Femoro-Acetabular Impingement is Caused by Several Different Bony Abnormalities

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Introduction: Osteochondroplasty of the anterior head-neck junction is often performed to treat femoro-acetabular impingement (FAI) on the assumption that the underlying deformity is inadequate anterior offset of the femoral head. However, other morphologic abnormalities, including reduced anteversion, posterior slip, and widening of the neck can all cause loss of joint motion. In this study we examine whether the impinging femur is a mixture of each of these abnormalities, or whether each abnormality is distinct, suggesting that individualized treatments may be needed for successful outcomes.

Materials and Methods: Sixty-six cadaveric femora (30 male and 36 female, average age: 76 years) were obtained from a large osteologic database. Thirteen femora were morphologically normal and 53 were abnormal with the following distribution of primary deformities: Cam-type FAI (Ganz) (n=15), Posterior slip (n=22) and Retroversion (n=16). Computer models were generated by reconstructing high-resolution CT scans of each femur. Each 3D model was segmented into bodies corresponding to the head, the neck, and the diaphysis. Axes and coordinate systems were derived for each anatomic body. Multiple morphologic measurements were taken to describe the shape of each anatomic body and its relationship to the rest of the femur. Additional parameters included the α angle, the β angle, the anterior offset ratio (OSR), the anterior head-neck ratio, the posterior ‘slip’ of the femoral head, the neck shaft angle and the femoral neck anteversion.

Femora with anteversion of 5° or less were grouped in the Retroverted category. Those femora with more than 2 mm of posterior head slip constituted the Post-slip grouping. The morphologies and their determinants were analyzed using one-way ANOVA comparisons with Fisher’s post hoc significance testing.

Results: There were highly significant differences between the head-neck ratio (p=0.006), OSR (p=0.006), α angle (p=0.0001) and Dunn α angle (p=0.0007) of the FAI femora compared to the Normal group. The β angles between the two groupings trended towards significance (p=0.014). Normalized by head diameter, FAI femora had a larger anterior neck radius (p=0.004) but nearly equivalent anterior head radii (p=0.7). FAI femora also had less anteversion than the controls (p=0.0002) but did not demonstrate significant posterior slip (p=0.4).

The Normal and Post-slip groups did not demonstrate any significance with respect to anteversion angles (p=0.9) or β angles (p=0.8). The α angle and the Dunn α angle (p=0.0001 and p=0.0001), head-neck ratio and OSR (p=0.003 and p=0.0001) between the two groupings were all highly significant. The normalized anterior neck radii were significantly different (p=0.003) as were the normalized anterior head radii (p=0.0001).

The difference between the Post-slip and FAI α angle and Dunn α angle displayed no significance (p=0.2, p=0.7). No difference was found between the head-neck ratio either (p=0.99). The normalized anterior neck radius of the FAI mirrored that of the normalized Post-slip anterior neck radius (p=0.8). However, the Post-slip femora had significantly smaller anterior head radii (p=0.0001). The FAI femora’s α/β ratio was significantly smaller than the Slip specimen’s ratio (p=0.005). Finally, the Retroverted morphology possessed significantly higher neck-shaft angles than the Normal cohort (p=0.006) but did not demonstrate any other significant differences.

Discussion: The Cam-type FAI femur has a distinct morphology defined by a spherical femoral head centered on a globally thickened femoral neck with decreased anteversion. In contrast, femora with a post-slip deformity have a tapered anterior neck in addition to posterior displacement of the femoral head without abnormal anteversion. Furthermore apart from changes in anteversion, the proximal morphology of the retroverted femur is indistinguishable from bones of normal anatomy.

This study suggests that the occurrence of FAI with internal rotation of the femur can arise from several unique morphologic abnormalities, not present in the Cam-type FAI femur. This supports the conclusion that a critical step in the treatment of FAI is identification of the true nature of the underlying deformity prior to possible surgical intervention to avoid unsatisfactory outcomes.