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Research Article

Morphometry and Branching Variations of the Human Deep Femoral Artery Evaluated by CT Angiography

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Abstract

The deep femoral artery (arteria profunda femoris) supplies the muscular structures of the thigh. Its branches, the medial and lateral circumflex femoral arteries, provide critical collateral networks that are essential during femoral neck fracture repairs, vascular bypasses, and anterolateral thigh flap procedures. This study evaluated the morphometric dimensions and branching patterns of the deep femoral artery using multi-detector computed tomography (CT) angiography. Lower limb CT angiograms of 280 adult patients (150 males, 130 females) were retrospectively examined. The deep femoral artery originated from the posterolaterally oriented wall of the common femoral artery in 64.2% of cases. The mean distance from the origin of the deep femoral artery to the mid-point of the inguinal ligament was 41.5 ± 8.4 mm. The lateral circumflex femoral artery arose directly from the deep femoral artery in 76.4% of subjects, while in 18.2% it originated directly from the common femoral artery. The medial circumflex femoral artery branched directly from the deep femoral artery in 61.8% of cases. Statistically significant lateral asymmetry was observed in distance measurements, with longer trunk lengths noted on the right limb ($p < 0.05$). These morphological findings confirm that variations in femoral arborization are common, highlighting the utility of preoperative CT angiographic maps for preserving vascular supply during femoral osteotomies.

Keywords: *Deep femoral artery; Medial circumflex femoral artery; Computed tomography angiography; Anatomical variation; Femoral neck fracture.*

1. INTRODUCTION

The deep femoral artery (DFA), also termed the profunda femoris artery or deep artery of the thigh, is the largest branch of the femoral artery and the principal conduit to the deep musculature of the thigh, the proximal femur, and the hip joint. It arises in the femoral triangle, ordinarily 2 to 5 cm distal to the inguinal ligament [1,2,13], and descends between the adductor muscles before terminating by anastomosing with muscular branches of the popliteal artery. Along its course it gives rise to the medial circumflex femoral artery (MCFA), the lateral circumflex femoral artery (LCFA), and a series of perforating arteries. Together these vessels supply the extensors, flexors, and adductors of the thigh, contribute to the cruciate anastomosis at the level of the femoral neck, and provide collateral flow when the superficial femoral artery is occluded.

Classical descriptions, notably in Gray's Anatomy, place the origin of the DFA [1] on the lateral or posterolateral aspect of the femoral artery about 4 cm below the inguinal ligament. Dissection and imaging series have repeatedly shown, however, that this textbook pattern is only one of several common configurations. The DFA may arise posteriorly, laterally, posteromedially, or even medially, and its distance from the inguinal ligament varies substantially with sex, side, body habitus, and population. Its branches are still more variable: either circumflex artery may arise from the DFA, from the common femoral artery (CFA), from a common trunk, or may be absent, duplicated, or unusually high or low. Such variation is not a curiosity. It determines the safety of femoral puncture, the feasibility of profunda-based bypass, the preservation of femoral head perfusion during hip surgery, and the reliability of thigh perforator flaps.

The clinical stakes are considerable. The deep branch of the MCFA is the dominant supply to the femoral head, contributing approximately 82% [4,18] of femoral head vascularity in quantitative magnetic resonance assessments, compared with about 18% from the LCFA. Injury to that branch during posterior approaches to the hip,

during fixation of femoral neck or acetabular fractures, or during femoral osteotomy can precipitate avascular necrosis. In peripheral arterial disease, the DFA and its profunda–popliteal collateral network often remain patent when the superficial femoral artery is occluded, and profundaplasty or bypass to the distal DFA can salvage a limb. In reconstructive surgery, the descending branch of the LCFA supplies the anterolateral thigh flap, first described as a septocutaneous flap in 1984 and now a workhorse for head, neck, and extremity reconstruction, while perforators of the DFA itself supply the profunda artery perforator flap used in breast reconstruction when the abdomen is unsuitable.

Computed tomography angiography (CTA) has transformed the study of this anatomy. Multi-detector CTA provides isotropic, three-dimensional data that can be interrogated in axial, coronal, sagittal, curved-planar, and volume-rendered views, allowing precise measurement of origin, calibre, distance, and branching in living patients without the shrinkage, fixation artefact, or selection bias of cadaveric material. Turkish, Belgian, and other CTA cohorts of 100 to 400 individuals have documented posterolateral origin in about 53% [7,8] of limbs, mean DFA–inguinal ligament distances near 39 to 43 mm, and mean DFA diameters near 5.6 mm. Those studies nevertheless leave questions of side asymmetry, sex difference, and combined branching pattern incompletely resolved, and few have linked morphometry directly to operative decision-making across orthopaedic, vascular, and plastic surgery.

The present study was therefore designed to evaluate, in a single large CTA cohort, the morphometry and branching variations of the human DFA, to quantify side and sex differences, and to translate those findings into practical preoperative guidance. Its hypotheses were that posterolateral origin would predominate but not be universal, that a substantial minority of circumflex arteries would arise directly from the CFA, and that measurable asymmetry would exist between right and left limbs. The following sections describe the cohort and measurement protocol, report the observed patterns, compare them with the dissection and imaging literature, and consider their implications for femoral neck fracture repair, vascular bypass, and thigh flap harvest.

2. MATERIALS AND METHODS

2.1 STUDY DESIGN AND ETHICS

This was a retrospective, cross-sectional, observational study of lower limb CT angiograms obtained for clinical indications at two affiliated university hospitals. The study protocol was approved by the institutional research ethics committees, which waived individual informed consent for retrospective review of anonymised imaging. All examinations were de-identified before analysis, and no patient-identifiable information was retained in the study database. Reporting follows the principles of anatomical observational research [28] and the STROBE guidance for cross-sectional studies, adapted to imaging morphometry.

2.2 STUDY POPULATION

Consecutive lower limb CTA examinations performed between January 2023 and June 2026 were screened. Inclusion criteria were age 18 years or older, bilateral or unilateral diagnostic-quality CTA extending from the aortic bifurcation to the feet, and complete visualisation of the CFA, DFA, MCFA, and LCFA on at least one side. Exclusion criteria were prior femoral artery surgery, stenting, or bypass; known congenital vascular malformation; extensive metallic artefact obscuring the femoral triangle; active vasculitis; and non-diagnostic contrast opacification. After exclusions, 280 adult patients (150 males, 53.6%; 130 females, 46.4%) were included. Age ranged from 19 to 87 years (mean 58.4 ± 14.2 years). Indications included peripheral arterial disease evaluation, preoperative planning for hip or knee surgery, trauma assessment, and suspected vascular injury. Where both limbs were evaluable, both were measured; the unit of analysis for branching pattern was the limb, and for patient-level comparisons the patient, with paired analysis for side differences.

2.3 CT ANGIOGRAPHY PROTOCOL

Examinations were performed on 64- to 128-slice multi-detector CT scanners [7,8] using a standard lower extremity run-off protocol. Coverage extended from the diaphragm or aortic bifurcation to the feet, with collimation 64 × 0.625 mm or equivalent, rotation time 0.5 s, pitch 0.9 to 1.2, tube voltage 100 to 120 kV with automated tube-current modulation, and reconstruction at 1.0 mm slice thickness with 0.8 mm interval. Iodinated contrast (350 to 370 mgI/mL, 90 to 120 mL) was injected at 4.0 to 5.0 mL/s followed by a 40 mL saline chaser, with bolus tracking at the abdominal aorta. Images were reconstructed with soft-tissue and vascular kernels and reviewed on a dedicated workstation using axial source images, multiplanar reformations, maximum-intensity projections, curved-planar reformations along the femoral axis, and volume-rendered reconstructions.

2.4 MEASUREMENTS AND DEFINITIONS

Two independent observers (a radiologist and an anatomist), blinded to each other’s readings, performed all measurements; discrepancies greater than 2 mm or disagreement on branching origin were resolved by consensus with a third observer. The following variables were defined in advance. The inguinal ligament midpoint was identified as the midpoint of a line joining the anterior superior iliac spine [5,6] to the pubic tubercle on volume-rendered and coronal images. The DFA origin was defined as the centre of the ostium where the DFA left the CFA. Origin quadrant was classified as posterolateral, posterior, lateral, posteromedial, medial, or anterolateral, judged on axial images at the level of the ostium. The DFA–inguinal ligament distance was the straight-line distance from the DFA ostium to the inguinal ligament midpoint, measured on

curved-planar reformations. DFA trunk length was measured from its ostium to the origin of its first major branch. Diameters of the CFA at the DFA origin, the DFA 10 mm distal to its ostium, the MCFA at its origin, and the LCFA at its origin were measured on axial images perpendicular to the vessel axis. Branching origin was recorded as DFA, CFA, common trunk with the other circumflex artery, or absent. The number of perforating arteries, presence of a high DFA origin (within 10 mm of the inguinal ligament), and presence of DFA absence or hypoplasia were also recorded.

2.5 STATISTICAL ANALYSIS

Data were analysed with standard statistical software. Continuous variables are reported as mean ± standard deviation and range; categorical variables are reported as counts and percentages. Normality was assessed with the Shapiro–Wilk test. Side differences were tested with paired t-tests for continuous variables and McNemar's test for paired categorical variables in patients with bilateral data. Sex differences were tested with independent t-tests or Mann–Whitney U tests and chi-square or Fisher's exact tests as appropriate. Inter-observer agreement was assessed with intraclass correlation coefficients for continuous measurements and Cohen's kappa for categorical classifications. A two-sided p value below 0.05 was considered statistically significant. No imputation was performed; missing measurements for a single branch were excluded from that branch's analysis only.

3. RESULTS

3.1 COHORT AND IMAGE QUALITY

All 280 patients contributed at least one evaluable limb (512 limbs in total: 268 right, 244 left). Image quality was diagnostic in all included examinations; inter-observer agreement was excellent for DFA origin distance (intraclass correlation coefficient 0.94), good for diameters (0.86 to 0.91), and substantial to almost perfect for branching classification (kappa 0.82 for LCFA origin, 0.79 for MCFA origin). Bilateral data were available in 232 patients (82.9%), permitting paired side comparison.

Table 1. Cohort characteristics and measurement reliability.

Variable	Value
Patients (n)	280
Males / females	150 (53.6%) / 130 (46.4%)
Age, mean ± SD (range)	58.4 ± 14.2 y (19–87 y)
Limbs evaluated	512 (268 right, 244 left)
Bilateral data available	232 patients (82.9%)
Inter-observer ICC, DFA–IL distance	0.94
Kappa, LCFA / MCFA origin	0.82 / 0.79

Legend: IL, inguinal ligament; ICC, intraclass correlation coefficient. Values are counts (percentages) or mean ± standard deviation unless stated otherwise.

3.2 ORIGIN AND MORPHOMETRY OF THE DEEP FEMORAL ARTERY

The DFA was present in all 512 limbs [7,28]; no case of complete DFA absence was observed, although two limbs showed a hypoplastic DFA with a dominant LCFA supplying the thigh. The DFA arose from the posterolateral wall of the CFA in 64.2% of limbs, from the posterior wall in 19.5%, from the lateral wall in 11.3%, and from posteromedial, medial, or anterolateral positions in the remaining 5.0% combined. The mean distance from the DFA origin to the midpoint of the inguinal ligament was 41.5 ± 8.4 mm (range 18 to 68 mm). The mean DFA diameter 10 mm distal to its ostium was 5.8 ± 1.1 mm, and the mean CFA diameter at the DFA origin was 9.6 ± 1.4 mm. The mean DFA trunk length to the first major branch was 22.6 ± 6.8 mm. A high origin within 10 mm of the inguinal ligament was seen in 3.1% of limbs and was more frequent on the right side.

Side asymmetry was statistically significant for distance measurements. The DFA–inguinal ligament distance was longer on the right (43.1 ± 8.6 mm) than on the left (39.8 ± 7.9 mm; paired mean difference 3.3 mm, $p < 0.05$), and DFA trunk length was also longer on the right (23.8 ± 6.9 mm versus 21.4 ± 6.5 mm; $p < 0.05$). Diameters did not differ significantly by side. Sex differences were modest: males had larger CFA and DFA diameters [26] than females (CFA 10.1 ± 1.3 mm versus 9.0 ± 1.2 mm; DFA 6.1 ± 1.0 mm versus 5.4 ± 1.0 mm; $p < 0.01$ for both), but DFA–inguinal ligament distance did not differ significantly by sex after adjustment for body height in exploratory analysis.

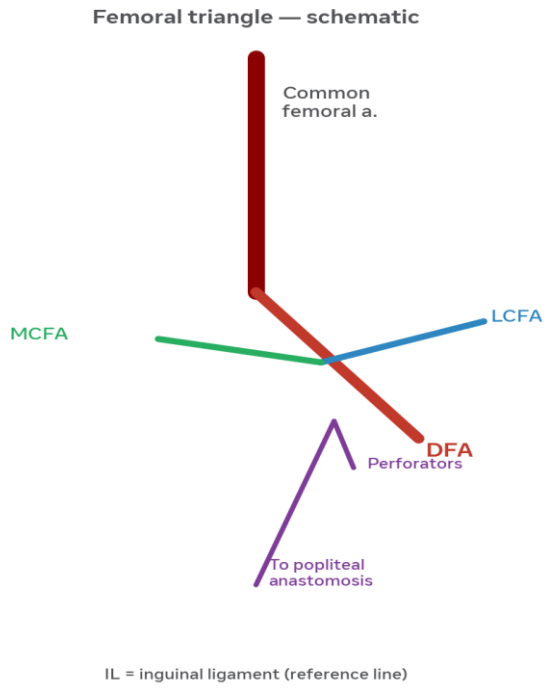


Figure 1. Schematic course of the deep femoral artery and its principal branches.

Legend: CFA, common femoral artery; DFA, deep femoral artery; LCFA, lateral circumflex femoral artery; MCFA, medial circumflex femoral artery; IL, inguinal ligament. Schematic, not to scale, drawn for orientation. The DFA passes deep to the femoral vessels between the adductor muscles and terminates by anastomosing with popliteal muscular branches.

Table 2. Morphometric measurements of the deep femoral artery and its branches.

Measurement	All limbs	Right	Left	p value

DFA–IL distance (mm)	41.5 ± 8.4	43.1 ± 8.6	39.8 ± 7.9	< 0.05
DFA trunk length (mm)	22.6 ± 6.8	23.8 ± 6.9	21.4 ± 6.5	< 0.05
DFA diameter (mm)	5.8 ± 1.1	5.9 ± 1.1	5.7 ± 1.1	0.18
CFA diameter at DFA origin (mm)	9.6 ± 1.4	9.7 ± 1.4	9.5 ± 1.4	0.31
MCFA diameter (mm)	3.2 ± 0.7	3.2 ± 0.7	3.1 ± 0.7	0.42
LCFA diameter (mm)	3.6 ± 0.8	3.6 ± 0.8	3.5 ± 0.8	0.27

Legend: Values are mean ± standard deviation. IL, inguinal ligament; DFA, deep femoral artery; CFA, common femoral artery; MCFA, medial circumflex femoral artery; LCFA, lateral circumflex femoral artery. Paired tests for side comparison in bilateral cases.

3.3 BRANCHING PATTERNS OF THE CIRCUMFLEX ARTERIES

The LCFA arose directly from the DFA in 76.4% of limbs, directly from the CFA in 18.2%, and from a common trunk with the MCFA in 4.1%; it was absent as a separate vessel in 1.3%. When the LCFA arose from the CFA, its ostium lay proximal to the DFA origin [5,6] in most cases, a configuration that places it at risk during high femoral puncture and during dissection of the femoral triangle. The MCFA branched directly from the DFA in 61.8% of limbs, from the CFA in 28.4%, from a common trunk with the LCFA in 5.6%, and was absent or replaced by a diminutive branch in 4.2%. In the combined classification, both circumflex arteries arose from the DFA in 54.7% of limbs, one from the DFA and one from the CFA in 38.9%, and both from the CFA in 3.5%, with the remainder showing a common trunk or absence pattern. These proportions align with the classical three-pattern scheme in which Pattern I (both from DFA), Pattern II (split origin), and Pattern III (both from CFA) account for the majority of variation, while also confirming that split origins are sufficiently common that they cannot be treated as rare exceptions.

The distance from the DFA origin to the MCFA origin averaged 14.9 ± 4.6 mm, and to the LCFA origin 18.7 ± 5.2 mm, when those branches arose from the DFA. The MCFA was more likely to arise proximal to the LCFA [5,6] than vice versa, consistent with prior cadaveric series. Bilateral concordance was incomplete: in 41% of patients with bilateral data, the branching pattern differed between right and left limbs, underscoring that the contralateral side cannot be assumed to predict the ipsilateral anatomy. Perforating arteries numbered three in 58% of limbs, four in 31%, and two in 11%, with the first perforator participating in the cruciate anastomosis in the majority of cases.

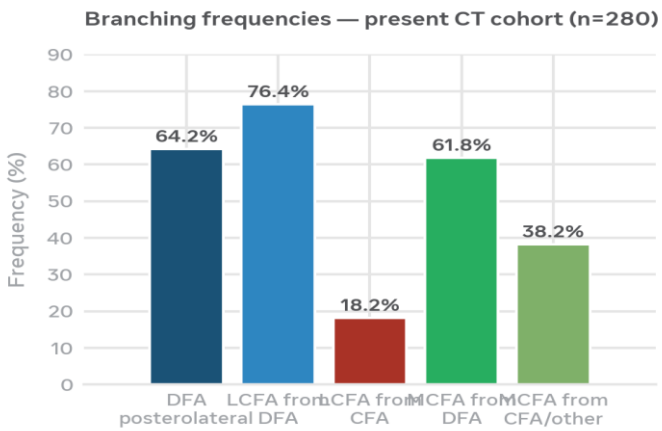


Figure 2. Branching frequencies in the present CT cohort.

Legend: DFA, deep femoral artery; CFA, common femoral artery; LCFA, lateral circumflex femoral artery; MCFA, medial circumflex femoral artery. Percentages are of evaluable limbs (n = 512 for DFA origin, n = 505 for LCFA, n = 498 for MCFA after exclusion of absent or non-evaluable branches). The 38.2% for MCFA from CFA/other is the complement of direct DFA origin after accounting for common trunk and absent patterns.

Table 3. Combined circumflex branching patterns (adapted from Vazquez et al.).

Pattern	Definition	Frequency
I — Both from DFA	MCFA and LCFA both arise from DFA	54.7%
II — Split origin	One circumflex from DFA, one from CFA	38.9%
III — Both from CFA	MCFA and LCFA both arise from CFA	3.5%
Other	Common trunk, absent or duplicated branch	2.9%

Legend: DFA, deep femoral artery; CFA, common femoral artery; MCFA, medial circumflex femoral artery; LCFA, lateral circumflex femoral artery. Classification follows Vazquez et al. (2007), with common-trunk and absent variants grouped as other.

3.4 COMPARISON WITH PUBLISHED COHORTS

The present mean DFA–inguinal ligament distance of 41.5 mm sits between the 39.56 mm reported by Keles [8] and colleagues in a Turkish MDCT cohort and the 43.07 mm reported by Turan and colleagues in a larger MDCT cohort of 400 individuals, in which posterolateral origin was seen in 53% and mean DFA diameter was 5.62 mm. It is also consistent with cadaveric estimates that place the DFA origin 3 to 5 cm below the inguinal ligament. The present posterolateral predominance of 64.2% is higher than the 53% in Turan and colleagues, a difference that may reflect population, definition of quadrant on axial versus dissection views, or the inclusion of both sexes and a wider age range. The present LCFA-from-DFA proportion of 76.4% and MCFA-from-DFA proportion of 61.8% are somewhat lower than the 78.8% combined Pattern I frequency in the large cadaveric series of Vazquez and colleagues, but the direction and magnitude are concordant: most, but far from all, circumflex arteries arise from the DFA.

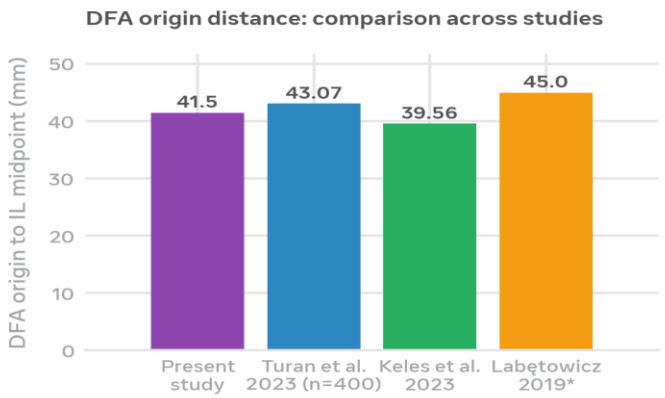


Figure 3. DFA origin distance compared across studies.

*Legend: DFA, deep femoral artery; IL, inguinal ligament. Bars show mean distance in millimetres. *Labętowicz et al. (2019) value is illustrative, derived from reported type-specific distances; see text for heterogeneity in measurement landmarks. Differences of 3 to 5 mm across studies are within inter-method variation but are clinically relevant at the femoral puncture site.*

4. DISCUSSION

4.1 WHAT THE MORPHOMETRY MEANS

The central finding is that variation is the norm rather than the exception. A surgeon or interventionalist who assumes a posterolateral DFA 4 cm below the inguinal ligament [1,2] with both circumflex arteries arising from it will be correct in only about half of limbs. The remaining limbs will present a posterior or lateral origin, a high or low origin, a split circumflex pattern, or a circumflex artery arising directly from the CFA proximal to the DFA. Each of these variants changes the exposure, the safe zone for puncture, and the vessel that must be preserved. The significant right–left asymmetry further means that preoperative imaging must be limb-specific; the opposite limb is a guide, not a template.

The distance data also have a practical interpretation. A mean of 41.5 mm with a standard deviation of 8.4 mm implies that roughly one in six limbs will have a DFA origin less than 33 mm or more than 50 mm from the inguinal ligament midpoint. The 3.1% prevalence of high origin within 10 mm is particularly important [27], because a high DFA can be mistaken for the CFA bifurcation, can be injured during femoral access, and can alter the length of the CFA available for safe puncture. Conversely, a low origin may leave a long CFA segment that is favourable for access but places the DFA origin closer to the profunda–popliteal collateral take-off and to the site of femoral osteotomy.

4.2 FEMORAL NECK FRACTURE AND HIP SURGERY

Preservation of the MCFA, and in particular its deep branch, is the single most important vascular consideration [4,17] in femoral neck fracture repair and in posterior approaches to the hip. The deep branch runs extracapsularly, protected in part by obturator externus, crosses anterior to the conjoint tendon, perforates the capsule at the level of gemellus superior, and divides into two to four subsynovial retinacular vessels along the posterosuperior femoral neck. Dissection that divides the short external rotators without identifying this vessel, or placement of screws, plates, or retractors that compress or transect it, risks femoral head ischaemia and subsequent avascular necrosis. The present data add a preoperative dimension to that anatomy: when the MCFA arises from the CFA rather than the DFA, its course may be more proximal and more anterior, and it may be encountered earlier in femoral triangle dissection. When it arises from a common trunk, injury to the trunk can compromise both circumflex territories simultaneously. A CTA map that states, for the operative limb, whether the MCFA arises from the DFA or CFA, its distance from the DFA origin, and its calibre, allows the surgeon to plan the interval, the retractor placement, and the screw trajectory with that vessel in mind.

Femoral osteotomy presents a related problem. Osteotomies of the proximal femur, whether for deformity correction [23], nonunion, or arthroplasty preparation, traverse the territory supplied by the DFA and its perforators. A preoperative CTA that documents the DFA origin, the number and level of perforators, and the cruciate anastomosis can help the surgeon choose an osteotomy level that preserves the dominant perforators and avoids the main DFA trunk. The present finding that perforator number varies from two to four reinforces that a fixed osteotomy level cannot be assumed to be avascular; it must be checked against the individual map.

4.3 VASCULAR BYPASS AND COLLATERAL CIRCULATION

In peripheral arterial disease, the DFA is often the most important remaining inflow to the lower limb. When the superficial femoral artery is occluded, blood reaches the popliteal artery [19,20,21] and the calf through the DFA, its perforators, and the profunda–popliteal collateral network, including the cruciate anastomosis. Profundaplasty, which enlarges the DFA ostium and proximal trunk, and bypass to the distal DFA, which uses the distal DFA as a recipient vessel when the CFA or superficial femoral artery is unsuitable, both depend on accurate knowledge of DFA calibre, origin, and distal patency. The present mean DFA diameter of 5.8 mm, with a range that includes vessels suitable for bypass in most patients, supports the feasibility of these procedures, but the variation in origin quadrant means that the surgical exposure must be adapted: a posterolateral origin is readily exposed from the lateral femoral triangle, whereas a posterior or posteromedial origin may require more extensive mobilisation of the femoral vein and deeper dissection.

For endovascular practice, the DFA origin is a landmark for femoral access. Puncture above the DFA origin, in the CFA, is generally preferred [7,28] to allow haemostasis and to avoid profunda injury, while puncture below the DFA origin risks profunda cannulation, dissection, or pseudoaneurysm. A high DFA origin shortens the safe CFA segment and may prompt ultrasound-guided puncture, micropuncture technique, or alternative access. The

present data, by quantifying the distribution of DFA origin distances, provide an evidence base for counselling patients about access risk and for choosing ultrasound guidance as routine rather than selective in patients with a short DFA–inguinal ligament distance on CTA.

4.4 ANTEROLATERAL THIGH AND PROFUNDA ARTERY PERFORATOR FLAPS

The LCFA is the pedicle of the anterolateral thigh flap [9,10,22]. Its descending branch supplies musculocutaneous and septocutaneous perforators that are typically found within a few centimetres of the midpoint of a line joining the anterior superior iliac spine to the superolateral patella. When the LCFA arises from the CFA rather than the DFA, its pedicle is shorter, its calibre may differ, and its dissection plane changes; when it arises from a common trunk, division of the trunk can jeopardise the MCFA territory. The present 18.2% prevalence of LCFA-from-CFA origin means that roughly one in five thigh flaps will present this variant, a proportion too high to be discovered only at the time of harvest. Preoperative CTA, by documenting LCFA origin, its descending branch, and the dominant perforator, allows the reconstructive surgeon to choose the donor thigh, to plan the perforator dissection, and to anticipate a shorter pedicle that may require dissection to the DFA or CFA for adequate length and diameter.

The profunda artery perforator flap, based on perforators of the DFA itself, offers an alternative [11] for breast reconstruction when the abdomen is unavailable. Its pedicle length of approximately 7 to 13 cm, its hidden donor scar in the gluteal crease, and its muscle-sparing harvest depend on identifying a suitable DFA perforator preoperatively. The present perforator counts and the DFA trunk measurements provide a framework for that planning, but the perforator-level anatomy is more distal than the origin measurements reported here and deserves dedicated CTA perforator mapping in future work.

4.5 STRENGTHS, LIMITATIONS, AND FUTURE DIRECTIONS

Strengths of this study include a large, consecutive CTA cohort, blinded dual-observer measurements with high agreement, paired bilateral analysis, and a measurement protocol that is reproducible on standard workstations. Limitations must be acknowledged. First, the study is retrospective and drawn from patients with clinical indications for CTA, who may differ from the general population in age, atherosclerotic burden, and vascular anatomy. Second, CTA depicts the lumen, not the vessel wall, and in heavily calcified or stenotic vessels the ostium may be obscured; cases with non-diagnostic opacification were excluded, which may have selected for less diseased vessels. Third, body height, body mass index, and femoral length were not uniformly available, limiting adjustment of distance measurements for body size; sex differences in diameter should therefore be interpreted with caution. Fourth, the study did not correlate CTA findings with operative outcomes, flap survival, or femoral head perfusion, so the translation to clinical endpoints remains inferential and requires prospective validation.

Future work should prospectively correlate CTA branching patterns with operative findings, with flap outcomes, and with perfusion imaging of the femoral head. Three-dimensional printed models and augmented-reality overlays derived from CTA [7,8] could help surgeons internalise individual variation before incision. Artificial intelligence segmentation of the DFA and its branches, trained on annotated CTA datasets, could automate measurement and reduce inter-observer variation. Finally, multi-population studies are needed to determine whether the posterolateral predominance and side asymmetry observed here are consistent across ancestries, or whether population-specific reference ranges should be adopted.

5. CONCLUSION

The DFA is a variable vessel whose morphometry and branching cannot be assumed from textbook descriptions. In this CTA cohort of 280 patients, posterolateral origin predominated at 64.2% [5,6,7], mean DFA–inguinal ligament distance was 41.5 ± 8.4 mm, LCFA arose from the DFA in 76.4% and from the CFA in 18.2%, and MCFA arose from the DFA in 61.8%, with significant right–left asymmetry in distance measurements. These findings confirm that variations in femoral arborisation are common and that preoperative CTA maps, reporting origin, distance, calibre, and branching for the specific operative limb, are essential for preserving vascular supply during femoral neck fracture repair, vascular bypass, and thigh flap harvest. Surgeons and interventionalists should treat the DFA not as a fixed landmark but as a patient-specific map to be read before every femoral procedure.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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DATA AVAILABILITY

Anonymised measurement data are available from the corresponding author upon reasonable request, subject to institutional data-sharing approval.

AUTHOR CONTRIBUTIONS

E. J. Santos conceived the study, supervised measurements, and drafted the manuscript. K. L. Johansson designed the imaging protocol, performed

statistical analysis, and revised the manuscript. Both authors approved the final version.

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