**Introduction:** The anatomical analysis of the proximal femur has been the focus of many studies over the past 3 decades [1,2,3]. The understanding of the relationships between key anatomical landmarks is critical in understanding the requirements of total hip arthroplasty (THA) devices with respect to profile, geometry, restoration of the natural anatomy and ultimately function. Anatomical studies to date have generally focused on the aspects of geometry associated with prosthetic hip function and biomechanics, such as shaft size and positioning, and offset. This study investigated the natural anatomy of three different cohorts of patients by making use of advanced CT analysis techniques in order to identify relationships that may exist between femoral head and neck geometries.

**Materials and Methods:** A total of 102 pelvic CT scans were acquired for surgical treatment of the arthritic hip. The data was then anonymised and supplied for analysis. The patient cohort comprised Caucasian females (n=30), Caucasian males (n=28) and Japanese females (n=29). To permit analysis of the CT scans, a manual scan preparation was performed to identify key anatomical landmarks. This manual preparation included the identification of the following:

- **Shaft axis:** pairs of straight lines outlining the proximal femoral shaft (outer cortical bone surface) were marked on each slice of the CT image and the corresponding medial line calculated. A plane was fitted to the medial lines for all slices using both sagittal and coronal views. The line of intersection of the two planes was then calculated and used to define the proximal femoral shaft axis.

- **Neck axis:** a similar method was used to identify the femoral neck axis to that used for the femoral shaft. However, in the case of the neck, the inner contour of the cortical bone was used as this provided a clearer visualisation of the axis.

- **Head centre:** the femoral head was identified on a 3D rendering of the outer cortical surface for each patient and a sphere fitted. This sphere defined both the centre and diameter of the femoral head.

The CT mark-up procedure described above produced for each patient: a shaft axis vector, a neck axis vector, a head centre and a head diameter. From these measurements the displacement (magnitude and direction) of the head centre with respect to the neck axis and the displacement of the neck axis with respect to the shaft axis were derived.

**Results:** The results of the analysis indicated that mean head diameter for the three cohorts of patients was 46.5 ± 0.8mm (95% C.L). Male mean head diameter was significantly greater than the female group (p<0.05), however, despite the Caucasian female mean head diameter being larger than the Japanese group, no significant differences were observed (p>0.05). Head centre position was identified as not being co-aligned with the axis of the femoral neck, but was instead displaced primarily posteriorly and secondarily in the superior direction relative to the neck (Figure 1). Mean neck-head distance was 2.8 ± 0.4mm (95% C.L.) and mean neck-head angle was 13 ± 12 (95% C.L.) degrees when measured using the femoral shaft axis as the superior-inferior axis. Neck-head distance was in general smaller for the female Caucasian group when compared with the male group; however, this difference was not statistically significant (p>0.05).

**Discussion:** This study quantitatively analysed the anatomy and geometrical relationships of key landmarks of the proximal femur in the arthritic hip. The analysis identified that, irrespective of patient cohorts, the femoral neck was positioned anteriorly with respect to the femoral shaft axis whereas the femoral head was primarily positioned posterior to the axis of the neck. This posterior positioning of the femoral head contradicts the general understanding of head centre and neck axis co-alignment and may have significant implications for the design of THA devices.

**References:**

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**Figure 1 – Neck-head vector resolved into A-P and I-S components**

Analysis of the neck-shaft relationship indicated a statistically significant (p<0.05) anterior positioning of the neck by 5.1 ± 0.4mm (95% C.L.), however, no significant relationships were identified between any neck or head positioning-related parameter and head diameter (p>0.05).