

Analysis of Femoral Head Microstructure and Vasculature Relevant to Legg-Calve-Perthes Disease

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Purpose: Legg-Calve-Perthes disease is an idiopathic avascular necrosis of the proximal femoral epiphysis. Interestingly, even in milder cases of Perthes, the anterior epiphysis collapses most reliably rather than the more weight-bearing lateral quadrant. The purpose of this study is to investigate whether there is a vascular or microstructural predisposition for anterior femoral epiphyseal collapse in Legg-Calve-Perthes Disease.

Methods: Thirty-two cadaveric proximal femoral epiphyses from 17 subjects (age 4-14 years old) underwent microcomputed tomography at 10-micron resolution. Specimens were divided into anterior, posterior, medial, and lateral quadrants. Vascular channels entering near the posterolateral epiphyseal tubercle (from the medial femoral circumflex artery) and at the ligamentum teres footprint (from the ligamentum

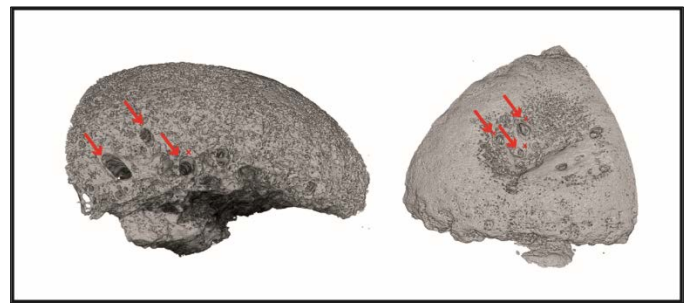


Figure 2. Prominent vascular channels (arrows) were primarily identified at two conserved locations: the medial femoral circumflex vessels at the posterior aspect of the lateral quadrant (left); and the ligamentum teres vessels in the fovea at the posterior aspect of the medial quadrant (right).

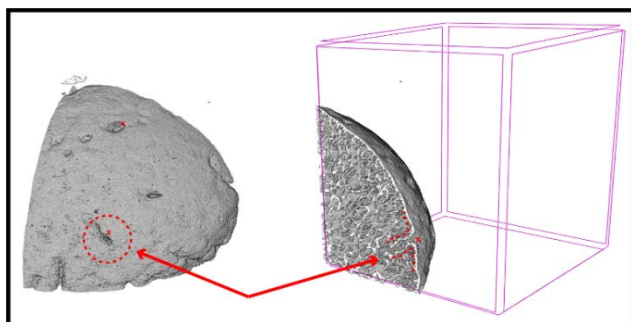


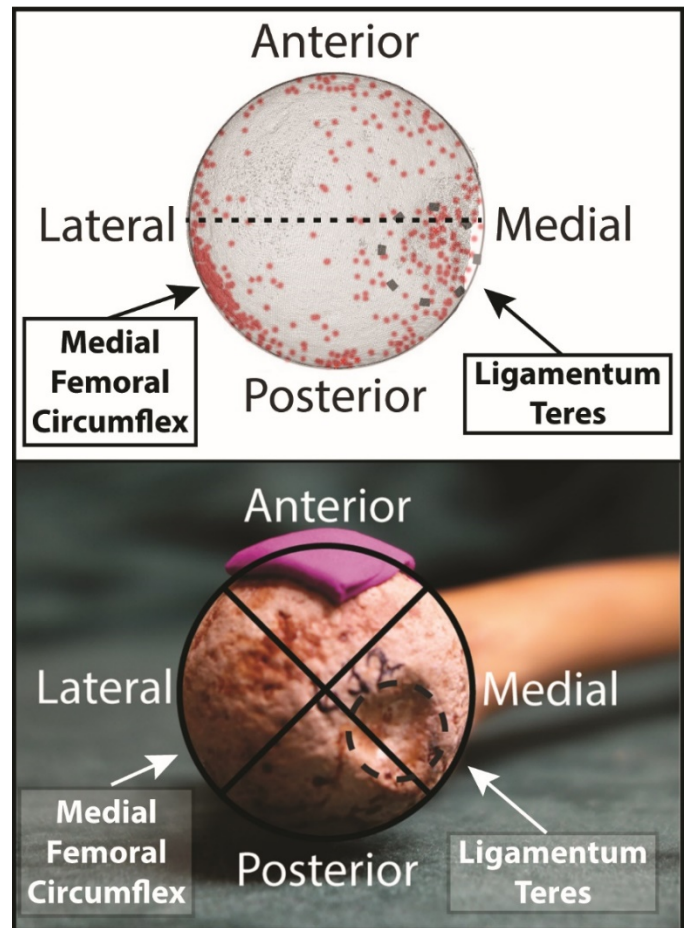
Figure 1. Vascular channels (arrows) were initially identified by correlating surface topography (left) and cross-sectional imaging (right) which demonstrated penetration of the channel into the epiphysis.

teres vessels) were identified by correlating surface topography with cross-sectional imaging. Each quadrant was then analyzed for four surrogate markers of trabecular bone strength: Bone Volume/Total Volume (BV/TV), Trabecular Thickness, Trabecular Separation, and Trabecular Number. Results: One-way ANOVA revealed a significant difference between the quadrants in trabecular microstructure and vascular patterns ($p < 0.001$). The medial quadrant had the lowest BV/TV, trabecular number, and the greatest trabecular separation ($p < 0.01$ for each), consistent with the fact that the medial quadrant is the least weightbearing. However, there was no significant difference between the anterior and lateral quadrants for any of the four surrogate markers of bone strength. 32/32 (100%) specimens demonstrated vascular channels from the medial femoral

Figure 3. Aggregate mapping of each vascular channel (top, red dots) onto a best fit circle representing a standardized epiphysis reveals that both the medial femoral circumflex and the ligamentum teres vessels enter the epiphysis posterior to midline (dashed line). These findings suggest a posterior-dominant blood supply to the capital femoral epiphysis. Cadaveric specimen (bottom) included for reference.

circumflex artery penetrating the posterior aspect of the lateral quadrant. Ligamentum teres vascular channels were visualized in the medial epiphysis in 26/32 (81%) specimens overall and 11/16 (68%) subjects aged 4-8 years. Paired samples t test revealed that the posterior half of the epiphysis had significantly more vascular channels than the anterior half (8.7 ± 4.0 vs 3.4 ± 3.1 vascular channels, $p < 0.001$). Vascular channel mapping illustrated the predominance of vessels in the posterior half of the epiphysis with both the ligamentum teres (medial quadrant) and the medial femoral circumflex vessels (lateral quadrant) entering the epiphysis at the 4 and 8 o'clock positions, respectively.

Conclusions: The lack of microstructural differences between the anterior and lateral quadrants, and the predominance of vascular channels in the posterior half of the epiphysis, suggest that the anterior femoral epiphysis may be a relative vascular watershed region which predisposes it to collapse after the vascular insult of Legg-Calve-Perthes.



Significance: This is the first study to utilize micro-computed tomography to examine trabecular microarchitecture and map vascular channels in the developing human femoral epiphysis.