COMPARISON OF HIP MORPHOLOGY IN FEMOROACETABULAR IMPINGEMENT AND NORMAL PATIENTS

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INTRODUCTION

Femoroacetabular impingement (FAI) is characterized by abnormal hip joint morphology that causes friction between the acetabulum and femur and can lead to osteoarthritis [1]. Hip degradation can be caused by variations in size, shape, and orientation of either the proximal femur or the acetabulum, or a combination of both [1-3]. Types of FAI include cam impingement due to abnormal femoral head shape and pincer impingement characterized by variations in acetabular morphology that result in over coverage of the femur. Previous studies have quantified the 3D morphology of normal hips and compared 3D and 2D hip measures [4-5]. The objective of this study was to quantify the 3D geometry of the acetabulum and femur in FAI and normal hips and determine morphological differences between these two groups.

METHODS

Computed tomography (CT) scans of 48 patients with FAI and 35 normal patients were analyzed. The FAI patients consisted of 24 females and 24 males (mean age: 29) with FAI classified as cam only, pincer only, cam and pincer, or non-cam and non-pincer. The normal patients consisted of 15 females and 20 males (mean age: 33). The acetabulum and femoral head of each hip were segmented using a semi-automated technique and 3D models were created (Figure 1). To calculate acetabular volume, a line was drawn to enclose the acetabulum (Figure 2, left) and the acetabular space occupied by the femoral head was filled (Figure 2, center). The original acetabulum mask was then subtracted to compute the acetabular volume (Figure 2, right).

RESULTS AND DISCUSSION

Significantly higher acetabular volume, overlapping surface areas, and femoral coverage measurements were found in FAI hips compared to normal hips with a Student’s t-test analysis (Table 1). These differences were significant even when gender was controlled, which further suggests the 3D measurements are capturing true differences in FAI and normal hip joint morphology.
A one-way ANOVA analysis was used to investigate morphological differences with differing types of FAI. Significantly higher acetabular volumes and areas of the acetabulum overlapping the femoral head in cam only impingements were found compared to normal hips ($p = 0.0040$ for each test).

Larger areas of the femoral head overlapped by acetabulum were found in the cam only and the cam and pincer groups compared to the normal group ($p = 0.0004$ and $0.0323$). The area of femoral head overlapped by the acetabulum was also significantly larger in the cam only group compared to the non-cam and non-pincer group ($p = 0.0287$).

Increased percent femoral head coverage was observed in all FAI groups compared to the normal group ($p = <0.0001$ for the cam only, pincer only, cam and pincer, and non-cam and non-pincer comparisons). The percent femoral head coverage was also significantly larger in the cam only group compared to the non-cam and non-pincer group ($p = 0.0006$).

The methodology employed in this study can be used to quantify morphological hip pathologies and could provide additional information for borderline FAI and acetabular dysplasia patients. While the method is more time consuming than traditional 2D measures, it eliminates parallax and allows for 3D overlap at the hip joint to be directly measured which is of clinical significance.

### CONCLUSIONS

This study presents a systematic method to quantify 3D hip joint morphology from CT scans of FAI and normal patients. Comparisons of acetabular volume, areas of overlap at the acetabular-femoral interface, and percent femoral head coverage found significantly higher values in FAI hips compared to normal hips.

Significant differences in hip joint morphology between different classifications of FAI and the normal hips were also detected. Overall, results suggest over coverage of the femoral head by the acetabulum in FAI hips compared to normal hips. The methodology and results of this study will assist clinicians in the diagnosis of hip abnormalities such as FAI. Characterization of hip joint morphology also assists surgeons in planning and performing surgeries to correct hip abnormalities such as FAI.

### REFERENCES


### Table 1: Results of t-tests comparing means of FAI and normal hip morphological measurements.

<table>
<thead>
<tr>
<th></th>
<th>Acetabular volume (cm$^3$)</th>
<th>Acetabulum overlapping femoral head (cm$^2$)</th>
<th>Femoral head overlapped by acetabulum (cm$^2$)</th>
<th>Percent femoral head coverage</th>
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<tbody>
<tr>
<td>FAI (mean)</td>
<td>32.982</td>
<td>38.06</td>
<td>28.66</td>
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<td>Normal (mean)</td>
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<td>p-value</td>
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<td>0.0052*</td>
<td>0.0006*</td>
<td>&lt;0.0001*</td>
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