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CONTACT STRESS ANALYSIS IN OPENFOAM: APPLICATION TO HIP JOINT BONES

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contact stress analysis, hip joint, finite volume, finite element.

1 INTRODUCTION

Total Hip Arthroplasty is a surgical procedure that reforms the hip joint, replacing the pathological joint with an artificial prosthesis. Due to post-operative joint instability, complications such as dislocation are still a significant problem [1]. This research aims to develop a realistic numerical model of a healthy hip joint and examine its stability. An initial model of the hip joint simulating stance has been developed using a *homogenous* material model.

2 METHODS & RESULTS

A 23-year-old male subject was chosen with no congenital or acquired pathology of the hip joint. Computed tomography (CT) and magnetic resonance imaging (MRI) scans of the subject's hip joint were acquired. The 3D bone surface geometry was extracted from the scans using open-source software 3D Slicer. Volume meshing was performed using Ansys ICEM CFD and the OpenFOAM utility *polyDualMesh*. A finite volume contact stress solver implemented in OpenFOAM was employed. Initially a *homogenous* model was considered; the bone was assumed to be a homogenous isotropic linear-elastic material with a Young's modulus of 500 MPa and a Poisson's coefficient of 0.2 [3].

The stance phase of gait has been simulated; a force corresponding the ground reaction force experienced by the hip during the stance phase of the gait analysis was applied to the distal end of the femur. The pelvis was fixed at the iliopubic joint and the iliosacral joint. Maximum

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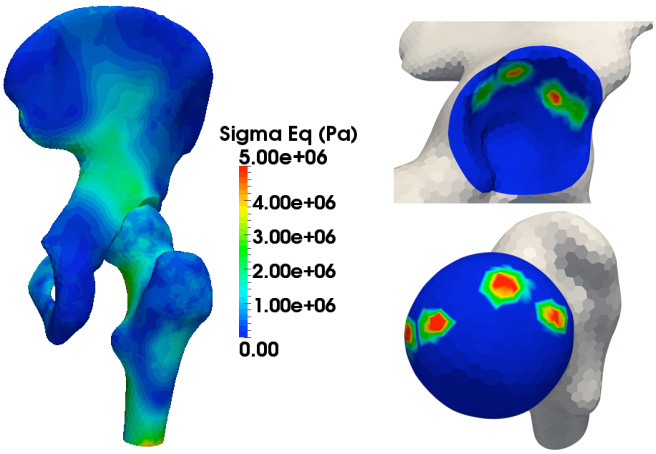

(a) Sigma Equivalent (Pa)

(b) Contact pressure (areas of high contact pressure are in red)

Figure 1: OpenFOAM *homogenous* hip joint model stress results

contact pressures of 10 MPa were found on the articular surfaces. A maximum sigma equivalent stress of 8 MPa was observed at the iliosacral joint fixture. The OpenFOAM *homogenous* model results were verified against finite element software Abaqus and good agreement was obtained. A *sandwich* model is currently being developed which assumes bone to be composed of a flexible cancellous core sandwiched inside a stiffer cortical shell.

3 CONCLUSIONS

A procedure has been developed to create a patient-specific 3D hip joint model from CT and MRI scans. Numerical analysis was performed using finite volume based OpenFOAM and compared with finite element based Abaqus. Initial results agree well with literature [3, 4]. The authors wish to acknowledge financial support from Tekno-Surgical, and the SFI/HEA Irish Centre for High-End Computing (ICHEC) for the provision of computational facilities.

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