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Original Research Article

A RETROSPECTIVE STUDY COMPARING POSTERIOR AND MEDIAL APPROACH FOR POPLITEAL ARTERY INJURIES

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ABSTRACT

Background: Popliteal artery injury carries a high risk of limb loss, with outcomes dependent on ischemia duration and timely revascularisation. While both posterior and medial surgical approaches are used, evidence remains inconclusive regarding superiority. This study compared posterior and medial approaches in such patients. **Materials and Methods:** This retrospective cohort study included 60 patients conducted between January 2021 and December 2024. Patients were categorised based on surgical approach, posterior or medial, with selection guided by injury site and surgeon preference. Pre-, intra-, and postoperative parameters, including ischaemia time, repair type, complications, limb salvage, and graft patency, were recorded. **Result:** The mean age was 42.8±14.6 years, with 41(68.3%) males. The right limb was affected in 35(58.3%), complete transection occurred in 34(56.7%), and the mean ischaemia time was 6.5±3.0 hours. Operative time (138±27 vs. 164±32 min, p=0.029) and blood loss (420±110 vs. 510±135 ml, p=0.041) were lower in the posterior group. Pain scores on Day 1, 2, 3, and 1 week were 6.1±1.2, 4.8±1.1, 3.9±0.9, 2.6±0.8 versus 6.5±1.4, 5.2±1.2, 4.3±1.1, 2.9±0.9 (p>0.05). Limb salvage at 30 days was 27(96.4%) vs 29(90.6%), amputation 1(3.6%) vs 3(9.4%), graft patency at discharge and 1 year was 27(96.4%) vs 30(93.7%), wound infection 1(3.6%) vs 3(9.4%), and flap necrosis 4(14.3%) vs 1(3.1%). Hospital stay was shorter in the posterior group (8.0±2.3 vs. 10.4±3.0 days, p=0.016). **Conclusion:** Both approaches achieved high limb salvage and graft patency. The posterior approach was associated with shorter operative time, less blood loss, and reduced hospital stay, supporting its effectiveness and safety in select trauma patients.

INTRODUCTION

Traumatic injury to the popliteal artery is an uncommon but devastating event in vascular trauma, often associated with high rates of limb loss, morbidity, and functional impairment.[1] It is estimated that popliteal artery injuries account for 5-10% of all extremity arterial traumas but carry the greatest risk of amputation among these injuries.[2] In a large series of traumatic popliteal artery repairs, major amputation rates of approximately 10-15% have been reported, highlighting the severity of such injuries.[3]

One of the major determinants of outcome in popliteal artery injury is the duration of limb ischaemia before revascularisation. Earlier revascularisation is widely accepted to improve limb salvage, reduce tissue necrosis, and limit reperfusion injury.[4] Some studies suggest that each hour of delay can reduce the probability of limb salvage, and ischemia beyond 6 hours is often cited as a critical threshold.[5,6] Indeed, in a military cohort, salvage probability fell from 86% when revascularisation was within 1 hour to only ~67% when beyond 6 hours.[5] However, other investigators have demonstrated that delayed revascularisation (beyond 6 or even 12 hours) may still yield acceptable salvage and functional outcomes in selected patients.[7]

Beyond ischaemic time, the choice of surgical approach may influence technical success, complications, and long-term outcomes. Historically,

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the posterior and medial approaches have been used for the surgical repair of popliteal artery pathology (including aneurysms). A classic comparative study in aneurysm repair showed similar limb salvage and patency between medial and posterior approaches, with minor differences in early thrombectomy requirement.[8] In traumatic settings, the posterior approach offers direct exposure to the arterial segment without extensive dissection of surrounding tissues and may reduce operative time and soft tissue disturbance.[9] In blunt popliteal trauma treated via the posterior route, favourable results in patency and limb salvage have been reported.[3] Conversely, the medial approach allows better access to concomitant injuries (e.g. venous, nerve, bone) and may facilitate combined reconstruction in complex limb trauma.[10] Despite these theoretical advantages and some retrospective reports, there is no clear consensus on which approach offers superior outcomes in the context of popliteal artery injury. Comparative data are sparse, especially in civilian trauma cohorts, and many studies focus on open surgical repair in general without stratifying by approach.[11] Given the critical nature of these injuries and the need to optimise surgical strategies, a comparative evaluation of these approaches, specifically for popliteal artery trauma, is warranted.

Therefore, the present retrospective study sought to compare the posterior and medial surgical approaches in patients with traumatic popliteal artery injury and to assess outcomes such as limb salvage, operative parameters, complications, and functional recovery. The objective was to determine which approach yields better clinical results and informs surgical decision-making in this high-stakes setting.

MATERIALS AND METHODS

Study design and setting

This retrospective cohort study included 60 patients from the Department of General Surgery of a tertiary care hospital. The study reviewed the medical records of patients who underwent surgical repair for popliteal artery injury between January 2021 and December 2024. The study protocol was approved by the Institutional Ethics Committee.

Inclusion Criteria

Patients aged ≥ 18 years who sustained popliteal artery injury confirmed by imaging, such as computed tomography angiography or intraoperative findings, were included. Patients who underwent operative intervention using either the posterior or medial approach for repair or reconstruction were included. Patients presenting within 24 h of injury were considered eligible to ensure timely revascularisation and uniformity of management. Both blunt and penetrating mechanisms of injury include road traffic accidents, falls, and crush injuries. Cases with or without associated injuries to adjacent structures, such as veins, nerves, or soft tissues, were also included, provided that the popliteal artery injury was the primary indication for surgery.

Exclusion Criteria

Patients with incomplete medical records, those managed nonoperatively, and individuals who presented with non-survivable injuries or died before surgical intervention were excluded.

Methods

All eligible cases were identified from the hospital's surgical database and categorised according to the surgical approach used for vascular exposure and repair, posterior or medial. The posterior approach involved direct access to the popliteal artery from behind the knee through a curvilinear incision in the popliteal fossa, whereas the medial approach was performed through a longitudinal incision along the medial thigh, extending toward the adductor canal. The choice of approach depended on the site of injury, associated injuries, and surgeon's preference. Preoperative data, such as age, sex, mechanism of injury, comorbid conditions, clinical presentation, and ischaemia time, were recorded. Intraoperative details, including the type of repair (end-to-end anastomosis, vein graft interposition, or patch repair), operative time, and blood loss, were noted. Postoperative parameters, such as pain score using the Visual Analogue Scale on days 1, 2, 3, and at one week, time to ambulation, wound infection, flap necrosis, and total duration of hospital stay were assessed. Limb salvage and graft patency at discharge and at one-year follow-up were also documented.

Statistical Analysis

All data were compiled and analysed using IBM SPSS Statistics v25. Continuous variables are expressed as mean ± standard deviation, and categorical variables are presented as frequencies and percentages. Comparisons between the two surgical approaches were made using the independent samples t-test for continuous variables and the chi-square test for categorical data. Statistical significance was set at $p < 0.05$.

RESULTS

The mean age of the patients was 42.8 ± 14.6 years, with a range of 18-78. There were 41 (68.3%) males and 19 (31.7%) females. Road traffic accidents were the most common type of injury, occurring in 36 (60%) participants, followed by falls in 8 (13.3%), penetrating trauma in 7 (11.7%). Comorbidities included hypertension in 10 (16.7%), diabetes mellitus in 8 (13.3%), a history of smoking in 14 (23.3%), and coronary artery disease in 4 (6.7%). [Table 1]

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Table 1: Demographic, injury, and comorbidity profile

Variable	Category	N (%) / Mean ± SD
Age (years)	Mean age	42.8 ± 14.6
Gender	Male	41 (68.3%)
	Female	19 (31.7%)
Type of injury	Road traffic accident	36 (60%)
	Fall	8 (13.3%)
	Penetrating trauma	7 (11.7%)
	Crush injuries	5 (8.3%)
	Sports-related	4 (6.7%)
Comorbidities	Diabetes mellitus	8 (13.3%)
	Hypertension	10 (16.7%)
	Smoking history	14 (23.3%)
	Coronary artery disease	4 (6.7%)

Table footer: Values are expressed as N (%) for categorical variables and Mean ± SD for continuous variables.

The right and left limbs were affected in 35 (58.3%) and 25 (41.7%) participants, respectively. Complete transection was the most common type of vascular injury, observed in 34 (56.7%) cases, followed by intimal tear/thrombosis in 20 (33.3%). Associated injuries included fractures or dislocations in 37 (61.7%), nerve injury in 5 (8.3%), and superficial peroneal nerve deficits in 6 (10%). The majority presented with limb ischaemia (48, 80%), while active bleeding and expanding haematoma were each seen in 6 (10%) participants. The mean ischaemia time was 6.5 ± 3.0 h. [Table 2]

Table 2: Clinical characteristics

Clinical characteristics		N (%) / Mean ± SD
Side affected	Right limb	35 (58.3%)
	Left limb	25 (41.7%)
Type of vascular injury	Complete transection	34 (56.7%)
	Intimal tear/thrombosis	20 (33.3%)
	Pseudoaneurysm	3 (5%)
	Arteriovenous injury	3 (5%)
Associated injuries	Fractures/dislocations	37 (61.7%)
	Nerve injury	5 (8.3%)
	Superficial peroneal nerve deficit	6 (10%)
Presentation	Limb ischaemia	48 (80%)
	Active bleeding	6 (10%)
	Expanding haematoma	6 (10%)
Mean ischaemia time		6.5 ± 3.0 hours

Table footer: Values are expressed as N (%) for categorical variables and Mean ± SD for continuous variables.

End-to-end repair was performed in 13 (46.4%) vs. 5 (15.6%) cases, vein graft in 14 (50.0%) vs. 23 (71.9%), and patch repair in 1 (3.6%) vs. 4 (12.5%) cases in the posterior vs. medial groups (p = 0.232). Operative time was significantly shorter in the posterior group (138 ± 27 minutes vs. 164 ± 32 minutes, p = 0.029). Similarly, blood loss was significantly lower in the posterior group (420 ± 110 ml vs. 510 ± 135 ml, p = 0.041). Pain scores (VAS) on day 1, 2, 3, and week 1 were 6.1 ± 1.2 vs 6.5 ± 1.4, 4.8 ± 1.1 vs 5.2 ± 1.2, 3.9 ± 0.9 vs 4.3 ± 1.1, and 2.6 ± 0.8 vs 2.9 ± 0.9, respectively, with no significant difference. Time to ambulation was comparable, with most patients walking by postoperative day 3 (67.9% vs. 68.8%, p = 0.908). [Table 3]

Table 3: Comparison of operative and postoperative outcomes between posterior and medial approaches

Variable	Category	Posterior (N=28)	Medial (N=32)	p-value
Type of repair	End-to-end	13 (46.4%)	5 (15.6%)	0.232
	Vein graft	14 (50.0%)	23 (71.9%)	
	Patch repair	1 (3.6%)	4 (12.5%)	
Operative time (minutes)		138 ± 27	164 ± 32	0.029
Blood loss (ml)		420 ± 110	510 ± 135	0.041
Pain scores (VAS)	Day 1	6.1 ± 1.2	6.5 ± 1.4	0.27
	Day 2	4.8 ± 1.1	5.2 ± 1.2	0.18
	Day 3	3.9 ± 0.9	4.3 ± 1.1	0.22
	1 week	2.6 ± 0.8	2.9 ± 0.9	0.19
Time to ambulation	Post-op Day 1	2 (7.1%)	2 (6.2%)	0.908
	Post-op Day 2	7 (25.0%)	8 (25.0%)	
	Post-op Day 3	19 (67.9%)	22 (68.8%)	

Table footer: Values are expressed as N (%) for categorical variables and Mean ± SD for continuous variables. VAS – Visual Analogue Scale for pain assessment. Statistical analysis was performed using the Chi-square test for categorical variables and the independent t-test for continuous variables. A P-value < 0.05 was considered significant.

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Limb salvage at 30 days was 27 (96.4%) vs. 29 (90.6%) in the posterior vs. medial groups (p = 0.38), while amputation occurred in 1 (3.6%) vs. 3 (9.4%) patients (p = 0.616). Graft patency at discharge was 27 (96.4%) vs. 30 (93.7%) (p = 0.610), and wound infection was seen in 1 (3.6%) vs. 3 (9.4%) cases (p = 0.616). Flap necrosis occurred in 4 (14.3%) and 1 (3.1%) (p = 0.165). The posterior group had a significantly shorter hospital stay (8.0 ± 2.3 days vs. 10.4 ± 3.0 days, p = 0.016). Graft patency at 1 year was 27 (96.4%) vs. 30 (93.7%) (p = 0.610).[Table 4]

Table 4: Comparison of postoperative outcomes between posterior and medial approaches

Outcome	Posterior (N=28)	Medial (N=32)	p-value
Limb salvage (30 days)	27 (96.4%)	29 (90.6%)	0.38
Amputation	1 (3.6%)	3 (9.4%)	0.616
Graft patency at discharge	27 (96.4%)	30 (93.7%)	0.610
Wound infection	1 (3.6%)	3 (9.4%)	0.616
Flap necrosis	4 (14.3%)	1 (3.1%)	0.165
Hospital stays (days)	8.0 ± 2.3	10.4 ± 3.0	0.016
Patency at 1 year	27 (96.4%)	30 (93.7%)	0.610

Table footer: Values are expressed as N (%) for categorical variables and Mean ± SD for continuous variables. Statistical analysis was performed using the Chi-square test for categorical variables and the independent t-test for continuous variables. A P-value < 0.05 was considered significant.

DISCUSSION

In our study, most participants were male, with injuries primarily resulting from road traffic accidents, followed by falls, penetrating trauma, crush injuries, and sports-related injuries. Some patients had comorbidities, such as hypertension, diabetes, smoking history, and coronary artery disease. **Fairhurst et al.** reported a median age of 45 years (range, 21-88 years) and 54% males among 24 patients. The injury mechanisms included low-energy trauma (33%), medium-energy trauma (38%), and high-energy trauma (29%). Preoperative ischemia lasted a median of 6 hours and 30 minutes, comparable to our mean ischemia time of 6.5 ± 3.0 hours.[4] **Bisdas et al.** reported 50 patients (58 PAAs) with a mean age of 59 years and a strong male predominance (88%). Hypertension (80%), hypercholesterolemia (66%), nicotine abuse (64%), and coronary artery disease (36%) were the most frequent comorbidities.[12]

Mazzaccaro et al. observed acute ischaemia in 20.9% (posterior) and 26.5% (medial) of patients, chronic ischaemia in 25.6% and 20.6%, and asymptomatic cases in 44.2% and 47.1%, respectively, with 1-3 patent runoff vessels and similar aneurysm dimensions between approaches.[13] These findings highlight demographic and etiological variations across studies, suggesting that the injury mechanism and ischaemia duration are influenced by both population characteristics and trauma dynamics. In the present study, both right and left limbs were affected, with complete transection being the most common type of vascular injury. Other injuries included intimal tears, pseudoaneurysms and arteriovenous injuries. Many patients also had associated fractures, dislocations, or nerve injuries, and most presented with limb ischaemia. **Abd El Fatah et al.** reported minimal perioperative vascular complications, with distal ischemia (2.5%) and wound seroma (2.5%) in the posterior group, and graft thrombosis (2.5%) and wound hematoma (2.5%) in the medial group; notably, no amputations occurred, and all patients survived the first month.[14] In contrast, **Mazzaccaro et al.** found acute leg ischemia in 20.9% (posterior) and 26.5% (medial), chronic ischemia in 25.6% and 20.6%, and asymptomatic cases in 44.2% and 47.1%, respectively, with 1–3 patent runoff vessels and similar aneurysm dimensions between approaches.[13] **Bisdas et al.** described that 83% of patients presented with symptoms of peripheral arterial disease due to popliteal artery aneurysms, while 17% were asymptomatic. Ischaemic symptoms were common, with most patients classified as Fontaine IIb (46%) or III (29%). In severe cases (class IV), no runoff vessels were observed.[12] Likewise, **Phair et al.** reported variable rates of asymptomatic patients (6–68%), acute ischaemia (0–67%), and chronic ischaemia (0–83%) across studies, with venous grafts employed in 9–90% of cases depending on the approach.[15] Our findings align with previous studies in demonstrating considerable variability in injury patterns and ischaemic outcomes, yet consistently reflect the popliteal artery's vulnerability to severe trauma and its significant implications for limb viability.

In our study, various vascular repair techniques were used in both groups of patients. The posterior approach was associated with a shorter operative time and less blood loss, whereas pain scores and time to ambulation were similar between the groups. **Fairhurst et al.** reported multiple reconstruction techniques, including direct anastomosis (17%), patch plasty (17%), short venous interposition (29%), and femoro-popliteal venous bypass (38%); intraoperative shunting was needed in 21%, while simultaneous orthopaedic procedures and fasciotomy were each performed in 50% of cases.[4] **Mazzaccaro et al.** likewise noted that all posterior approach patients underwent interposition grafting (100%), compared to 64.7% interposition grafts and 35.3% bypass in the medial group. PTFE grafts were used more often posteriorly (83.7% vs. 52.9%), whereas

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reversed GSV was favoured medially; operative time was comparable (posterior: 160 min, medial: 172 min, p = 0.26).[13]

Bisdas et al. performed both posterior and medial approaches, reporting a 100% perioperative graft patency rate and no amputations during the 30-day postoperative period. The median hospital stay was 7 days. No neurological or deep venous complications were noted.[12] **Phair et al.** also demonstrated predominant use of interposition grafts in posterior approaches (64.7–100% vs. 35–75% for medial), while primary closure and patch plasty were less common.[15] Across multiple studies, the posterior approach consistently shows favourable intraoperative outcomes, although graft selection and repair techniques continue to vary based on anatomical and clinical considerations.

In our study, limb salvage, graft patency, and complication rates were comparable between the two groups. The posterior approach was associated with shorter hospital stays. **Abd El Fatah et al.** reported 100% limb salvage at 30 days with no amputations or deaths, minimal complications, and a shorter hospital stay (3.5 days).[14] **Fairhurst et al.** likewise noted 92% limb salvage (22/24) at 30 days, no deaths or amputations, hospital stays of 10–21 days, and no re-interventions.[4] **Bisdas et al.** observed excellent limb salvage during follow-up, with 3-year rates of 100% in the posterior group and 90% in the medial group (P = .237). Graft patency was also higher with the posterior approach (76% vs. 52%, P = .056). Wound infection was more frequent in the posterior group (28% vs. 14%), though not statistically significant (P = .20).[12] **Phair et al.** also observed 90–100% limb salvage, low mortality, and posterior approaches with fewer re-interventions, low infection rates, and good graft patency.[15] In summary, across studies, limb salvage, graft patency, and complication rates are largely similar between approaches, yet the posterior approach consistently demonstrates shorter hospital stays and fewer re-interventions.

Limitations

This study was limited by its single-centre retrospective design, which may affect generalisability, and the relatively short-term follow-up, restricting the assessment of long-term functional outcomes and graft durability.

CONCLUSION

In patients with traumatic popliteal artery injury, both posterior and medial approaches achieved high limb salvage and graft patency rates. The posterior approach was associated with a shorter operative time, less blood loss, and reduced hospital stay, whereas pain scores, time to ambulation, and complication rates were comparable between the two approaches, supporting its effectiveness and safety in select trauma cases. The posterior approach may be preferred for isolated arterial injuries or when rapid revascularisation is needed, whereas the medial approach remains useful for complex injuries with associated fractures or soft tissue damage. Future multicentre studies with larger cohorts and longer follow-ups are warranted to confirm these findings and guide standardised surgical decision-making.

REFERENCES

1. Feliciano DV. Blunt injury to the popliteal artery. Trauma Surg Acute Care Open 2018;3:e000215. https://doi.org/10.1136/tsaco-2018-000215.
2. Tamteki N B, Gülsen Ersoy G. Our surgical results in popliteal and infrapopliteal artery injuries: 21 cases without amputation. Emerg Med Int 2024; 2024:1721047. https://doi.org/10.1155/2024/1721047.
3. O'Banion LA, Dirks R, Saldana-Ruiz N, Farooqui E, Yoon WJ, Pozolo C, et al. Contemporary outcomes of traumatic popliteal artery injury repair from the popliteal scoring assessment for vascular extremity injury in trauma study. J Vasc Surg 2021; 74:1573-1580.e2. https://doi.org/10.1016/j.jvs.2021.04.064.
4. Fairhurst PG, Wyss TR, Weiss S, Becker D, Schmidli J, Makaloski V. Popliteal vessel trauma: Surgical approaches and the vessel-first strategy. Knee 2018; 25:849–55. https://doi.org/10.1016/j.knee.2018.06.012.
5. Perkins ZB, Kersey AJ, White JM, Lauria AL, Propper BW, Tai NRM, et al. Impact of ischemia duration on lower limb salvage in combat casualties. Ann Surg 2022; 276:532–8. https://doi.org/10.1097/SLA.0000000000005560.
6. Lauria AL, Hicks CW. Ischemia duration and lower limb salvage. Adv Surg 2023; 57:59–71. https://doi.org/10.1016/j.yasu.2023.05.003.
7. Yu L, Deng L, Zhu S, Deng K, Yu G, Zhu C, et al. Limb-salvage outcomes of arterial repair beyond time limit at different lower-extremity injury sites. Med Sci Monit 2021;27:e927652. https://doi.org/10.12659/MSM.927652.
8. Kropman RHJ, van Santvoort HC, Teijink J, van de Pavoordt HDWM, Belgers HJ, Moll FL, et al. The medial versus the posterior approach in the repair of popliteal artery aneurysms: a multicenter case-matched study. J Vasc Surg 2007; 46:24–30. https://doi.org/10.1016/j.jvs.2007.03.019.
9. Makaloski V, Stellmes A, Wyss D, Weiss S, Becker D, Wyss TR, et al. Posterior approach for revascularization in blunt popliteal vessel injury. Ann Vasc Surg 2018; 48:89–96. https://doi.org/10.1016/j.avsg.2017.10.019.
10. Zhu YL, Xu YQ, Li J, Wang Y, Luo G. Medial approach for popliteal artery injuries. Chin J Traumatol 2010;13(2):83–6. https://pubmed.ncbi.nlm.nih.gov/20356442/
11. Mitsuzawa S, Yamashita S, Tsukamoto Y, Takeuchi H, Ota S, Onishi E, et al. What is the optimal treatment protocol for traumatic popliteal artery injury? A comparative study between two institutions. J Emerg Trauma Shock 2024; 17:178–83. https://doi.org/10.4103/jets.jets_164_23.
12. Bisdas T, Paraskevas KI, Pichlmaier M, Wilhelmi M, Haverich A, Teebken OE. Dorsal (posterior) versus medial approach for the surgical repair of popliteal artery aneurysms. Angiology 2010; 61:248–52. https://doi.org/10.1177/0003319709355802.
13. Mazzaccaro D, Carmo M, Dallatana R, Settembrini AM, Barbetta I, Tassinari L, et al. Comparison of posterior and medial approaches for popliteal artery aneurysms. J Vasc Surg 2015; 62:1512–20. https://doi.org/10.1016/j.jvs.2015.06.227.
14. Abd El Fatah HAEM. Comparative study between medial and posterior approaches in the management of popliteal artery aneurysm. Egypt J Hosp Med 2022; 86:190–3. https://doi.org/10.21608/ejhm.2022.211046.
15. Phair A, Hajibandeh S, Hajibandeh S, Kelleher D, Ibrahim R, Antoniou GA. Meta-analysis of posterior versus medial approach for popliteal artery aneurysm repair. J Vasc Surg 2016; 64:1141-1150.e1. https://doi.org/10.1016/j.jvs.2016.05.064.

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