Ethnic Differences in Femoral and Acetabular Version in Developmental Dysplasia of the Hip: A 3D CT-Based Comparative Study of Japanese and Caucasian American Cohorts

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INTRODUCTION: Developmental dysplasia of the hip (DDH) is associated with variable patterns of acetabular and femoral orientation that influence hip mechanics and surgical planning. While femoral version (FV), acetabular version (AV), and their sum—combined version (CV)—are known to affect impingement risk, how these parameters distribute across populations with DDH remains unclear. We aimed to clarify: (1) whether Japanese and Caucasian American patients with DDH differ in FV, AV, and CV; (2) how FV–AV distribution patterns compare between populations; and (3) which morphological factors most strongly explain interethnic differences.We hypothesized that ethnic groups would show different FV–AV distributions and that Japanese patients would have higher FV and CV.

METHODS: Following IRB approval, we conducted a retrospective, two-center, propensity-matched cohort study of 110 hips (55 Japanese, 55 Caucasian American; 94.5% female; mean age ≈25 years) with symptomatic DDH undergoing periacetabular osteotomy (PAO). Preoperative CT scans were analyzed using a validated CNN-enabled 3D pipeline (VirtualHip™, Boston Children's Hospital) to quantify FV (Murphy method) and AV (central and proximal). CV was calculated as FV+AV. FV and AV were categorized as decreased (<10°), normal (10–25°), or increased (>25°). Group differences were tested using t/Mann–Whitney and χ^2/Fisher's exact tests, with α=0.05.

RESULTS: Acetabular depth was greater in the American cohort, but AV and center-edge angles did not differ between groups. Japanese patients demonstrated significantly higher FV (mean difference +5.5°, $P < 0.05$) and CV (mean difference +5.5°, $P < 0.05$). FV–AV distribution patterns diverged markedly ($P = 0.0031$): increased FV (>25°) was more prevalent among Japanese patients (65.5% vs 40.0%), while normal FV (10–25°) and decreased FV (<10°) were more frequent in Americans (49.1% vs 29.1% and 10.9% vs 5.5%, respectively). The dominant pattern in Japanese patients was normal AV with increased FV (45.5%), whereas Americans most commonly showed normal AV with normal FV (36.4%). Despite these shifts, the overall FV spectrum overlapped across populations.

DISCUSSION: We demonstrated that ethnic differences in DDH morphology are driven primarily by femoral version rather than acetabular orientation. Japanese patients presented with higher FV and CV and a skewed distribution toward increased FV, while American patients clustered around normal FV with a higher prevalence of decreased FV. Because AV was comparable, CV differences arose almost entirely from FV. These findings underscore the need to explicitly account for FV–AV combinations when planning PAO, anticipating posterior extra-articular impingement in high-FV hips and anterior impingement risk when FV is low. In such scenarios, combined surgical strategies, including femoral (de)rotation, may be required.

SIGNIFICANCE: Interethnic differences in DDH are morphology-driven, with FV—not AV—underpinning disparities in CV. This highlights the importance of tailoring PAO planning to individual femoral version patterns, ensuring that derotational strategies are incorporated when indicated to optimize functional outcomes.

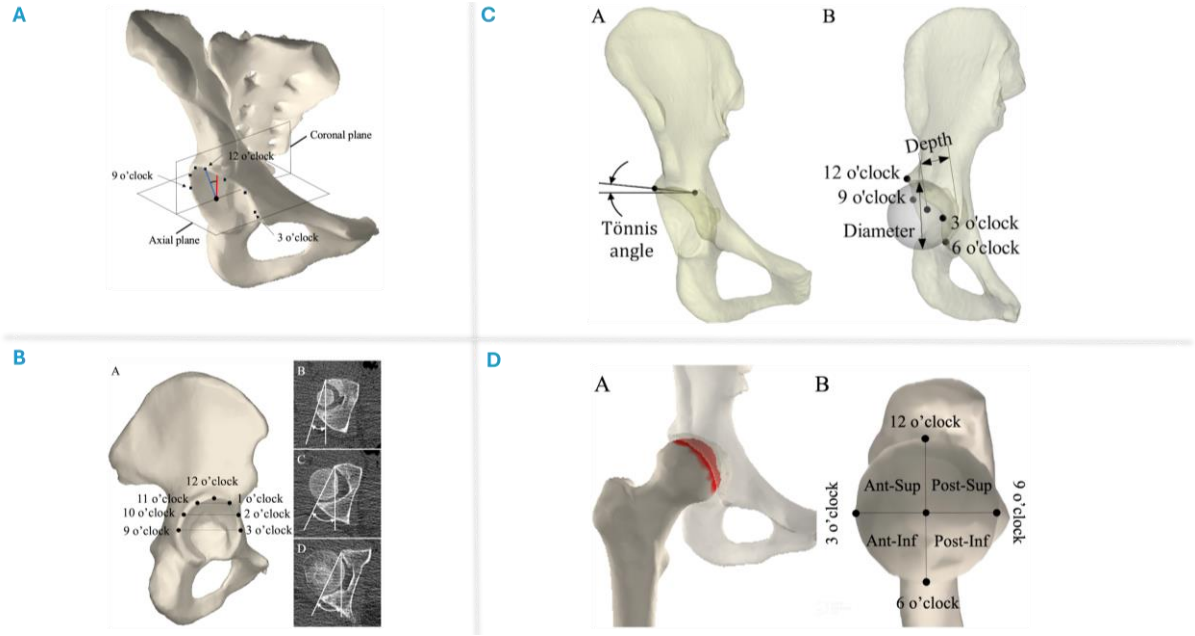

Figure 1: (A) The center-edge (CE) angle is defined at each clock position as the angle between the line from the femoral head center to the acetabular clock face and its sagittal plane projection. **(B)** Acetabular version (AV) is defined as the angle between the line connecting the anterior and posterior rims of the acetabulum and its projection onto the sagittal plane. **(C)** The Tönnis angle and Acetabular diameter measurements. **(D)** (A) Hip coverage (B) Femoral head coverage was quantified as the percentage of total surface area covered, either overall or within four quadrants: anterior-superior (12–3 o'clock), anterior-inferior (3–6 o'clock), posterior-inferior (6–9 o'clock), and posterior-superior (9–12 o'clock). Ant-Sup = anterior-superior; Ant-Inf = anterior-inferior; Post-Inf = posterior-inferior; Post-Sup = posterior-superior.