Peripheral Arteries

Eur J Vasc Endovasc Surg (2025) 69, 110—117

EJVES Open Access

Elective Surgical Repair of Popliteal Artery Aneurysms with Posterior Approach *vs*. Endovascular Exclusion: Early and Long Term Outcomes of Multicentre PARADE Study

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WHAT THIS PAPER ADDS

Open surgical repair via a posterior approach and endovascular exclusion are associated with comparable outcomes in terms of overall patency and amputation free survival in the early and long term after intervention for popliteal artery aneurysms measuring $\leq$60 mm in a non-acute (elective) setting. In open surgery via a posterior approach, nerve injury might be an issue. Endovascular repair is associated with a considerable number of re-interventions.

Objective: The aim of this study was compare elective surgical repair of popliteal artery aneurysms (PAAs) via a posterior approach *vs*. endovascular exclusion, analysing early and five year outcomes in a multicentre retrospective study.

Methods: Between January 2010 and December 2023, a retrospectively maintained dataset of all consecutive asymptomatic PAAs that underwent open repair with posterior approach or endovascular repair in 37 centres was investigated. An aneurysm length of $\leq$60 mm was considered the only inclusion criterion. A total of 605 patients were included; 440 PAAs (72.7%) were treated via a posterior approach (open group) and the remaining 165 PAAs (27.3%) were treated using covered stents (endo group). Continuous data were expressed as median with interquartile range. Thirty day outcomes were assessed and compared. At follow up, primary outcomes were freedom from re-intervention, secondary patency, and amputation free survival. Secondary outcomes were survival and primary patency. Estimated five year outcomes were compared using log rank test.

Results: At 30 days, no differences were found in major morbidity, mortality, graft occlusion, or re-interventions. Three patients (0.7%) in the open group experienced nerve injury. The overall median duration of follow up was 32.1 months. At five year follow up, freedom from re-intervention was higher in the open group (82.2% *vs*. 68.4%; $p = .021$). No differences were observed in secondary patency (open group 90.7% *vs*. endo group 85.2%; $p = .25$) or amputation free survival (open group 99.0% *vs*. endo group 98.4%; $p = .73$). A posterior approach was associated with better survival outcomes (84.4% *vs*. 79.4%; $p = .050$), and primary patency (79.8% *vs*. 63.8%; $p = .012$).

Conclusion: Early and long term outcomes following elective repair of PAAs measuring $\leq$60 mm via a posterior approach or endovascular exclusion seem comparable. Nerve injury might be a rare but potential complication for those undergoing open surgery. Endovascular repair is associated with more re-interventions.

Keywords: Covered stent, Endovascular repair, Popliteal artery aneurysm, Posterior approach
Article history: Received 8 April 2024, Accepted 12 August 2024, Available online 21 August 2024

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https://doi.org/10.1016/j.ejvs.2024.08.011

INTRODUCTION

The popliteal artery is the most common location for peripheral artery aneurysms, and is associated with a contralateral popliteal artery aneurysm (PAA) or abdominal aortic aneurysm in 33% and 50% of cases, respectively.[1,2] Current guidelines recommend treatment in patients with an asymptomatic PAA measuring $>$ 20 mm in diameter to avoid acute limb ischaemia, which remains a limb threatening condition with relatively high amputation rates.[3,4] It has been extensively reported that outcomes after elective surgery are superior compared with emergency procedures.[5] Fortunately, not all patients present with acute limb ischaemia, but a non-negligible proportion suffer from intermediate clinical conditions such as intermittent claudication due to distal embolisation in the runoff vessels or aneurysm thrombosis without any clinical impact, if a valid collateral circulation has developed. With the advent of endovascular techniques, treatment of asymptomatic PAAs has changed considerably. Nowadays, the two main options are open surgical repair via a medial or posterior approach, and endovascular repair with covered stents.[6] To some extent, the morphology of the PAA will dictate the type of repair necessary. Size and access to the PAA are the major determinants of open repair via medial or posterior approach. The posterior approach appears to be superior for selected PAAs, i.e., those not extending above the adductor hiatus, because of higher primary and secondary patency rates in the long term, combined with low post-operative complication rates.[7–10] A meta-analysis demonstrated that endovascular repair is a safe alternative to open surgery, even though short term graft thrombosis and re-intervention rates are significantly higher.[11,12] However, robust multicentre pragmatic evidence comparing open *vs*. endovascular treatment for asymptomatic PAAs is still lacking, and previously described reports did not differentiate between aneurysm extent and type of surgical approach used accordingly. Finally, a randomised controlled trial in this setting would be challenging given the rarity of the pathology.

The aim of this study was therefore to compare early and long term outcomes of elective surgical repair for non-acute PAAs via a posterior approach *vs*. endovascular repair using pragmatic data from a global retrospective study (PARADE Study).

MATERIALS AND METHODS

Study population

A multicentre, retrospective cohort study was conducted under the auspices of the Research Collaborative in Peripheral Arterial Disease (RCPAD; https://www.rcpad.org), a pan-European scientific collaboration of vascular specialists. A total of 37 departments (seven countries) participated (Supplementary Table S1). Each of the participating centres had its own study in which patient data were collected at the time of surgery and were later added to the PARADE Study.

Patients with non-acute elective PAA undergoing open repair via a posterior approach or endovascular exclusion with covered stenting were enrolled in this study. Pre-operative duplex ultrasound (DUS) and computed tomography angiography (CTA) were required to include patients in the study and analysis.

Treatment selection was based on the preferences of the treating clinicians and local multidisciplinary team (pragmatic study design). Given the pragmatic nature of the study, all departments applied their local or regional standardised protocols for peri-operative medication and follow up examinations and or imaging. The follow up protocol included a physical examination combined with DUS or CTA one month after the index procedure, at six months, and annually thereafter. All patients provided written consent for the procedure and to the fully anonymised processing of data.

A retrospective review of patients with PAA electively treated in the 37 participating centres between January 2010 and December 2023 was performed. The local collaborator (site lead) identified all consecutive patients with available pre-operative DUS and CTA imaging who met the study inclusion criteria and collected data using medical records retrospectively. During the 14 year study period, 956 consecutive patients with PAA were treated in the participating centres by an open surgical posterior approach or using endovascular means (covered stents in all cases).

A PAA length $\leq$ 60 mm, alongside availability of DUS and CTA imaging at baseline, were considered criteria for inclusion in the present analysis. Furthermore, only patients with completed pre- and post-operative information were included. Based on these criteria, 351 patients were excluded from the present analysis because their PAA was $>$ 60 mm in length. A total of 605 patients were therefore included in the present study, comprising 440 PAAs (72.7%) treated with open repair with a posterior approach (open group) and 165 PAAs (27.3%) treated using endovascular repair with covered stents (endo group). Inclusion of patients in the studied population is presented in Figure 1.

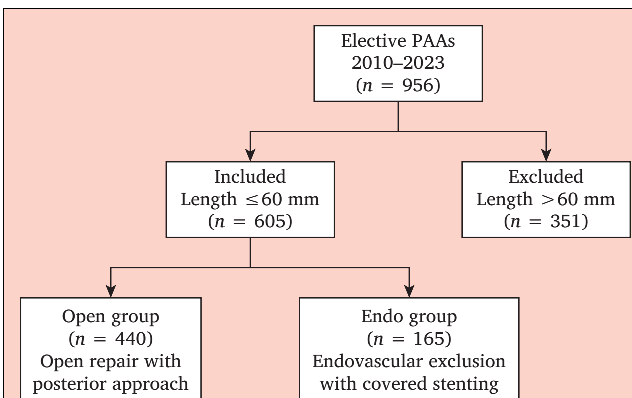


Figure 1. Flowchart of patient inclusion in the studied population. PAA = popliteal artery aneurysm.

Table 1. Summary of pre-operative and intra-operative data recorded.

Pre-operative data
Open and endo† groups*
Risk factors
History of other aneurysmal disease
Previous intervention in index limb
Clinical presentation
Medical treatment
Length of aneurysmal lesion
Diameter of popliteal artery
Intra-operative data
Open group*
Type of material used
Graft diameter and length
Endo† group
Access site
Number, length, and diameter of covered stents
Open and endo† groups*
All adjunctive procedures

* Popliteal artery aneurysms treated with open surgical repair by a posterior approach.
† Popliteal artery aneurysms treated by endovascular exclusion using covered stents.

Pre-operative and intra-operative data

All patients underwent pre-operative evaluation, which included clinical examination and DUS. During the data analysis, CTA was used to identify the length of the aneurysm as well as the diameters of the popliteal artery 1 cm above and 1 cm below the aneurysm sac. A summary of the pre- and intra-operative data recorded is presented in Table 1.

Definitions and outcome measures

Chronic limb threatening ischaemia (CLTI) was defined as the presence of peripheral artery disease in combination with rest pain, gangrene, or a lower limb ulceration of ≥ 2 weeks in duration.[13] Runoff status was defined on the basis of the number of patent tibial vessels, based on imaging (diagnostic angiogram) obtained during the index procedure and pre-operative DUS and or CTA. Runoff status was considered poor when there were no patent below the knee vessels or one patent vessel with indirect flow. Other definitions of clinical events and or imaging parameters were as per the reporting standards of the Society for Vascular Surgery for peripheral arterial disease.[14]

All data on surgical intervention (open or endovascular) were complete as they were retrospectively recalled from the medical records of the interventions, and then merged into a dedicated database.

Remaining definitions and outcome measures are summarised in Table 2.

Table 2. Definitions and outcome measures.

Definition	Explanation
Immediate technical success	Surgical or endovascular graft patency with direct flow into at least one below the knee vessel
Primary patency	No evidence of re-stenosis of the graft during follow up, namely a peak systolic velocity ratio $\geq$2.5 or graft occlusion, based on duplex ultrasound
Secondary patency	Graft patency maintained by repeat intervention after complete graft occlusion
Freedom from re-intervention	Absence of re-intervention in the index limb during follow up strictly related to the index procedure
Major lower limb amputation	Any amputation ipsilateral to the target lesion above the level of the ankle joint

Outcome measures and statistical analysis

A *post hoc* power calculation including α error was used to define the statistical power of the study based on two groups with a ratio of 2.5:1. All data regarding the procedures were collected retrospectively in a dedicated online database. This included demographics, pre-operative risk factors, clinical and diagnostic pre-operative assessments, intra-operative features, 30 day data, and follow up data. All data regarding re-interventions were also recorded in the same database and adjudicated locally by the lead and other site collaborators. All data were anonymised.

Early (30 day) outcomes were assessed and compared between both groups in terms of death, major adverse cardiovascular events (MACEs), and graft occlusions. In addition, re-intervention and major amputation rates were recorded and compared. Furthermore, the number of identified nerve injuries was assessed via clinical examination during follow up, and access site complications were also recorded for a minimum of 30 days, including those not requiring surgical revision.

At follow up, the main primary outcomes were freedom from re-intervention, secondary patency, and amputation free survival. Secondary outcomes were survival and primary patency. Estimated five year outcomes were compared using Kaplan—Meier curves. The two groups were compared using the log rank test. Estimates were given with 95% confidence interval (CI).

Continuous data were expressed as mean $\pm$ standard deviation or median with interquartile range (IQR). Categorical data were expressed as percentages. Pearson's χ^2 test, mean *t* test, or analysis of variance (ANOVA) were used to compare values between groups, based on the nature of the data and variables. Statistical significance was defined at $p < .050$. SPSS Statistics for Apple Version 24.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

RESULTS

Demographics and morphological data

Demographic data of both groups are presented in Table 3. No differences were found in clinical presentation between the two groups. Overall, approximately 30% of patients had either intermittent claudication or CLTI due to proximal lesions located in the iliac and or femoral arteries.

Table 3. Demographic data for patients ($n = 605$) with elective popliteal artery aneurysm undergoing open surgical repair via a posterior approach (open group) or endovascular exclusion with covered stenting (endo group).

Characteristic	Open group ($n = 440$)	Endo group ($n = 165$)	*p* value
Male sex	426 (96.8)	152 (92.1)	.014
Age – y	69.9	75.1	<.001
Age >80 y	80 (18.2)	61 (37.0)	<.001
Risk factors			
Smoking	156 (35.4)	35 (21.2)	<.001
Hypertension	325 (73.9)	123 (74.5)	.48
Hypercholesterolaemia	267 (60.7)	97 (58.8)	.36
Diabetes mellitus	82 (18.6)	29 (17.6)	.43
Coronary artery disease	121 (27.5)	48 (29.1)	.39
Chronic kidney disease*	21 (4.8)	9 (5.4)	.44
Dialysis treatment	4 (0.9)	0 (0.0)	.28
Clinical presentation			.76
Asymptomatic	302 (68.6)	114 (69.1)	
Intermittent claudication	75 (17.0)	30 (18.2)	
CLTI	63 (14.4)	21 (12.7)	

Continuous data are presented as the mean and categorical data as *n* (%). CLTI = chronic limb threatening ischaemia.
* Glomerular filtration rate < 30 mL/min.

Overall, in 16 cases (2.6%) a previous vascular intervention had been carried out in the index limb (11 splenectomy, three superficial femoral artery angioplasty, and two femoral endarterectomy).

The location of other aneurysmal disease in the whole study population is presented in Table 4. With regard to morphological data, both groups were homogeneous in terms of artery diameters, lesion lengths, and runoff vessels. Pre-operative morphological data are presented in Table 5.

A *post hoc* power calculation demonstrated a 100% *post hoc* power of the study (comparative analysis between the two groups) with an α error of 0.05.

Intraprocedural outcomes (open group)

The graft material used was an autologous vein in 203 cases (46.1%), expanded polytetrafluoroethylene in 188 cases (42.7%), and Dacron and heparin bonded Dacron in the remaining 49 cases (11.2%). The most frequently used venous conduit was the ipsilateral great saphenous vein (166; 81.8%). Other autologous veins used included ipsilateral small saphenous veins (19; 9.4%), contralateral great saphenous veins (six; 2.9%), and arm veins (12; 5.9%).

Table 4. Other aneurysmal diseases in patients with elective popliteal artery aneurysm in the whole study population ($n = 605$).

Aneurysmal disease	Patients ($n = 605$)
Abdominal aortic aneurysm	179 (29.6)
Contralateral popliteal artery aneurysm	221 (36.5)
Iliac aneurysm	21 (3.5)
Thoracic aortic aneurysm	13 (2.1)
Femoral artery aneurysm	16 (2.6)
Ascending aorta aneurysm	5 (0.8)
Type IV thoraco-abdominal aortic aneurysm	3 (0.5)
Splenic artery aneurysm	2 (0.3)

Data are presented as *n* (%).

Table 5. Pre-operative morphological data for patients ($n = 605$) with elective popliteal artery aneurysm undergoing open surgical repair via a posterior approach (open group) or endovascular exclusion with covered stenting (endo group).

Characteristic	Open group ($n = 440$)	Endo group ($n = 165$)	*p* value
Lesion length – mm	44.5 ± 13.9	46.8 ± 14.7	.073
Maximum diameter of aneurysmal sac – mm	30.9 ± 12.1	30.2 ± 10.6	.48
Diameter of popliteal artery – mm			
1 cm above aneurysm	7.9 ± 2.2	7.7 ± 1.7	.25
1 cm below aneurysm	7.4 ± 1.9	7.1 ± 1.5	.064
Patent tibial vessels – *n*	2.4 ± 0.6	2.4 ± 0.6	.89
Patent tibial vessels			.18
0	1 (0.2)	3 (1.8)	
1	68 (15.4)	18 (10.9)	
2	137 (31.2)	60 (36.4)	
3	234 (53.2)	84 (50.9)	

Data are presented as mean ± standard deviation or *n* (%).

Regarding prosthetic material, the mean graft diameter was 6.3 ± 1.6 mm and the mean bypass length was 65.9 ± 45.7 mm. Intraprocedural DUS was performed in 229 cases (52.0%), whereas a completion angiography was carried out in 51 cases (11.6%). In 18 cases (4.1%), an adjunctive procedure was performed, including 11 procedures of tibial vessel angioplasty.

Acute technical success was achieved in all cases.

Intraprocedural outcomes (endo group)

Access site was percutaneous antegrade femoral in 131 cases (79.4%), percutaneous contralateral femoral approach in 19 cases (11.5%), surgical antegrade femoral in 13 cases (7.9%), percutaneous brachial approach in one case (0.6%), and percutaneous retrograde tibial approach in one case (0.6%).

In most cases (164/165), the stent graft used was a self expandable Viabahn (Gore Medical, Flagstaff, AZ, USA) device. In one case (0.6%) an iCover (iVascular, Barcelona, Spain) was used.

The mean number of stents used for each case was 1.7 ± 0.8. The mean stent diameter was 8.6 ± 1.6 mm. The mean length of the covered stents used was 181.1 ± 77.9 mm. In 44 cases (26.7%) an adjunctive procedure was carried out, including 15 angioplasty and or stenting procedures to the superficial femoral artery, and 13 procedures of angioplasty of tibial vessels.

Acute technical success was not achieved in two cases (1.2%) due to residual type Ia endoleak (one case) and residual type Ib endoleak (one case). Of these, one patient underwent an open conversion, whereas the other was followed up because they were unfit for any type of re-intervention. Flexed knee view angiography was carried out in all cases to minimise technical graft failure.

Thirty day data

Mean length of hospital stay was longer in the open group (6.1 ± 3.8 days *vs*. 4.8 ± 4.8 days; $p < .001$). Post-operative medical management for each group is presented in Table 6. Three patients (0.7%) in the open group experienced a post-operative permanent nerve injury. The lesions involved the sciatic-popliteal nerve, which required a posterior tibial tendon transposition followed by long physiotherapy.

At 30 days, three patients died (two in the endo group *vs*. one in the open group; $p = .18$), with an overall 30 day mortality rate of 0.5%. No deaths were related to the intervention (cardiovascular deaths).

In addition, 30 day rates of MACEs (open group, 7/440 [1.6%] *vs*. endo group, 1/165 [0.6%]; $p = .31$), graft occlusion (open group, 10/440 [2.3%] *vs*. endo group, 7/165 [4.2%]; $p = .15$), procedure related re-interventions (open group, 12/440 [2.7%] *vs*. endo group, 9/165 [5.4%]; $p = .087$), and major amputation (open group, 1/440 [0.2%] *vs*. endo group, 1/165 [0.6%]; $p = .35$) did not differ between groups.

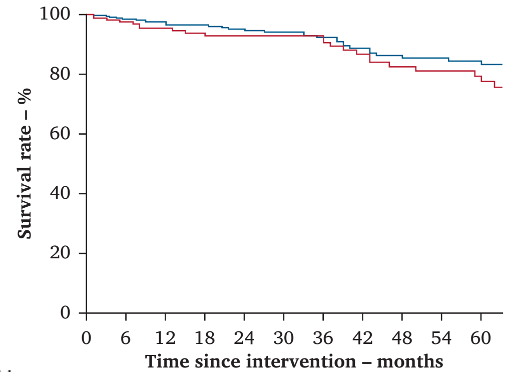
Long term outcomes

Follow up was available for all patients with a median follow up of 32.1 (IQR 11.4, 30.3) months. During the final follow up period, 61 further deaths occurred. The cause of death was unknown in 21 cases (34.4%) and was related to malignancy in nine cases (14.8%), acute myocardial infarction in eight cases (13.1%), chronic heart failure in four cases (6.6%), sepsis and multi-organ failure in four cases (6.6%), COVID-19 in four cases (6.6%), ruptured abdominal aortic aneurysm in three cases (4.9%), fatal dysrhythmia in two cases (3.3%), stroke in two cases (3.3%), trauma in one case (1.6%), liver cirrhosis in one case (1.6%), peritonitis in one case (1.6%), and pneumonia in one case (1.6%).

Table 6. **Post-operative medical management of patients (n = 605) with elective popliteal artery aneurysm undergoing open surgical repair via a posterior approach (open group) or endovascular exclusion with covered stenting (endo group).**

Treatment	Open group (n = 440)	Endo group (n = 165)	p value
Single antiplatelet therapy	206 (46.8)	31 (18.8)	.003
Dual antiplatelet therapy	118 (26.8)	108 (65.4)	<.001
Warfarin	61 (13.9)	10 (6.1)	.004
Direct oral anticoagulants	63 (14.3)	6 (3.6)	<.001
Statin	271 (61.6)	95 (57.6)	.066

Data are presented as n (%).



No. at risk

	0	12	24	36	48	60
Open group						
Outcome – %	99.8	97.5	94.7	92.4	86.3	84.4
Patients at risk – n	438	284	199	151	95	72
Standard error – %	0.2	0.8	1.3	1.7	2.6	3.1
Endo group						
Outcome – %	98.8	95.4	92.9	92.9	82.6	79.4
Patients at risk – n	163	123	100	80	55	44
Standard error – %	0.9	1.7	2.2	2.2	4	4.4

Figure 2. Cumulative Kaplan–Meier estimate of five year survival for patients with popliteal artery aneurysm undergoing open surgical repair via a posterior approach (open group) or endovascular exclusion with covered stenting (endo group). Number of limbs at risk and standard error values for each group are shown.

The estimated five year survival was higher for the open group (84.4% [95% CI 78.5 − 87.2%] *vs*. 79.4% [95% CI 75.2 − 83.6%]; $p = .050$, log rank = 3.399) (Fig. 2).

In addition, during follow up 71 additional graft occlusions occurred (24 in the endo group *vs*. 47 in the open group), and 74 further re-interventions (35 in the endo group *vs*. 39 in the open group) were performed, including six procedures for type Ia/b or III endoleak in the endo group. Finally, four further major amputations were recorded (one in the endo group *vs*. three in the open group; $p = .13$).

The full list of re-interventions during follow up is presented in Table 7.

Overall, at five years no differences were found in secondary patency (open group, 90.7% [95% CI 86.5 − 94.7%] *vs*. endo group, 85.2% [95% CI 81.2 − 89.8%]; $p = .25$, log rank = 0.876) and amputation free survival (open group, 99.0% [95% CI 98.9 − 100.0%] *vs*. endo group 98.4% [95% CI 97.9 − 99.7%]; $p = .73$, log rank = 0.054). Regarding secondary outcomes, at five years estimated rates of primary patency (79.8% [95% CI 75.6 − 83.2%] *vs*. 63.8% [95% CI 58.5 − 67.3%]; $p = .012$, log rank = 6.543) and freedom from re-intervention (82.2% [95% CI 78.4 −86.6%] *vs*. 68.4% [95% CI 64.8 − 75.2%]; $p = .021$, log rank = 5.262) were higher for the open group (Fig. 3).

DISCUSSION

In the present analysis, outcomes following surgical treatment for asymptomatic PAAs ≤60 mm in length via a posterior approach are comparable with those achieved by endovascular repair using covered stent grafts, with an estimated five year secondary patency and amputation free

Table 7. Re-interventions during follow up of patients (n = 605) with elective popliteal artery aneurysm undergoing open surgical repair via a posterior approach (open group) or endovascular exclusion with covered stenting (endo group).

Type of re-intervention	Open group (n = 440)	Endo group (n = 165)
Percutaneous transluminal angioplasty (PTA)		
Intrabypass	5	0
Intrastent	0	1
Proximal anastomosis	1	0
Distal anastomosis	7	0
Proximal and distal anastomosis	1	0
Stenting		
Proximal anastomosis	1	0
Type Ia endoleak	0	2
Type III endoleak	0	2
Surgical		
Bypass for distal pseudoaneurysm	1	0
Conversion to surgical bypass	0	6
Bypass for type Ib endoleak	0	2
Thrombectomy	13	5
Thrombo-aspiration	0	3
Thrombo-aspiration and PTA	0	1
Thrombo-aspiration and stenting	1	2
Thrombolysis	6	4
Thrombolysis and PTA	2	2
Thrombolysis and stenting	1	5

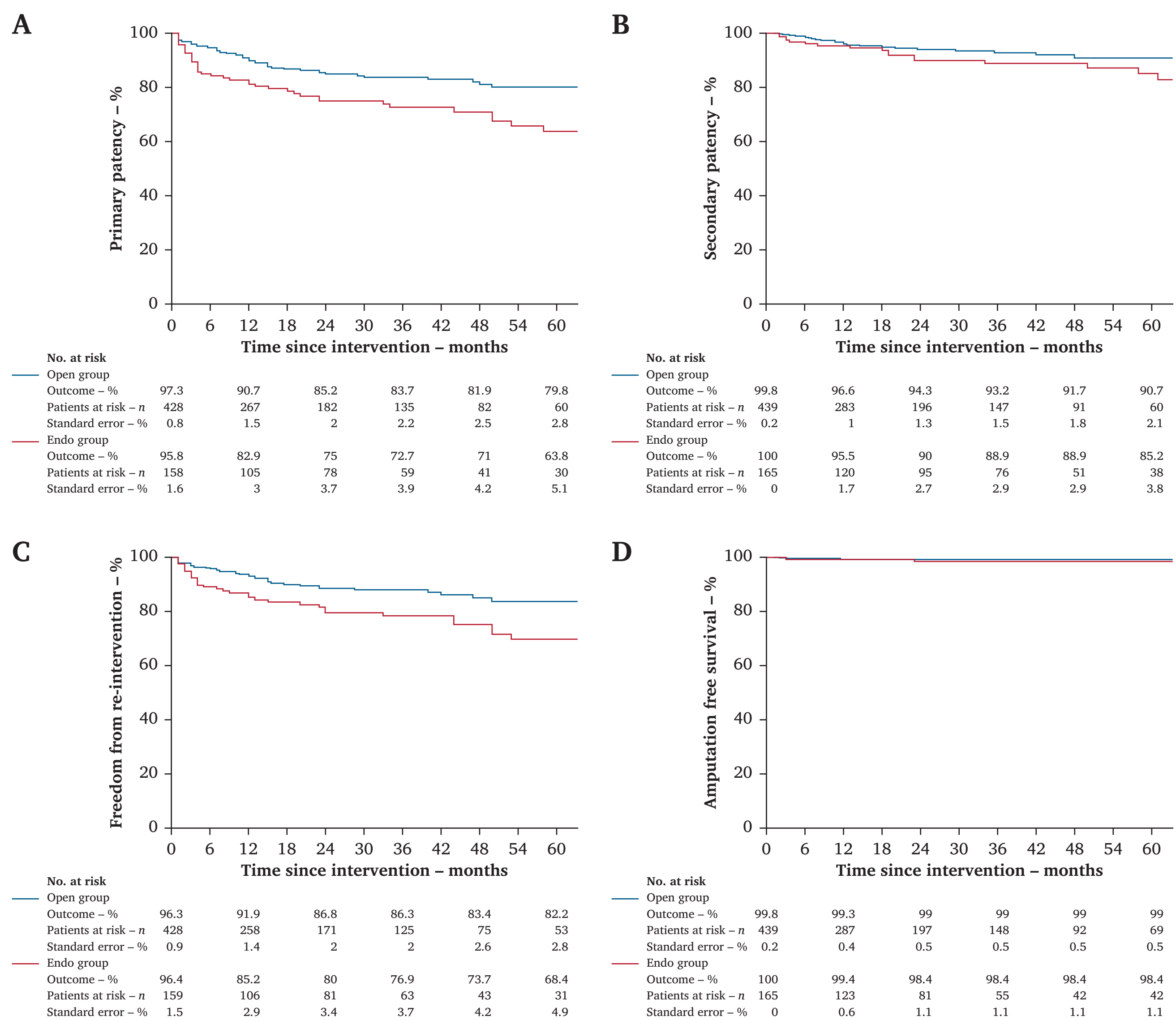
Data are presented as numbers. PTA = percutaneous transluminal angioplasty.

survival up to 90.7% and 99.0%, respectively. These outcomes are similar to those reported for open surgery in previous studies.[15,16] Despite these satisfactory results, during the past decade there has been much debate regarding the issue of whether or not patients with asymptomatic PAAs measuring <3 cm should be treated conservatively. Early elective repair is recommended for average risk patients.[17,18] Furthermore, the sensible reduction in morbidity and mortality of endovascularly repaired PAAs has shifted clinical practice towards an interventional approach. Therefore, patients with smaller PAAs, especially those with mural thrombus, should be treated either with an open or endovascular approach.[19—22] Indeed, open bypass remains the benchmark of treatment, especially considering its durability.

In the present study, both groups were homogeneous; in particular, no differences were found in pre-operative diameter and distal runoff. It can be hypothesised that the diameter could influence the good outcomes, especially for patients undergoing an endovascular procedure. In fact, in the present study, two intra-operative type I endoleaks were reported in the endo group, probably related to a predestined technical error of size mismatch, which was clearly the anticipated outcome from undersized or poorly sized grafts. Regarding distal runoff, on the basis of the pre-operative CT scan, it can also be assumed that a distal embolisation occurred in no more than 20% of cases, even though all patients remained asymptomatic or developed intermittent claudication due to insufficient vessel collateralisation.

Several studies have already demonstrated excellent long term results in terms of sac enlargement, even in patients treated by proximal and distal ligation, and subsequent bypass with autologous vein.[23,24] However, a subgroup analysis on short bypasses showed more sac expansion for the medial approach than for the posterior approach.[25] This complication is similar to a type II endoleak when endovascular therapy is used, although its frequency was negligible in the current cohort, resulting in a technical success rate of 98.8%. Indeed, the length of the aneurysm influences the choice between open surgery via either medial or posterior approach, and endovascular exclusion with covered stent grafts. In the present study, both the open and endo groups were homogeneous in terms of anatomical features of the PAA, underlining strict application of the inclusion criteria. Indeed, only for short aneurysms and those located in P2/P3 zones, the open and endovascular approaches can become almost interchangeable. In fact, no differences were recorded in MACEs, graft occlusion, procedure related re-interventions, and major amputation at 30 days between the open and endo groups. These favourable early outcomes are in line with those reported in the literature, even though a definitive superiority of endovascular repair over open surgery has not yet been demonstrated.[26,27] Furthermore, open surgery with a posterior approach is more likely to be a definitive treatment, but at the same time is burdened by a longer hospital stay and a higher rate of nerve injury. However, if a correct surgical technique is used, lesions of the sciatic popliteal nerve can easily be avoided. This should be considered particularly in patients in a poor pre-operative clinical condition, as these two factors can contribute to worsening early outcomes after surgery. On the other hand, according to previous reports, in the long term estimated primary patency and freedom from re-intervention rates were better in the open group.[28—30] However, considering secondary patency and amputation free survival, no difference between open and endo groups has been recorded. The slighter impact of endovascular therapy combined with accurate patient selection, based both on anatomical consideration and clinical condition, may justify these satisfactory results during follow up. On the other hand, the overall five year survival seems to be higher in the open group in the current cohort. This could be explained by the higher age in the endo group at the time of the index procedure, even though the two groups were relatively homogeneous in terms of pre-operative comorbidities. This may justify the choice of an open approach in fit patients with relatively longer life expectancy.

In any case, endovascular treatment of PAAs may be considered in patients with short aneurysms (≤ 6 cm in length in the current cohort) to minimise the length of artery covered, especially in cases with poor runoff, but at the same time to guarantee a valid proximal and distal sealing of ≥ 2 cm. This fact, combined with the need for extending



A — No. at risk

Open group						
Outcome – %	97.3	90.7	85.2	83.7	81.9	79.8
Patients at risk – n	428	267	182	135	82	60
Standard error – %	0.8	1.5	2	2.2	2.5	2.8
Endo group						
Outcome – %	95.8	82.9	75	72.7	71	63.8
Patients at risk – n	158	105	78	59	41	30
Standard error – %	1.6	3	3.7	3.9	4.2	5.1

B — No. at risk

Open group						
Outcome – %	99.8	96.6	94.3	93.2	91.7	90.7
Patients at risk – n	439	283	196	147	91	60
Standard error – %	0.2	1	1.3	1.5	1.8	2.1
Endo group						
Outcome – %	100	95.5	90	88.9	88.9	85.2
Patients at risk – n	165	120	95	76	51	38
Standard error – %	0	1.7	2.7	2.9	2.9	3.8

C — No. at risk

Open group						
Outcome – %	96.3	91.9	86.8	86.3	83.4	82.2
Patients at risk – n	428	258	171	125	75	53
Standard error – %	0.9	1.4	2	2	2.6	2.8
Endo group						
Outcome – %	96.4	85.2	80	76.9	73.7	68.4
Patients at risk – n	159	106	81	63	43	31
Standard error – %	1.5	2.9	3.4	3.7	4.2	4.9

D — No. at risk

Open group						
Outcome – %	99.8	99.3	99	99	99	99
Patients at risk – n	439	287	197	148	92	69
Standard error – %	0.2	0.4	0.5	0.5	0.5	0.5
Endo group						
Outcome – %	100	99.4	98.4	98.4	98.4	98.4
Patients at risk – n	165	123	81	55	42	42
Standard error – %	0	0.6	1.1	1.1	1.1	1.1

Figure 3. Cumulative Kaplan–Meier estimates of five year outcomes for patients with popliteal artery aneurysm undergoing open surgical repair via a posterior approach (open group) or endovascular exclusion with covered stent (endo group): (A) primary patency; (B) secondary patency; (C) freedom from re-intervention; and (D) amputation free survival. Number of patients at risk and standard error values for each group are shown.

the stented zone to the superficial femoral artery or to soften the mismatch between the edges of the stent graft and the artery, can explain the relatively high median length of the stent in this cohort. The best choice among treatments, however, should be targeted on the individual patient. Therefore, in the decision making process, the superiority of endovascular technique in avoiding the risk of nerve injury and reducing the length of hospitalisation should be considered in selected patients. These potential advantages are completely offset by the higher rate of re-intervention required to maintain graft patency and limb preservation. Indeed, an accurate evaluation of the risk–benefit balance is mandatory to achieve satisfactory results with both treatments. A randomised controlled trial with a larger sample size may be useful to better clarify the superiority or not of one treatment over another.

Limitations

The present study has several limitations. First, it was a retrospective collection of data with very low numbers reported, which could potentially lead to selection bias. Second, the non-randomised nature of enrolment could have partly affected the generalisability of the results, including also the non-homogeneous distribution of the cases (open *vs*. endo) carried out in each participating centre. Third, the groups are not matched for patient and lesion characteristics, including only a selected population of patients with short asymptomatic PAAs.

Conclusion

Early and long term outcomes of elective surgical repair of PAAs by a posterior approach or endovascular exclusion could be considered comparable. Nerve injury is a rare but potential complication in case of open repair with a posterior approach. Endovascular repair requires more re-interventions during follow up to maintain overall graft patency and limb preservation.

CONFLICT OF INTEREST

Nicola Troisi declares honoraria and lecture fees/consulting for LeMaitre; Athanasios Saratzis declares honoraria and lecture fees/consulting for Shockwave, Abbott, and Cook, educational grant support from Cook, and research funding from Shockwave, Abbott, Boston Scientific, and Angiodroid; Luca Bertoglio declares honoraria and lecture fees/consulting for Shockwave, Abbott, Cook, and Angiodroid, and research funding from Shockwave and Abbott. All other authors have no conflicts of interest to declare.

FUNDING

None.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejvs.2024.08.011.

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