

## INTRODUCTION

- Hemi-arthroplasty (HA) surgery was used in the management in 50% of urgent fractured neck femur between 2010 and 2016 in England. HA may be preferred due to reduced operative time, surgical specialism availability and lower complication rates, especially for multimorbid patients.
- Meta-analyses have shown that THA and HA result in similar outcomes.
- However, there has been limited investigation of cartilage erosion caused by the articulating femoral head against the natural acetabulum in HA, particularly under anatomical conditions. This hinders the development of alternative materials for this application.
- This study assessed cartilage surface changes in hip hemiarthroplasty using an experimental anatomical hip simulator that applied clinically relevant loads and motions.**

## MATERIAL AND METHODS

### Specimen preparation.

- Porcine hips (full joint / acetabulum)
- CoCr femoral heads

Acetabulum and femoral components were cemented so axes of rotation were coincident with the simulator.

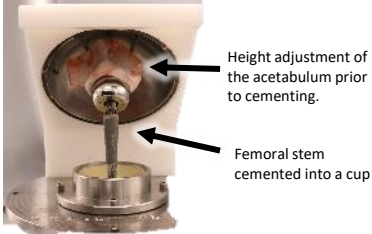


Figure 1. Specimen preparation

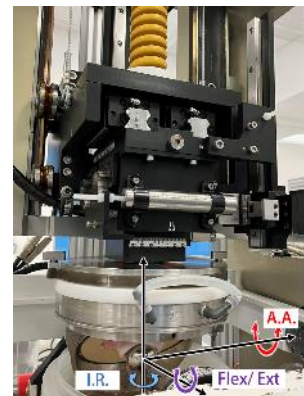


Figure 2. Anatomical Hip Simulator, indicating the axis of rotation of the joint at the COR

**Experimental design.** Natural acetabula were randomly distributed into three groups (n=4) based on radial clearance with the femoral component [see Table], and compared to natural joints

| GROUP  | Acetabulum Diameter (mm) | Femoral Head Diameter (mm) | Radial Clearance (mm) |
|--|--------------------------|----------------------------|-----------------------|
| Natural joint (natural head & cup)             | 42                       | 40.75                      | 0.63                  |
| HA - Small clearance (CoCr head / natural cup) | 39.25                    | 38.8                       | 0.13                  |
| HA - Large clearance (CoCr head / natural cup) | 39                       | 35.25                      | 1.88                  |

The acetabular cup was fixed to the simulator holder, and cup inclination adjusted so as clinically relevant.

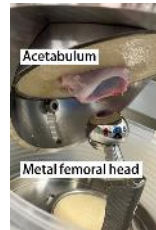


Figure 3. HA assembly during simulation

Ringers solution (0.04% sodium azide) was used as a lubricant throughout the simulation.

## ANATOMICAL HIP SIMULATOR

An electromechanical hip joint simulator (AHS) was used for experimental simulations.

Motion and loading profiles consisted of applying a simplified twin peak gait cycle adapted for porcine models from the ISO 14242 standard for wear of total hip-joint prostheses. This included:

- Twin peak axial load of 900N
- Flexion – Extension 20° to -30°
- Abduction – Adduction 4.8° to -8.8°
- Internal – External rotation 2° to -10°
- Simulation time: 6 hrs ( 21,600 cycles)
- Simulation Frequency: 1 Hertz

## RESULTS

### ARTICULAR SURFACE ASSESSMENT

Degradation of the cartilage and labrum were recorded by photogrammetry at 2-hr intervals for 4 hrs (control group) and at 1-hr intervals for 6 hrs (HA groups).

- In the control group, no changes were observed to the cartilage surface or labrum.
- Both hemi-arthroplasty groups showed a degree of damage to the articular cartilage (dotted line).

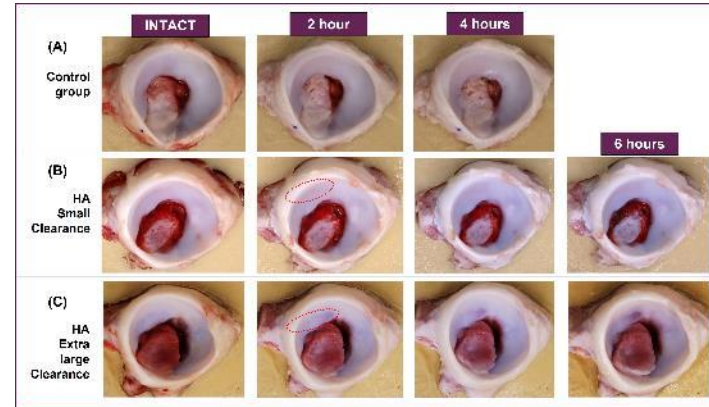


Figure 4. Comparison of cartilage degradation at time intervals

### COMPARISON BETWEEN HA GROUPS

After six hours of simulation:

Both groups presented discolouration and minor superficial scratches at the posterior-superior part of the acetabulum (Figures 4 and 5).

- HA - Small Clearance group**
  - The damage was towards the outer edge of the acetabulum.
  - No changes of colour occurred after the 1 hr of testing.
- HA - Extra-large clearance group**
  - The damage was located at the inner edge of the acetabular fossa
  - Discolouration increased every hour.

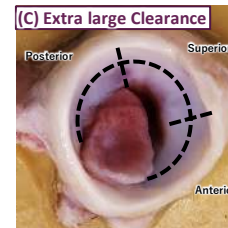
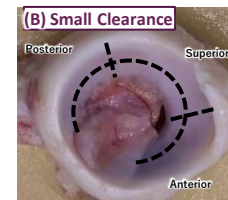
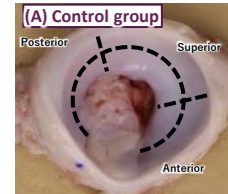


Figure 5. Cartilage degradation after testing completion

## DISCUSSION

- Hemi-arthroplasty was successfully experimentally simulated in clinically relevant conditions
- Photogrammetry showed that metal heads with similar dimensions to the natural head (smaller clearance) caused less damage to acetabulum surfaces compared to larger clearances group
- Future studies will aim to quantify cartilage degradation, extend the research to human cadaveric hips, and assess alternative candidate materials for hemi-arthroplasty.

## CLINICAL RELEVANCE

These results are relevant to understand the effect of the artificial femoral head size on cartilage wear under more approximate anatomical motion. Future work implementing the method in human cadaveric hips may help surgeons undertaking HA in selecting femoral heads.

### REFERENCES:

- Khan A. et al. Ann R Coll Surg Engl. 2019;101(2):86-92. doi:10.1308/rcsann.2018.0123.
- Ekhtiari S. et al, J Bone Jt Surg. 2020;102(18):1638-1645. doi:10.2106/JBJS.20.00226.
- Lizhang J. et al, Proc Inst Mech Eng [H]. 2013;227(12):1284-1291. doi:10.1177/0954411913502156



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