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3D Numerical Analysis of an ACL Reconstructed Knee

M. Chizari, B. Wang

School of Engineering, University of Aberdeen, Aberdeen AB24 7QW, UK

Abstract: Numerical methods applicable to the tibia bone and soft tissue biomechanics of an ACL reconstructed knee are presented in this paper. The aim is to achieve a better understanding of the mechanics of an ACL reconstructed knee. The paper describes the methodology applied in the development of an anatomically detailed three-dimensional ACL reconstructed knee model for finite element analysis from medical image data obtained from a CT scan. Density segmentation techniques are used to geometrically define the knee bone structure and the encapsulated soft tissues configuration. Linear and non-linear elastic constitutive material models are implemented to mechanically characterize the behaviour of the biological materials. Preliminary numerical results for the model qualitative evaluation are presented.

Keywords: *Finite element, modelling, ACL reconstruction, 3D knee Model, CT scan*

1. Introduction

Geometric complexity and non linearity of the materials of the knee make the analytical solutions of the mechanical behaviour of the knee joint difficult. The knee is the most complex joint within the human body. Proper motion of the joint relies significantly on the function of the soft tissue constituents including the four ligaments of the tibiofemoral joint. These ligaments allow primarily flexion/extension and rotation of the joint by enabling the bony constituents (femur and tibia) to translate and rotate relative to each other. In addition to the ligaments, soft cartilage in the joint space permits nearly frictionless contact between the bones.

Computational modeling of the knee provides a way for better understanding the interplay between the hard and soft tissue constituents of the knee during normal and pathologic function (Bischoff et al., 2008). Additionally, properly validated models can be used in the design of knee implant systems by understanding the mechanics of the restored knee and guiding optimization of the design in order to more closely replicate the healthy knee.

This paper presents a numerical method applicable to the bone and soft tissue biomechanics of the ACL reconstructed knee. The paper uses a finite element model to analyse an anatomically detailed three-dimensional ACL reconstructed knee joint using medical image data obtained from a CT scan.

A geometrical model and mesh design for the component parts (pre-processing) were created using the software package program Mimics 10 (Mimics, 2007). The data analysis (post-

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