs examined)	Provocation MRI and MRA used in all subjects (plantar flexion)	By limb (MRI/MRA): >99% popliteal artery occlusion on provocation = 9/13 (69%), 75-99% popliteal artery occlusion on provocation = 3/13 (23%), <50% popliteal artery occlusion on provocation = 1/13 (8%)	Impairment of popliteal artery flow occurs on plantar flexion in asymptomatic subjects as demonstrated by both MRI/MRA and ABPI	
Cohort study	Mean age 31.9 (range, 27-44) yrs, 9M:4F	Provocation ABPI used in all subjects	MRI demonstrates muscular compression of popliteal artery in at 2 levels (plantaris/gastrocnemius and plantaris/popliteus) in 13/13		Study selection: no
Single center (USA)	1/13 = "marathon runner", 12/13 = "physically active"	Note: muscle fatigue during provocation MRI noted to be a problem	ABPI: occlusion = 9/13 (69%), decrease of at least 0.15 = 3/13 (23%), no change = 1/13 (8%)		Blinding of assessors: no
Study period: NS			100% correlation between MRI/MRA and ABPI		Incomplete outcome data: yes Selective outcome reporting: yes Source of funding: unclear Academic: yes SIGN level of evidence: 2- Free from risk of bias?
Akkersdijk (1995) ⁶²	16 asymptomatic subjects (32 limbs)	Provocation DUS used in all subjects (subjects prone, active and passive foot dorsiflexion and plantar flexion)	By limb (DUS on active plantar flexion) at most distal level: Popliteal artery occlusion = 19/32 (59%), increased PSV = 4/32 (13%), decreased PSV = 4/32 (13%), no change in PSV = 5/32 (15%)	Active plantar flexion is the only provocative maneuver that influences popliteal artery flow on DUS	
Cohort study/nested case-control study	Mean age 25 (range, 20-27) yrs, 12M:4F	Popliteal artery assessed at 3 levels (above knee, at level of knee, proximal to trifurcation)	Less significant results noted above knee and at level of knee for active plantar flexion	Reduction of flow in the popliteal artery on active foot plantar flexion is a physiologic phenomenon and of limited value in diagnosing PAES	Subject selection: unclear

Appendix VII (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of findings	Conclusions of authors	Risk of bias/SIGN level
Single center (Netherlands)	8/16 (50%) = "semi-professional rowers", 8/16 (50%) = nonathletic ("without intensive physical training")		Results not significant with other provocation maneuvers	No significant difference between athletes and nonathletes	Blinding of assessors: no
Study period: NS					Incomplete outcome data: yes Selective outcome reporting: yes Source of funding: unclear Academic: yes SIGN level of evidence: 2- Free from risk of bias?
Hoffman (1997) ⁶³	42 asymptomatic subjects (84 limbs)	Provocation DUS used in all subjects (subjects prone, plantar flexion)	By limb (DUS): Popliteal artery occlusion on provocation = 67/84 (80%), no occlusion on provocation = 17/84 (20%)	Popliteal artery occlusion on plantar flexion occurs in asymptomatic subjects	Subject selection: unclear
Cohort study/nested case-control study	Mean age 30.6 ± 12.1 yrs, 25M: 17F	Provocation MRI done in 1 patient; also showed bilateral popliteal artery occlusion but no anatomic abnormality demonstrated	Bilateral popliteal artery occlusion in 30/42 subjects	No significant difference between athletes and nonathletes in prevalence of occlusion	
Single center (Switzerland)	18/42 (43%) = "highly trained athletes", 4/42 (57%) = nonathletes			Occlusion requires less force in athletes compared to nonathletes ($P < .02$)	Blinding of assessors: no
Study period: NS					Incomplete outcome data: yes Selective outcome reporting: yes Source of funding: unclear Academic: yes SIGN level of evidence: 2- Free from risk of bias?
De Almeida (2004) ⁶⁴	42 asymptomatic subjects (84 limbs)	Provocation ABPI used in all subjects (active plantar flexion)	By limb (ABPI): 7/84 (8.3%) showed reduced ABPI with provocation	Using provocation DUS as a gold standard reference test; provocation ABPI and provocation Doppler US have good specificity (1 and 0.9, respectively) and sensitivity (0.7 and one) in identification of popliteal artery compression	Subject selection: unclear
Cohort/nested case-control study	Mean age 20 ± 4 yrs, M/F NS	Provocation Doppler US used in all subjects (active plantar flexion)	17/84 (20.2%) showed altered Doppler signal indicating popliteal artery compression during provocation	No significant difference between athletes and nonathletes in prevalence of compression	
Single center (Brazil)	21/42 (50%) = "indoor soccer players", 21/42 (50%) = nonathletic ("sedentary")	Provocation DUS used in all subjects (active plantar flexion)			Blinding of assessors: no
Study period: NS			DUS: 6/84 (7.1%) showed popliteal artery occlusion on provocation 4/84 (4.7%) showed popliteal artery stenosis on provocation Bilateral compression/occlusion on DUS found in 4/42 subjects (9.5%)		Incomplete outcome data: yes Selective outcome reporting: yes Source of funding: unclear Academic: yes SIGN level of evidence: 2-

Appendix VII (online only). Continued

Reference	Patient characteristics	Diagnostic adjuncts	Classification of findings	Conclusions of authors	Risk of bias/SIGN level
Pillai (2008) ⁶⁵	88 asymptomatic subjects (176 limbs)	Provocation Doppler US used in all subjects (active plantar flexion)	By patient (Doppler US): 16/88 (18%) bilateral occluders; 8/88 (9%) unilateral occluders; 58/88 (67%) bilateral nonoccluders; 6/88 (7%) not classifiable	Variations in the extent of attachment towards the midline of the medial head of gastrocnemius represents a normal embryologic variant	Free from risk of bias?
Cohort/nested case-control study	Mean age 50 (M), 38.4 (F) yrs, 50M:38F	Provocation DUS used in 22 subjects (active plantar flexion)	12/16 bilateral occluders scanned with DUS (10/12 noted to occlude bilaterally and progressed to MRI)	The increased extent of midline attachment in asymptomatic occluders may represent a group who are prone to develop symptoms (eg, as a result of muscular hypertrophy) and who would then otherwise be classed as having functional PAES	Subject selection: no
Single center (South Africa)	0/88 = athletic	Bilateral static MRI used in 20 subjects (40 limbs assessed)	10/58 bilateral nonoccluders scanned with DUS (10/10 noted to not occlude bilaterally and progressed to MRI)		Blinding of assessors: yes
Study period: NS	88/88 = "normally active adult volunteers"	Note: muscle fatigue during provocation MRI noted to be a problem	MRI: 10 bilateral occluders (20 limbs), 10 bilateral nonoccluders (20 limbs)		Incomplete outcome data: yes
	Exclusion and inclusion criteria for recruitment of cohort stated	Note: provocation ABPI felt to be unreliable	More extensive attachment of medial head of gastrocnemius toward midline noted in occluders vs nonoccluders		Selective outcome reporting: yes
					Source of funding: yes Academic: no SIGN level of evidence: 2-

ABPI, Ankle-brachial pressure index; DUS, duplex ultrasound; DVT, deep vein thrombosis; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; NS, not stated or not specified; PAES, popliteal artery entrapment syndrome; PSV, peak systolic velocity; SIGN, Scottish Intercollegiate Guidelines Network; US, ultrasound.