CHARACTERISING 3D SOFT TISSUE FEATURES ON JOINT SURFACES

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INTRODUCTION

A crucial aspect of orthopaedic implant design is the prediction of surgical outcomes when the shape of a bone is necessarily altered by the addition of the implant. Matching native kinematics as closely as possible is generally considered a core aim of joint replacement surgery [1]. The overall hypothesis behind this research is that soft tissue geometry, including cartilage thickness distribution and ligament attachment sites, influences kinematics in the knee joint. In order to enable investigation of possible links between geometry and kinematics, the ability to characterise the shape variation of the soft tissue relative to the underlying bony geometry must first be developed. This is the aspect which has been addressed in this work.

MATERIALS AND METHODS

Data consisted of clinical magnetic resonance (MR) volumes of the knee from 33 non-osteoarthritic cadaveric subjects. The outer surfaces of the left distal femur, proximal tibia and patella, and their respective cartilage plates were segmented from the MR files and exported as smoothed triangulated surfaces using Mimics© image analysis software

In the technique described, both bone and cartilage surface models are analysed together using the VTK image analysis platform. At each vertex of the bone model, a normal vector is projected outward and the distance between the bone surface and the point at which this vector intersects with the cartilage surface is logged. Allowance is made for errors in segmentation which may mean that there is a gap between the bone model surface and the under surface of the cartilage model. In these cases the second intersection between the vector and the cartilage surface normal is chosen as the point of interest. In this way, a scalar value is added to each vertex on the bone model which represents the thickness of the cartilage at that point. These can be visualized in contour form as shown in Figure 1. In a similar manner, a scalar value representing the presence or absence of ligament attachment tissue is also added to each vertex. The 3D models which have been thus "tagged" can now be fed into a statistical model which analyses the variation of soft tissue geometry as a function of the underlying bony geometry.
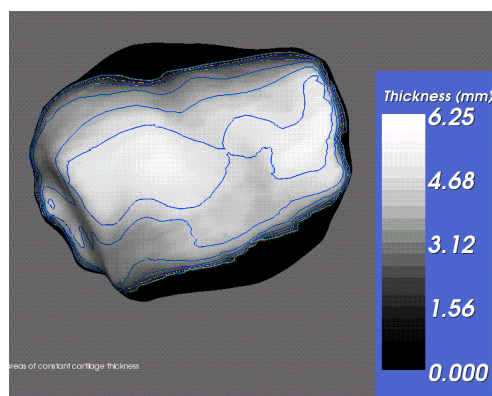
RESULTS

Figure 1 Cartilage thickness mapping for a sample patella model

DISCUSSION

This work enables the understanding of soft tissue distribution on individual subjects. While this understanding is useful in itself, its primary utility is as an enabling technology for the end objective of this research, the investigation of links between skeletal anatomy and joint kinematics. This will be done through comparison of a principal component model of the bony geometry with scalar data attached, to knee kinematic envelope data captured by researchers at Kansas University [2].

This will enable the visualisation of variation in hard and soft tissue geometry, and so characterise the relationship between variations in soft tissue geometry and kinematic envelopes.

REFERENCES

[1] Kurosawa H. et al., Journal of Biomechanics, 18(7): pp. 105-108. 1985.
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