REAL TIME EVALUATION OF THE MECHANICAL PROPERTIES OF ARTICULAR CARTILAGE DURING COLLAGENASE INDUCED DIGESTION

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Introduction

Articular cartilage is a connective tissue, responsible for baring all loads in the joint. Over time its structure may be degraded due to pathological reasons leading to disability. Evaluation of the tissue's mechanical properties is of the utmost importance in the study of degenerative diseases such as osteoarthritis (OA). Herein we address the real time monitoring of Young's Modulus (E) during the collagenase induced digestion of the tissue.

Methods

OA Cartilage tissue was obtained from patient undergoing hip-joint replacement surgery. A cartilage disk, 3mm in diameter, was removed from the explant with a biopsy punch, placed on the bottom of 24 well plate, filled with 1.5 ml DMEM and supplemented with collagenase Type II (from Clostridium histolyticum) of 0.4% w/v concentration. An indentation test of the cartilage disk followed, using BOSE Electroforce 3100. The disk was compressed with a steady force of 0.1304N and displace-ment over time was measured (Creep test).

E was calculated using a biphasic unconfined compression model, implemented in FEBio software (figure 1).

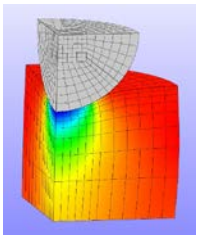

Figure 1: biphasic unconfined compression model

The measured time-displacement curve was approximated by a series of steady states and FEBio was called iteratively to compute E in every one of those states. Only time-points later than 9500 sec were considered, to ensure transient phenomena are insignificant. The hydraulic permeability of the tissue is not evaluated at this point and is set to a nominal value of $0.0001 \bullet 10^{-15} m^4 / Ns$**Error! Bookmark not defined.** .

Results

The results exhibit a time dependent decrease of E, during the collagenase digestion. E decreases at a much faster rate compared to the tissue's displacement. Therefore by using the E curve, as it represents an important material property, one can obtain a good estimate of how the tissue degradation progresses over time. The E within a time period of 2.5 days was decreased by 89% (0.72Mpa—0.08Mpa).

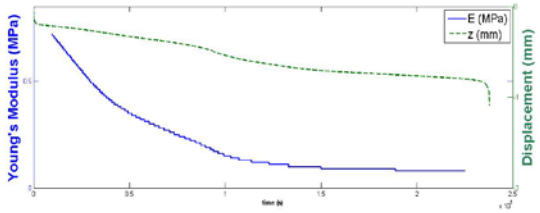

Figure 2: Young's modulus–time curve (blue), Displacement – time curve (green-dotted).

Discussion

Herein we developed an FEM model in order to address the real time monitoring of cartilage degeneration. As a control study, degeneration was induced using collagenase type II. As future plans, the current approach will be refined to include more complex phenomena (alteration of the shape of the specimen) and will be applied to monitor the degeneration capability of OA-relevant mediators such as IL1a and TNFa, leading to even better understanding of the mechanics of cartilage degradation.

References

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