Femeroacetabular Impingement

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INTRODUCTION: The pathomechanism of hip pain and hip osteoarthritis is multi-factorial. One probable mechanism is femoro-acetabular impingement. “Cam” impingement results from abnormalities on the femur, in the form of a non-spherical femoral head or a protuberance extending from the head towards the femoral neck. When the femur flexes, this contacts the labrum on the acetabular rim, impinges and eventually enters the acetabulum, deforming the acetabular cartilage. The “pincer” type impingement occurs due to over-coverage of the femoral head by a deep acetabulum. In this case, the normal femoral neck impinges against the labrum during flexion, compressing and deforming the labrum. In contrast to the pincer type joint, the dysplastic pathological joint is the result of an insufficient coverage of the femur head, which leads to high pressures across the small acetabular roof. Joint preservation surgery is an option to restore normal hip geometry. A comprehensive knowledge of hip function and the stress distribution inside the normal and pathological joints can help to identify critical regions and provide a scientific basis for surgical planning. The goal of our ongoing work is to simulate the influence of hip joint morphology on the internal mechanical environment of the joint, to evaluate the hypothesis that impingement or dysplasia may be biomechanical precursors to joint degeneration.

METHODS: The geometries of normal and pathological joints were simulated, based on standardized morphometric measures. The most appropriate parameter to define the morphology of a cam type pathological joint is the alpha (α) angle, defined as the angle between the line from the head center to the center of narrowest part of the neck, and the line connecting the head center to point at which the femoral head becomes aspherical. For the normal joint, this is approximately 40°, but for pathological joints may vary between 60° - 90°. The center-edge (CE) angle is defined as the angle in the frontal plane between the vertical line through the femoral head center and the line from the center of the femoral head to the acetabular rim. A normal CE angle is about 25°. A CE angle of less than 15° is associated with the dysplastic hip and a CE angle of greater than 35° is characteristic of a pincer type joint. Joint models were developed with CE angles of 40°, 35°, 30°, 25°, 20°, 15°, 10°, 5°, and 0°. The cam type joints were developed with alpha angles of 80°, 70°, 60° and 50°. The diameter of the femoral head was 50mm, with a cartilage thickness of 2 mm. Loading and kinematic data for daily activities of stance, walking and sitting down were derived from in vivo measurements. The material properties were extracted from literature values.

RESULTS: It was observed that changing the CE angle results in a shift of the regions of high shear stress within the cartilage layers. For low CE angles, a zone of high shear stress occurs near the acetabular rim, where labrum hypertrophy and calcification occurs for dysplastic joints. For large CE angles increasing to normal (about 25°), the area of high shear stress is reduced, as well as peak stress values. Increasing the CE angle to 40° leads to high shear stresses in the antero-lateral portion of the acetabulum, where the acetabular cartilage connects to the labrum. During motion, regions of high shear stresses are observed for both the cam and pincer joints, initiating at the labrum where it is being impinged and spreading to the acetabular cartilage, at the interface where it connects to the labrum.

DISCUSSION & CONCLUSIONS: Regions of high intra-articular shear stresses observed for low CE angle (i.e. dysplasia) and for impingement cases are relevant and correspond with clinical findings of region-specific cartilage delamination or calcification. This study highlights a safe range for the alpha and CE angles, in which the hip joint can function without a heterogeneous articular loading or local cartilage stress concentrations. The results of such simulations can provide guidance for the preoperative planning of joint preservation surgery, to determine target values for post-operative joint morphology.

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