Introduction

- Cam femoroacetabular impingement (FAI) is characterized by a malformed femoral head or reduced concavity of the femoral head-neck junction that may cause altered mechanics and hip osteoarthritis (OA).1
- Radiographic measurements to diagnose cam FAI often assume the ideal femur shape to be spherical and cannot indicate the exact location and size of a lesion or the amount of surgical resection required to normalize anatomy.
- Statistical shape modeling (SSM) can objectively compare complex 3D femoral morphology without the need to assume ideal geometry.
- SSM applied to cam FAI may improve our understanding of the FAI disease spectrum and allow more exact diagnoses through quantitative comparison of individual patients to objectively determined healthy and cam FAI femurs.

Objective

- Generate accurate 3D reconstructions of femoral heads from volumetric CT images and apply SSM to quantify 3D variation and morphologic differences between femurs with and without cam FAI.

Methods

Subject Selection

- 30 patients with cam FAI (IRB # 56086, 1024270)
  - Demographics (mean±SD): 27±8 yrs, 84±15 kg, 1.81±0.08 m, 25.6±4.3 kg/m² BMI.
  - Presented with hip and groin pain, tested positive for FAI during clinical exam, had radiographic evidence of FAI, were scheduled for hip preservation surgery.
- 41 control femurs (15 live volunteers, 26 cadavers)
  - Screened for cartilage damage and bony abnormalities.
  - Demographics (mean±SD): 31±10 yrs, 80±18 kg, 1.77±0.08 m, 25.4±5.5 kg/m² BMI.
- Radiographic characterization with α-angle and head-neck offset in frog-leg lateral view2
  - Patients: α-angle = 68.4±15.6°, head-neck offset = 4.4±1.7 mm.
  - Controls: α-angle = 43.0±5.2°, head-neck offset = 7.3±1.6 mm.

Results

- Hotelling $T^2$ test demonstrated significant difference between control and cam FAI mean shapes ($p<0.001$).
- Mean cam FAI shape protruded above the control mean by a maximum of 3.3 mm in the anterolateral head neck junction (Fig. 3).
- Sustained protrusions of 2.5-3.0 mm distributed from anterior-posterior midline of femoral neck along anterolateral head-neck junction and distally along anterior neck.
- First 12 modes (i.e. principal components) captured 90% of cumulative variation among femurs. First 6 modes captured statistically significant variation (i.e. 83.8% of variation) (Fig. 4).

Discussion

- Location of maximum differences between control and cam FAI mean shapes corresponded well with reports of cam lesion locations and chondrolabral damage.5
- Individual cam FAI cases could be compared to mean normal shape to delineate the amount and location of tissue necessary to debride (Fig. 5).
- SSM confirmed known locations of deformities; it also suggested that the distance between the greater and lesser trochanters was different between groups (possibly due to some developmental deformity) - which has not been described to date. SSM could be used to develop new measurements of anatomy previously unknown to be pathologic.
- Use of SSM for cam FAI in the clinical setting could improve understanding of femoral morphology, provide more exact diagnoses, and improve pre-operative planning.

References