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Original Research Article

Anatomical Variations of Femoral Head Vascular Supply and Their Surgical Implications: A Cadaveric and Imaging-Based Study

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Abstract

Background: The vascular supply of the femoral head is a critical determinant of bone viability and successful outcomes following hip trauma or surgical intervention. The medial circumflex femoral artery (MCFA), lateral circumflex femoral artery (LCFA), and the artery of the ligamentum teres collectively contribute to femoral head perfusion. However, significant anatomical variations in these vascular structures have been reported, which may influence susceptibility to avascular necrosis (AVN) and surgical complications.

Objective: This study aimed to evaluate anatomical variations in the arterial supply to the femoral head through cadaveric dissection and correlate these findings with clinical imaging observations to better understand their potential implications in hip surgery and fracture management.

Methods: A descriptive anatomical study was conducted on 20 cadaveric hip specimens to identify the origin, course, and branching patterns of arteries supplying the femoral head. Particular attention was given to the retinacular branches of the MCFA, contributions from the LCFA, and the presence and size of the artery of the ligamentum teres. These anatomical findings were compared with imaging observations from patients undergoing Magnetic Resonance Angiography (MRA) for hip pathology evaluation.

Results: The medial circumflex femoral artery was identified as the dominant contributor to femoral head vascularity in 85% of specimens. Significant variations were observed in the number and caliber of retinacular vessels. The artery of the ligamentum teres was present in all specimens but demonstrated variable size and contribution to femoral head perfusion. Specimens with fewer retinacular branches demonstrated reduced vascular redundancy, suggesting a higher theoretical susceptibility to ischemic complications.

Conclusion: Considerable anatomical variation exists in the vascular supply of the femoral head. Understanding these variations is essential for surgical planning and may help reduce complications such as avascular necrosis during hip surgery and fracture fixation.

Keywords: Femoral Head Vascular Supply, Medial Circumflex Femoral Artery, Cadaveric Study, Anatomical Variation, Avascular Necrosis, Hip Surgery.

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Introduction

The vascular anatomy of the femoral head has been a subject of extensive investigation due to its critical role in maintaining the viability of the hip joint. The femoral head relies on a relatively delicate arterial network that is highly susceptible to disruption during trauma or surgical intervention.

Compromise of this vascular supply can lead to avascular necrosis (AVN), a devastating complication characterized by osteocyte death, collapse of the femoral head, and progressive degenerative arthritis of the hip joint (Mont et al., 2020). Among the arteries supplying the femoral head, the medial circumflex femoral artery (MCFA) is widely recognized as the principal contributor. The retinacular branches of the MCFA ascend along the femoral neck and penetrate the femoral head to supply the majority of the weight-bearing superior region (Trueta & Harrison, 1953; Gautier et al., 2000).

The lateral circumflex femoral artery (LCFA) provides additional vascular contributions, primarily to the anterior aspect of the femoral neck, although its role in supplying the femoral head

itself is generally considered secondary (Crock, 1980). Another vascular structure of interest is the artery of the ligamentum teres. Historically regarded as a minor vessel in adults, recent studies suggest that it may provide an important collateral pathway in certain individuals, particularly in cases where the primary retinacular vessels are compromised (Novais et al., 2015).

The extent to which this artery contributes to femoral head perfusion remains an area of ongoing investigation. Anatomical variability in the vascular supply to the femoral head has been reported in numerous studies.

Variations in the origin, number, and diameter of retinacular vessels may influence the resilience of femoral head perfusion following trauma or surgical intervention (Gosselin et al., 2015).

Methods

Study Design: This descriptive anatomical study was conducted using cadaveric specimens obtained from the anatomy department of a tertiary medical institution. Ethical approval for the study was obtained from the institutional review board.

Cadaveric Specimens: A total of 20 cadaveric hip specimens were included in the study. Specimens with prior hip surgery, severe degenerative changes, or obvious trauma were excluded.

Dissection Procedure: Each specimen underwent careful anatomical dissection to identify the arterial supply to the femoral head. The course of the medial circumflex femoral artery, lateral circumflex femoral artery, and artery of the ligamentum teres was documented. The number of retinacular vessels and their branching patterns were recorded.

Data Analysis: Data were summarized using descriptive statistics including frequency and percentage distribution. Basic comparative analysis was performed to evaluate variability in vascular patterns.

Results

Table 1: Distribution of Primary Arterial Supply

Arterial Source	Number (n=20)	Percentage
Dominant MCFA	17	85%
MCFA + LCFA contribution	2	10%
Prominent ligamentum teres artery	1	5%

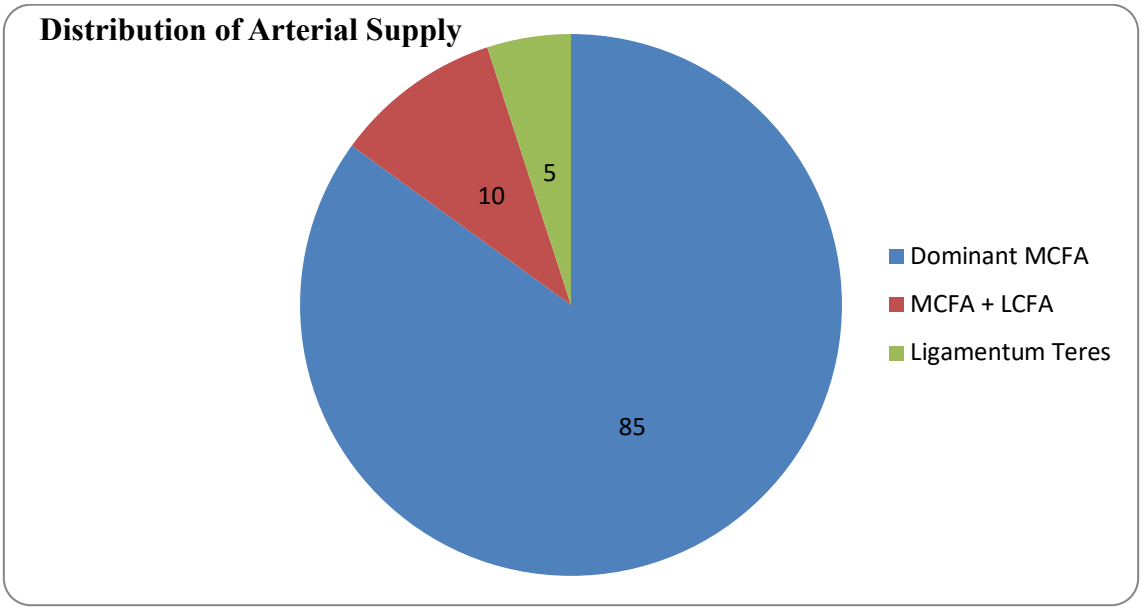

Figure 1: Distribution of Arterial Supply

Narration: The medial circumflex femoral artery (MCFA) was identified as the principal vascular source in the majority of specimens (85%). This confirms the widely accepted anatomical concept that the MCFA is the dominant contributor to femoral head perfusion. A combined supply from both MCFA and LCFA was observed in 10% of specimens, indicating the existence of collateral circulation in certain individuals. Only one specimen showed a prominent ligamentum teres artery contribution, supporting the view that this vessel usually plays a supplementary rather than primary role in femoral head blood supply.

Table 2: Variation in Number of Retinacular Vessels

Retinacular Branches	Number of Specimens	Percentage
2–3 vessels	6	30%
4–5 vessels	9	45%
>5 vessels	5	25%

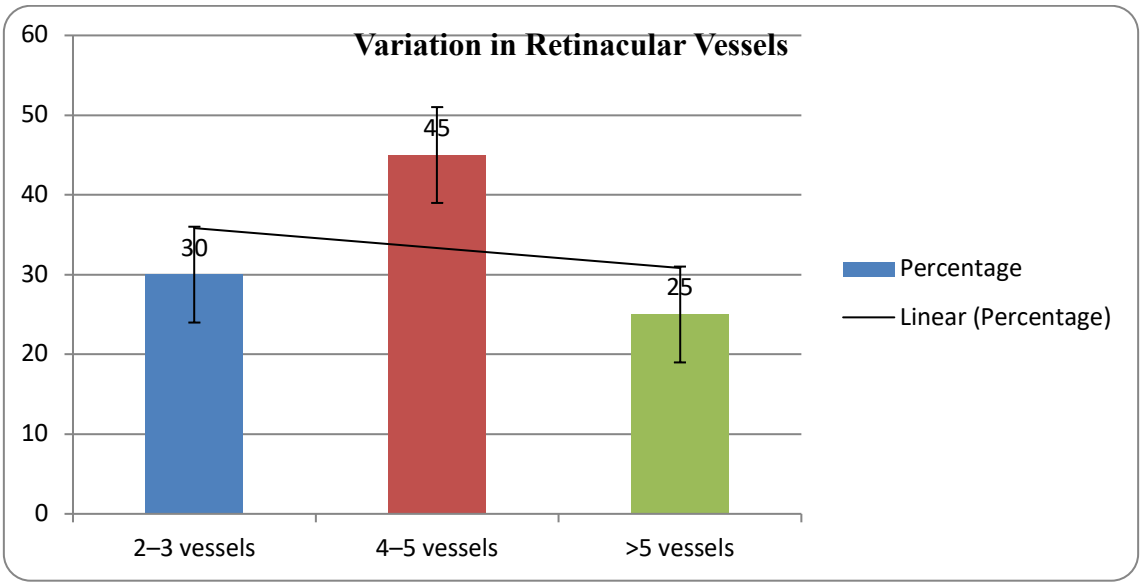

Figure 2: Variation in Retinacular Vessels

Narration: Considerable variability was observed in the number of retinacular vessels supplying the femoral head. The most frequent pattern involved four to five retinacular branches (45%). Specimens with fewer vessels (2–3) accounted for 30% and may represent individuals with lower vascular redundancy. Conversely, 25% of specimens demonstrated more than five branches, indicating a richer vascular network which may provide better protection against ischemic injury.

Table 3: Summary of Vascular Redundancy Categories

Vascular Pattern	Specimens	Percentage
Low redundancy (≤3 vessels)	6	30%
Moderate redundancy (4–5 vessels)	9	45%
High redundancy (>5 vessels)	5	25%

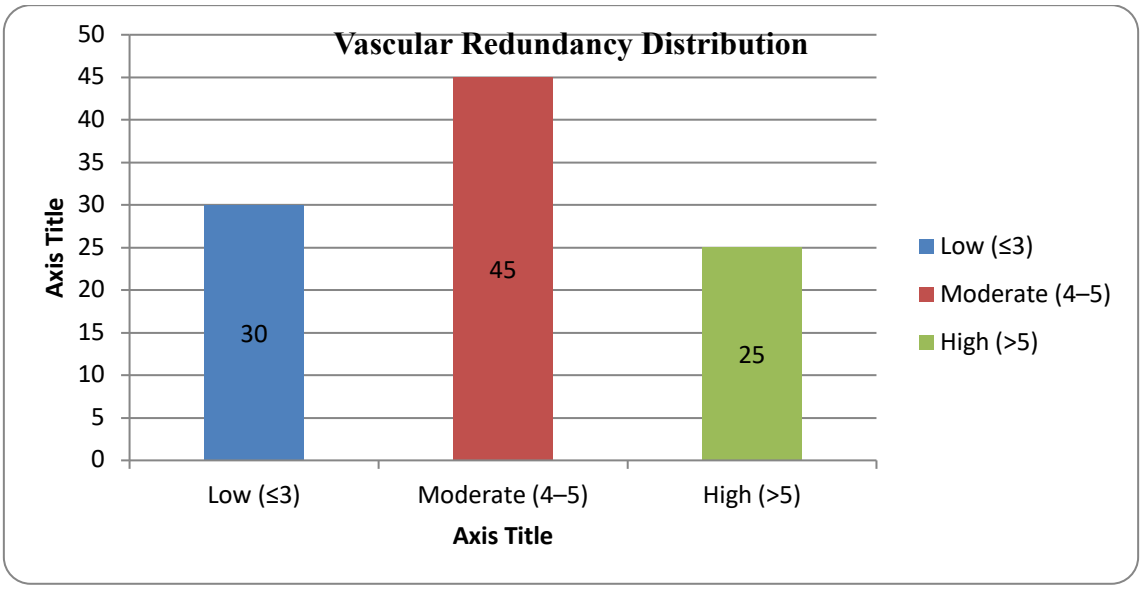

Figure 3: Vascular Redundancy Distribution

Narration: When grouped according to vascular redundancy, most specimens demonstrated moderate redundancy (45%). Low redundancy patterns were present in 30% of specimens and may represent individuals at higher theoretical risk of compromised femoral head perfusion if vascular injury occurs. High redundancy patterns were observed in 25% of specimens and may provide greater collateral circulation.

These statistical observations indicate that while the MCFA is consistently the main arterial source, the degree of collateral vascularization varies substantially among individuals. Such anatomical variation may partly explain differences in susceptibility to avascular necrosis following femoral neck fractures.

Discussion

The present cadaveric investigation demonstrates that the medial circumflex femoral artery remains the dominant vascular source supplying the femoral head. These findings are consistent with classical anatomical studies (Trueta & Harrison, 1953; Gautier et al., 2000). However, significant variability exists in the number and distribution of retinacular vessels, suggesting differences in vascular redundancy between individuals. Variation in retinacular vessel density may have important clinical implications. Individuals with fewer vessels may possess reduced vascular reserve, making them more susceptible to ischemic complications following trauma or surgical injury (Gosselin et al., 2015). Conversely, specimens with multiple retinacular branches may benefit from increased collateral circulation.

The artery of the ligamentum teres was present in all specimens but rarely served as the dominant supply, supporting previous literature suggesting its secondary role in adults (Novais et al., 2015).

Conclusion

The medial circumflex femoral artery remains the principal arterial supply to the femoral head.

However, substantial anatomical variability exists in retinacular vessel number and vascular redundancy. Recognition of these variations is important for surgical planning and may help reduce the risk of avascular necrosis during hip surgery and fracture fixation.

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