ROLE OF FIXATION AND MECHANICAL PROPERTIES OF IMPLANTED CARTILAGE REPLACEMENTS IN SUCCESSFUL REPAIR OF ARTICULAR CARTILAGE INJURIES

Abstract

by

Ali Vahdati

Partial- and full-thickness cartilage lesions of the knee caused by trauma, disease or joint instability are a common disorder affecting people of all ages. Implanted cartilage replacements (ICR) have the potential to overcome the limitations of conventional treatment methods and are a promising approach to restore functionality of the joint. In spite of some success in engineering cartilaginous tissue, inferior biomechanical and biochemical properties of ICR compared to native articular cartilage (AC) and inadequate quality of fixation and integrative repair of tissues remain significant clinical challenges.

An axisymmetric biphasic swelling finite element (FE) study was conducted to elucidate the effects of a lower modulus, lower proteoglycan content and a lack of integration at the interface on the mechanical environment of a transplanted ICR in the knee joint. In comparison to intact joint, load partitioning between different phases of cartilage was affected by inferior properties of the ICR. Analysis of the relative sliding at the ICR/native AC interface suggested

that when subjected to axial loading, an implant with inferior properties does not disrupt the integrative repair process anymore than an ideal implant.

In this first study, the process of delamination at the interface could not be explored because the model was limited to the cases of full integration or no integration at the interface. Thus in the next study, a three-dimensional FE analysis was conducted to investigate damage in fibrin adhesive under conditions that included sliding loads. Damage and failure of fibrin at the interface was represented by a cohesive zone model with coefficients based on previously published experimental data. Results of this study demonstrated that fibrin glue alone may not be strong enough to withstand physiologic loads in vivo while fibrin glue combined with chondrocytes may effectively prevent damage at the interface. The results also suggested that fibrin fails mainly in shear during off-axis loading.

Finally a third FE study was performed to evaluate the effect of several important implant material and geometric properties on the failure of the adhesive bond between the ICR and native tissue. Results of this study demonstrated that ICR size and material properties have a significant effect on the failure of the fibrin that adheres the implant to the native tissue. In the future, results of these studies may be used to improve implant design and surgical techniques and eventually help researchers develop more efficient and successful long-term biological articular joint repair.