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Developing an Algorithm for A Generic Human Knee Joint Model

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ABSTRACT

Joint mechanical modelling is necessary to investigate the mechanical function of joints. Previous poromechanical model studies focused on subject-specific models to establish the modelling approaches. The results are therefore dependent on individual subjects. When considering a larger group, the statistical shape modelling method (SSM) will become necessary as its advantage in providing average results for a bigger population. Few research has applied SSM on full knee joint. The reason may be due to the lack of imaging data and difficulties associated with the large parameter set involved when all tissues are considered. After having reviewed SSM used in implant designs and a pilot study on modelling elastic response of human knee joint, we are proposing a SSM of the human knee joint from magnetic resonance images (MRI) that can be used to describe the poromechanical response for a specific population. MRI of 6 knees has been obtained. Mimics is being used for knee model segmentation from MRI. Each knee joint tissue will be registered separately for nodal correspondence in MATLAB. The size of knee joint geometric dataset will be reduced from a large number of corresponding points to a smaller number of shape parameters using principal component analysis which in MATLAB by Dr. Brent Edwards' team for the SSM of bones. The developed knee joint shape model will be then used to predict contact response in ABAQUS. Currently, a finite element analysis on dimension change of a knee joint model was tested to see the changes in knee joint mechanics. An 85% scaled model was compared with the reference model of a human subject. A compressive creep load of 390 N was used in the analysis in ABAQUS. The results showed higher maximum contact pressure and higher peak fluid pressure for smaller knee joint. The contact area decreased with knee joint size. The preliminary results do exhibit significant variance in knee joint contact and fluid pressure regarding dimensional change of the knee joint. We are currently developing the approach and testing algorithms to build an average knee model from MRI of 4-6 participants. Anatomic data for a large group will be implemented later to develop a generic model for a sub-population.

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