# SUBJECT-SPECIFIC FEMOROACETABULAR IMPINGEMENT SEVERITY COMPUTATIONAL ASSESSMENT OVER VARIOUS ACTIVITIES

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## Introduction

Femoroacetabular impingement (FAI) is associated with specific shape features of the hip joint and has been shown to increase the chances of developing osteoarthritis [1]. People with cam-type FAI are subject to repeated contact between excessive femoral bone and the acetabular rim, which can result in soft tissue damage in the acetabulum. This study aims to demonstrate the ability of a computational shape-motion model of cam-type FAI to differentiate impingement severity in a set of cam patients.

## Methods

Patient-specific bony shape features were extracted for 20 clinically diagnosed cam-type hips (10 males and 10 females, age range 22-49 years) [2]. Points representing the acetabular rim and the femoral cam lesion were extracted from segmented three-dimensional CT images. These points were used as inputs to an existing computational impingement model [3], where 126 motion cases were applied. Motion cases included 14 hip activity motions, each completed by nine volunteers. The activities included variations of walking, sitting, squatting, lunging, cycling and a golf swing. The relative position of the acetabular and cam points was defined based on population average hip orientation from literature. The modelling assumption was that any overlap of the acetabular and cam points during a motion indicated that impingement had occurred. For each subject, the metrics recorded were: the total number of motion cases where impingement occurred (out of 126); and the maximum depth of impingement into the acetabular, averaged over all of the motion cases where impingement occurred. Depth was recorded in terms of the angle between the neck-cam and acetabular rim points. Mean depths for activities registering a singular impingement were not calculated.

## Results

All subjects showed evidence of impingement, with the number of motion cases generating impingement varying from two (out of 126) to all 126 (Table 1). The mean maximum impingement depth for most subjects was within the range of 4°-10°. Just one subject had a much higher mean maximum depth of 22°. The hip that produced the highest depth possessed the largest cam alpha angle. Qualitatively, predicted impingement location varied with subject cam lesion location (Figure 1). Areas of predicted impingement displayed a greater proportion of anterior impingement from anterior cams, and a greater proportion posteriorly from superior cams.

| PC | IF (/126) | Depth, mean ± stdev (°) | PC | IF (/126) | Depth, mean ± stdev (°) |
|---|---|---|---|---|---|
| **53L** | 126 | 22 ± 8 | **38L** | 26 | 5 ± 4 |
| **17L** | 119 | 6 ± 5 | **34L** | 25 | 8 ± 7 |
| **33L** | 86 | 8 ± 5 | **18R** | 22 | 5 ± 3 |
| **75L** | 81 | 10 ± 6 | **27R** | 21 | 5 ± 4 |
| **02R** | 75 | 6 ± 5 | **79L** | 15 | 4 ± 4 |
| **01R** | 60 | 6 ± 4 | **28L** | 8 | 4 ± 2 |
| **11R** | 57 | 6 ± 4 | **09R** | 4 | |
| **16R** | 49 | 5 ± 4 | **22R** | 3 | |
| **06R** | 45 | 4 ± 4 | **81L** | 2 | |
| **07R** | 28 | 4 ± 3 | **51L** | 2 | |

*Table 1 – Patient-specific predicted impingement frequency and depth. (PC = patient code, IF = impingement frequency out of 126 possible cases).*

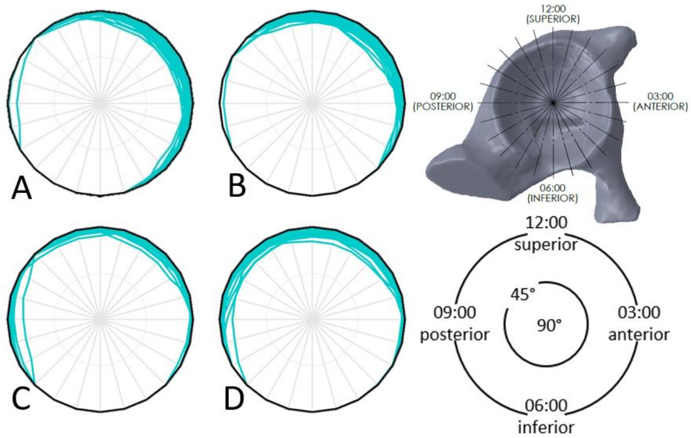


*Figure 1 – Clockface plots of the acetabulum of four subjects. Subject cam location is most anterior, A, progressing to most superior, D. Each line shows the impingement depth reached throughout a motion case.*

## Discussion

The results demonstrated the ability of the model to differentiate impingement severity in a set of cam patients. Impingement depth showed to be independent of cam location, congruent with a study using theoretical cams [3]. Whilst varying with cam location, it is unclear how impingement location mapping correlates to damage. The combination of higher impingement frequency and depth indicate greater impingement severity and potential for acetabular tissue damage.

## References

1. Ganz, R., et al., Clinical Orthopedics 417: 112-120, 2003.
2. Cooper, R, University of Leeds, 2017.
3. Jones, A, et al., ESB, June 26-29, 2022, Porto, Portugal.