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INTRODUCTION

- Instrumented prostheses studies are not representative of a healthy natural joint [1].
- Non-intrusive study of the contact mechanics and tribology of natural joints is not possible.
- The only alternative is to utilise analytical or numerical models.
- Existing three-dimensional models of the natural hip joint represent cartilage as an elastic or hyperelastic material.
- The biphasic nature of the cartilage plays an important role.

AIMS/OBJECTIVES

- To investigate the contact mechanics of natural hip joint.
- To understand the role of interstitial fluid in tribology and contact mechanics.

METHODS

- Pelvic model and all material properties in previous study [2].

METHODS

- Femoral head and acetabular cartilages
 - spherical.
 - thickness – 2 mm (uniform).
 - radius – 28 mm (outer – femoral head).
 - no clearance
 - in MR images both cartilages appear as one [3][4].
 - solid phase – neo-Hookean [2].
- Femoral head - elements
 - bone (assumed cortical only)
 - 432 six-node linear triangular prism.
 - 1872 eight-node linear brick.
 - cartilage
 - 5322 eight-node trilinear displacement and pore pressure reduced integration.
- Vertical load of 2000 N (Fig. 1).
- Contact dependent surface fluid flow [5].
- Frictionless contact.
- Analysis in ABAQUS (v6.7).

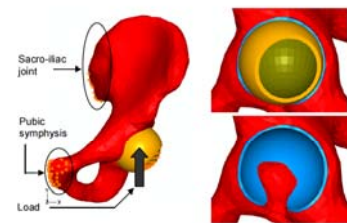


Fig 1: FE model of natural hip joint

METHODS

- Verification - cup and ball model
 - three-dimensional poro-hyperelastic model – relaxed ABAQUS controls
 - Axisymmetric cartilage - cartilage methodology [5] - no relaxed controls.
 - Comparison based on
 - peak contact and fluid pressures.
 - contact area and total fluid load support.

RESULTS

Table 1: Comparison of two- and three-dimensional cup and ball model for validation

	Peak Contact Pressure (MPa)	Contact Area (mm ²)	Peak Fluid Pressure (MPa)	Total Fluid Load Support (%)
Axisymmetric model	1.242	4807.22	1.224	98.25
3D model	1.256	4866.24	1.246	98.75
Difference (%)	1.13	1.23	1.80	0.51

- Natural joint (soon after loading)
 - peak contact pressure - 2.15 MPa.
- Pressure distribution
 - antero-posterior direction (Fig. 2).
- Area of contact: ~83.02 %.
- Total fluid load support: ~94.40 %.

RESULTS

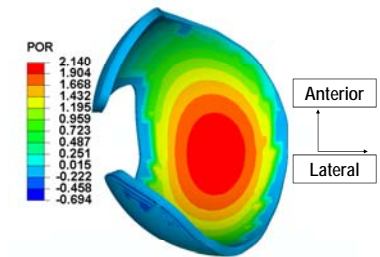


Fig 2: The contour of fluid pressure (MPa) on the acetabular cartilage contact surface after 1 second of loading

DISCUSSION

- The 3D methodology – suitable.
- Peak contact and fluid pressures low despite a very high load
 - due to conforming surfaces and zero clearance.
- Load carried by fluid - very high
 - lower coefficient of friction due to decrease in solid-solid contact [6].
- Lower contact stresses and coefficient of friction
 - reduced frictional shear stresses.
 - survival potential of natural cartilage – Person's life time.
- Subject-specific models in future.

References

- [1] Hodge et al., *J Bone Joint Surg Am* 1989 [2] Pawaskar et al., *Med Eng & Phy* 2011 [3] Naish et al., *Osteo and Cart* 2006 [4] Li et al., *IEEE Trans Biomed Eng* 2008 [5] Pawaskar et al., *J Biomech Eng* 2010 [6] Krishnan et al., *J Ortho Res* 2004.

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