ORIGINAL ARTICLE
Turk J Surg

Unveiling the secrets of the profunda femoris artery: A cadaveric journey with morphometric insights

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ABSTRACT

Objective: Profunda femoris artery (PFA), a branch of femoral artery primarily supplies blood to skin, muscles of the inner thigh and proximal femur and plays a significant role in collateral blood supply. This study aimed to investigate the origin, branching pattern and morphometries of PFA in cadavers.

Material and Methods: Lower limbs of male and female cadavers (n=41) were analyzed for origin of PFA, lateral circumflex artery (LCFA) and medial circumflex artery (MCFA), distance from mid-inguinal point, course, branching pattern and their external calibers. Data were tabulated and analyzed using SPSS.

Results: The PFA showed origins that are posterolateral, posteromedial, and posterior. The distance between PFA and the midpoint of the inguinal ligament was (L=3.7-6.2; mean =5.19±0.7 cm; R=3.2-6.2 cm, mean =4.74±0.9 cm). The origin of MCFA was medial (R=61%, L=52%) and posteromedial (R=39%, L=48%); LCFA was lateral (R=100%, L=78%) and posterolateral (R=0%, L=22%). The average diameter of PFA, MCFA, & LCFA was (L=5.04, 2.9, 2.8 cm and R=5.4, 3.09, 3.71 cm). The paired t-test with a significant p-value (95% confidence) demonstrated that differences in the diameters of the arteries at the specified levels between the left and right limbs could have clinical implications, such as differences in blood flow or susceptibility to vascular conditions.

Conclusion: To reduce intra-operative and post-operative complications in the femoral region branches during diagnostic and surgical procedures, it is essential to comprehend the normal and variant positions and distances of the PFA's origin and its circumflex branches.

Keywords: Profunda femoris artery, circumflex artery, variations, vascular

INTRODUCTION

Profunda femoris artery (PFA) is the first and largest branch of femoral artery (FA). It is also known as the deep femoral artery (DFA), which arises mostly postero-laterally from the FA, 3.5 cm distal to the inguinal ligament. It spirals posterior to the superficial FA and femoral vein to reach the medial side of the femur. Near the distal third of the thigh, it perforates the adductor magnus muscle, providing the principal supply to the adductor and flexor muscles of the thigh.

PFA branches from the FA. The branching may be on the lateral, medial, or dorsal aspect of FA. The branches of PFA include circumflex arteries, both lateral and medial [lateral circumflex artery (LCFA) and medial circumflex artery (MCFA)], and three to four perforating muscular arteries, namely, perforans prima, perforans secunda, and perforans tertia (Figure 1). LCFA arises near the root of Profunda femoris and traverses the anterior and posterior branches of the femoral nerve, subsequently branching into its ascending branch, transverse, and descending branches. The lateral circumflex femoral artery (LCFA) measures 5 mm in diameter and is more prominently developed compared to the MCFA and hence is robust (1,2). MCFA arises from the posteromedial side of the PFA. It rarely arises from FA. The diameter of MCFA is around 4 mm. When the artery reaches the upper edge of the adductor magnus muscle, it splits into two branches: Transverse and ascending. These branches then connect with other arteries: The lateral LCFA, the inferior gluteal artery, and the first perforating branch of the PFA. These connections (anastomoses) help ensure a continuous blood supply to the surrounding muscles and tissues, even if one pathway is blocked or damaged.

Cite this article as: Dhaminirithika AG, Rajilarajendran H, Kavinnilavan G, Indra P. Unveiling the secrets of the profunda femoris artery: A cadaveric journey with morphometric insights. *Turk J Surg.* [Epub Ahead of Print]

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Received: 06.09.2024
Accepted: 01.03.2025
Epub: 28.03.2025

DOI: 10.47717/turkjsurg.2025.6571

Available at www.turkjsurg.com

The head and neck of the femur are supplied by the LCFA and the Medial circumflex FA, MCFA. The important anastomoses, such as trochanteric, spinous, cruciate, and chain anastomoses, are formed by the branches of PFA (3).

PFA acts as the crucial collateral channel between the common iliac artery and the FA, extending to the distal end. The role of PFA in atherosclerotic occlusive disease, i.e., in the occlusion of the FA, is well documented in the formation of collateral arteries. These collaterals are formed among the artery of the knee joint, popliteal, its branches, and iliofemoral artery (4).

The PFA is traditionally used for other surgical purposes, while its branches are used in anterolateral perforator thigh flaps as a long vascular pedicle, during breast reconstruction after mastectomy. Knowledge on any deviation from the typical arterial pattern or structure is helpful during heart catheterization, diagnostic angiography (5), and surgeries for embolism.

Understanding the origin of the LCFA is crucial for administering anesthesia to the femoral nerve, performing orthopedic hip and femur surgeries, harvesting the anterolateral thigh flap for reconstructive surgery, and conducting bypass procedures (aorto-popliteal, intra and extra cranial, and coronary artery).

It is imperative to have a thorough understanding of the course of the MCFA during femoral osteotomies to avoid iatrogenic vascular necrosis of the head of the femur, flap reconstruction surgery, intervention radiology, and other procedures.

The study aimed in identifying the source and point of origin of PFA, measuring the distance of origin from bony landmarks, origins of MCFA and LCFA in addition to measuring the external calibers of PFA, LCFA and MCFA, analyses the statistical significance of the data.

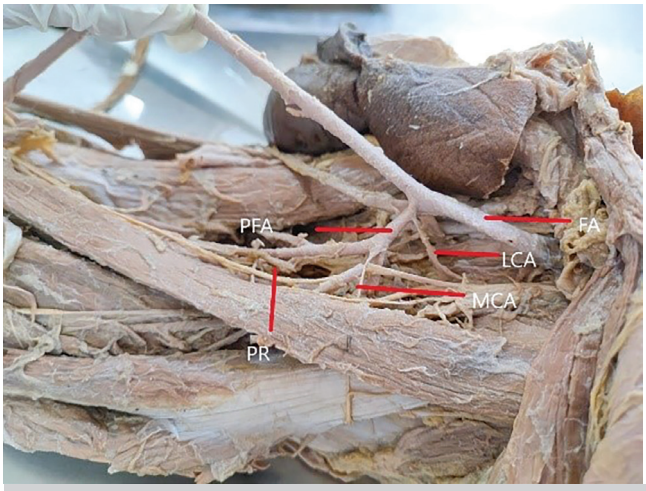


Figure 1. PFA-normal course.

FA: Femoral artery, PFA: Profunda femoris artery, LCFA: Lateral circumflex artery, MCFA: Medial circumflex artery, PR: Perforator

MATERIAL and METHODS

Meticulous dissection of 41 formalin fixed lower limb preserved specimens was carried out. An incision was made on the front of the thigh. The skin was lifted. Following this, the superficial fascia was reflected. After the identification of the long saphenous vein, the lymph nodes of the inguinal region were identified and an incision of the fascia lata was carried out to expose the femoral triangle. FA and its branches were uncovered. The PFA, along with its medial and lateral circumflex branches, was meticulously dissected. The distance from the mid-inguinal point to the origin of the PFA was precisely measured with calipers. The distance from the origin of the PFA to the pubic tubercle and the anterior superior iliac spine was measured. The diameter of the PFA, MCFA, and LCFA was measured.

All the measurements were taken in triplicate to avoid errors. Mapping of variations in branching pattern and their relation to adjacent muscles was recorded, i.e., topographic analysis.

The study design was approved by the Ethics Review Board of the Institutional Human Ethics Committee (CARE IHEC-II) (number: IHEC-I/1163/22, date: 08.08.2022). Informed consent is not applicable for this study as it was conducted on cadavers used for study purpose.

Statistical Analysis

The data obtained were entered in an Excel sheet and tabulated. SPSS software was used for tabulated data analysis. The mean, standard deviation, and standard error of the mean was calculated. Student's t-test was used to compare the means among the groups. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

PFA and Its Branches

The PFA emerges from the FA posterolateral side. Originating from the lateral side of PFA is the LCFA. The medial circumflex FA emerges from the medial side PFA.

Site of Origin of PFA

The origin of PFA was from the FA (100%); no case arose from the external iliac artery. In the current investigation, three distinct PFA originating sites were identified.

On the right side, 12 cases were found to arise from the posterolateral aspect (67%) and 6 cases from the posteromedial aspect (33%). On the left side, 17 cases were found to arise from the posterolateral aspect (74%), 4 from the posteromedial aspect (17%), and 2 (9%) from the posterior aspect. We could not find any cases arising from the anterolateral aspect (Table 1).

Table 1. Origin of PFA			
S. no	**Posterior aspect (%)**	**Posterolateral aspect (%)**	**Posteromedial aspect (%)**
Right limb	-	67 (n=12)	33 (n=6)
Left limb	9 (n=2)	74 (n=17)	17 (n=4)
PFA: Profunda femoris artery			

Pattern of Origin of PFA

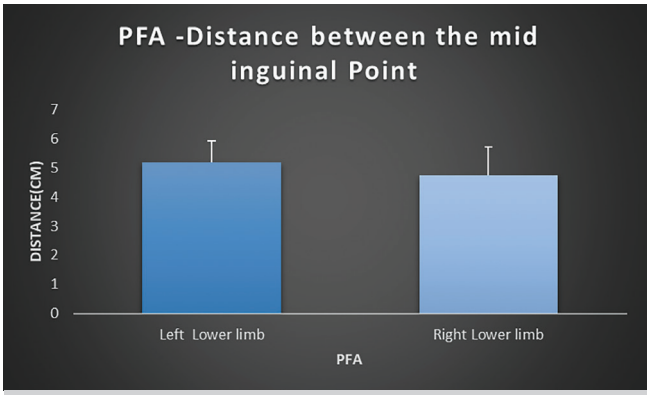
Diverse PFA origination patterns were observed in the study. In 11% of cases, the PFA on the right side originated from a common trunk with the medial circumflex femoral artery (MCFA), and in another 11%, it originated from a common trunk with the LCFA. In 26% of the cases on the left side, PFA originated as a common trunk with MCFA, and in 8.7% as a common trunk with LCFA. No instances of trifurcation were observed in either the right or left lower limb.

Origin of PFA-distance Between Mid Inguinal Point

The intervening space between PFA origin and mid-inguinal point (halfway distance between pubic symphysis and anterior superior iliac spine) was 3.7-6.2 cm in left limbs and 3.2-6.2 cm in right limbs, with mean measurements of 5.19±0.7 cm for the left limbs and 4.74±0.9 cm for the right limbs (Table 2, Graphic 1).

Site of Origin of MCFA

The origin of MCFA is 61% medial and 39% posteromedial (in the case of the right limb) and 52% medial and 48% posteromedial (in the case of the left limb). 11% in the case of the right limb arose directly from the femoral artery, and 26% in the case of the left limb arose directly from the femoral artery.



Graphic 1. Mean distance and SD from mid inguinal point with error bars.

SD: Standard deviation, PFA: Profunda femoris artery

Site of Origin of LCFA

The origin of LCFA is 100% lateral in the case of the right limb, and 78% lateral, and 22% posterolateral in the case of the left limb. 11% in case of right limb arose directly from FA and 26% in case of left limb arose directly from Femoral artery. 77% of LCFA arose distal to MCFA in the right limb, and 78% arose distal to MCFA in the left limb.

Double MCFA/LCFA

2MCFA were identified in one of the left lower limbs whereas a total of 2 duplicate LCFA were identified in another lower limb (Figure 2).

Comparative Analysis of Diameter of PFA, MCFA and LCFA

The average diameters of PFA at origin; diameter of MCFA; and diameter of LCFA were 5.04, 2.9, and 2.8, respectively, for the left limb and 5.4, 3.09, and 3.71, respectively, for the right limb (Table 3, Graphic 2). The paired t-test conducted for the diameters of PFA at the level of P1, P2, and P3 (perforator arteries) at the 95% confidence value revealed the p-value to be significant for Pairs P1, P2, and P3 for the left and right legs.

DISCUSSION

Variations were observed at the site of origin of PFA. The site of origin of PFA on the right limb was 63% in the posterolateral aspect and 37% from the posterior aspect, whereas for the left limb, it was 75% in the posterolateral aspect, 17% in the posteriormedial aspect, and 8% from the posterior aspect (Table 1). These findings are similar to the study by Rajani et al. (6). One possible explanation for variations in the PFA genesis site is variations in the rete femorale's regression pattern as an influencing factor during embryogenesis (7).

PFA's position with respect to FA is crucial because its postero-lateral orientation facilitates access, keeping FA and other structures out of the way. The medial proximity of the femoral vein to the FA poses a threat because an injury to this vein is probable, making the lateral zone of the FA more secure than the medial or posteromedial regions.

Table 2. Mean distance and SD from mid inguinal point				
S. no	**Distance from mid inguinal point (cm)**	**Range (upper and lower limit)**	**Standard deviation**	**Standard error of mean**
Left (n=23)	5.1913	3.70-6.20	±0.7321	0.18761
Right (n=18)	4.7406	3.20-6.20	±0.969	0.23455

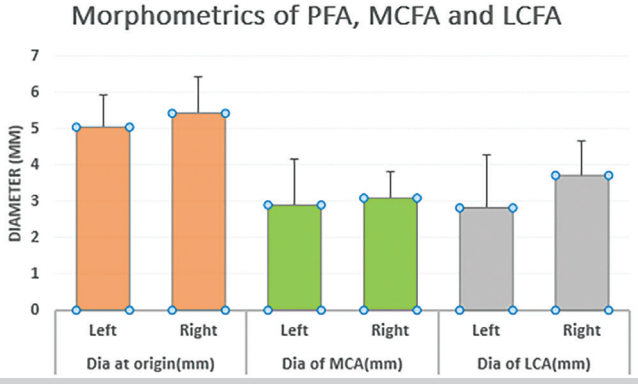
Table 3. External caliber of PFA, MCFA and LCFA

S. no	Diameter at origin (mm) with SD	Diameter of MCFA (mm) with SD	Diameter of LCFA (mm) with SD
Left (n=23)	5.0443±0.899	2.9±1.249	2.82±1.45
Right (n=18)	5.4261±0.99513	3.09±0.473	3.71±0.944

SD: Standard deviation, PFA: Profunda femoris artery, LCFA: Lateral circumflex artery, MCFA: Medial circumflex artery

Figure 2. Variation-LCFA-right limb showing double lateral circumflex artery.

FA: Femoral artery, PFA: Profunda femoris artery, LCFA: Lateral circumflex artery, MCFA: Medial circumflex artery, PR: Perforator



Graphic 2. External caliber of PFA, MCFA and LCFA.

PFA: Profunda femoris artery, LCFA: Lateral circumflex artery, MCFA: Medial circumflex artery

PFA, with its most important branch, the lateral circumflex, facilitating collateral development, often preserves limbs in cases of atherosclerotic illness and major artery diseases involving the aorto-ileofemoral segments because of its rich collateralization (8).

The length of separation between the origin of PFA and the mid-inguinal point was 3.7-6.2 cm in left limbs and 3.2-6.2 cm in right limbs. The average measurements were 5.19±0.7 cm on the left limbs and 4.74±0.9 cm on the right limbs. This varies with the study by Nasr et al. (1), where a mean of 5.15±0.19 cm on the right side and 4.97±0.19 cm on the left side was recorded, and also with the study by Chauhan et al. (9), where 3.1-4.0 cm on the right and 2.1-3.0 cm on the left with a mean of 3.01 cm was recorded. The FA is frequently used for catheterization and angiography procedures. Thus, it is crucial to be aware of the original location and relative height of the PFA, especially its high origin, in order to prevent the potential for iatrogenic damage that could occur during therapeutic or diagnostic operations.

This study showed PFA branching pattern of type-1, type-2, but did not record any type-3 pattern as per the classification of Vazquez et al. (10). A study by Kumar and Murlimanju (11) recorded three types or patterns 1, 2, and 3 having 56%, 40%, and 4% cases, respectively.

There exist six distinct variations of the MCFA and LCFA as described by Łabętowicz (12). Haemorrhagic shock and catastrophic bleeding are examples of intraoperative problems that can be avoided by being aware of the anatomical changes in the arterial system, particularly the MCFA and LCFA. One of the PFA's branches, the MCFA is crucial for vascularizing the femur head and neck, fatty tissue in the acetabular notch, and the medial (adductor) compartment of the thigh.

The origin of the MCFA is more proximal when it emerges from the FA than when it emerges from the PFA or LCFA. This study showed that 11% of the right limbs and 26% of the left limbs had MCFA origin directly from FA.

The origin of MCFA from FA has also been documented by Appaji and Desai (13) with an incidence of 3.3%. Studying the level of MCFA is important in orthopedic surgery as its damage may induce osteonecrosis due to avascularization of the head of the femur.

LCFA, a branch of PFA, divides into three branches, namely the ascending, transverse, and descending branches. It is helpful in anastomosis at the anterior superior iliac spine. The tensor fascia lata (a versatile muscle of the anterolateral aspect of the thigh), utilized in reparative and aesthetic procedures or surgeries, receives its robust blood supply from the LCFA. In our study, 11% of the right limbs and 8.7% of left limbs showed the origin of the MCFA directly from the FA. Also, the planning of flap dissection requires thorough pre-evaluation of the origin of the LCFA (14).

The average diameter of PFA at origin, diameter of MCFA, and diameter of LCFA is 5.04, 2.9, and 2.8, respectively for the left limb, and 5.4, 3.09, and 3.71, respectively for the right limb. This correlates with a study (15) where the DFA, the MCFA, and the LCFA had respective average sizes of 5.62 mm, 3.01 mm, and 3.44 mm. Chauhan et al. (9) compared the diameters of the PFA between the right and left lower limbs and male and female limbs but did not find any significant variation between them.

The paired t-test conducted for the diameters of PFA at the level of P1, P2, and P3 (perforator arteries) at the 95% confidence level (Table 4) revealed the p-value to be significant for Pair P1, P2, and P3 for the left and right legs. This implies that variations in the diameter of the arteries of the left and right limbs at the designated levels may have clinical consequences, such as altered blood flow or an increased risk of vascular diseases.

There were variations in the numbers of MCFAs and LCFAs. 2MCFA were identified in one of the left lower limbs, and 2 duplicate LCFA were identified in the other left lower limb. This correlates with the study of Claassen et al. (2). Vascular muscle grafts and ALT flaps are significantly impacted by the course and structural diversity of LCFA. Furthermore, it is important to consider the MCFA deviations for both artery bypass treatments and hip joint surgery techniques.

CONCLUSION

Knowledge of the origin and branches of the PFA is clinically significant in diagnostic and interventional procedures. They also aid in lowering the incidence of intraoperative and postoperative complications in the femoral area.

Continued investigations into the variations in the course of the PFA and its branches can provide deeper insights. This ongoing research can enhance the current understanding and lead to improved surgical techniques and outcomes.

By focusing on these aspects, healthcare professionals can improve both the safety and efficacy of procedures involving the femoral region, ultimately leading to better patient care and outcomes.

Table 4. Statistical analysis of the morphometric by t-test at 95% confidence level

Group			Paired differences					t	df	Sig. (2-tailed)
			Mean	95% CI						
				SD	SEM	Lower	Upper			
Left	Pair 1	Dia at origin (mm) Above P1	0.92273	0.72680	0.21914	0.43445	1.41100	4.211	10	0.002
	Pair 2	Dia at origin (mm) Above P2	1.83333	0.27289	1.11141	1.54696	2.11971	16.456	5	0.000
	Pair 3	Above P1 (mm)- Above P2	1.138	0.683	0.279	0.422	1.855	4.083	5	0.010
Right	Pair 1	Dia at origin (mm) Above P1	1.06900	1.26865	0.40118	0.16146	1.97654	2.665	9	0.026
	Pair 2	Dia at origin (mm) Above P2	1.97500	0.03536	0.02500	1.65734	2.29266	79.00	1	0.008
	Pair 3	Above P1 (mm)- Above P2	1.405	0.191	0.135	-0.310	3.120	10.407	1	0.061

SD: Standard deviation, CI: Confidence interval, SEM: Standard error of mean

Ethics

Ethics Committee Approval: The study design was approved by the Ethics Review Board of the Institutional Human Ethics Committee (CARE IHEC-II) (number: IHEC-I/1163/22, date: 08.08.2022).

Informed Consent: Informed consent is not applicable for this study as it was conducted on cadavers used for study purpose.

Footnotes

Author Contributions

Concept - H.R.; Supervision - H.R.; Data Collection or Processing - A.G.D.; Analysis or Interpretation - P.I.; Literature Search - G.K.; Critical Review- A.G.D.; Writing - A.G.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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