Predicting degenerated disc behavior by changing the biochemical content

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Introduction

Present research focuses on clarifying degenerative processes due to ageing and pathological effects. Degeneration implies specific deleterious changes in disc composition, structure and function [1]. The main disc components are; water, proteoglycans (FCD) and collagen fibers (figure 1a). Their proportion and structure differ within the intervertebral disc (figure 1b), and determine the biomechanical properties.

Figure 1. (a) IVD Extracellular matrix composition. (b) Proportions across the disc ( healthy disc, degenerated disc).

Objective

To determine to what extent is degenerated disc behavior, dependent on biochemical content changes that characterize a grade 3 degenerated disc.

Material and methods

The model:

A 3D osmo-poro-visco-hyper-elastic disc (OVED) model [2] models the healthy and degenerated disc using different biochemical composition (table 1). The elemental properties are a function of material properties of each constituent and their proportions.

<table>
<thead>
<tr>
<th>Disc</th>
<th>NUCLEUS</th>
<th>ANNULUS</th>
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<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Deg.</td>
</tr>
<tr>
<td>Water [% wet weight]</td>
<td>82.5%</td>
<td>77.5%</td>
</tr>
<tr>
<td>Collagen [% dry weight]</td>
<td>9%</td>
<td>15%</td>
</tr>
<tr>
<td>FCD [meq/ml]</td>
<td>0.3%</td>
<td>0.15%</td>
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Table 1. Composition of the healthy (left) and degenerated (right) intervertebral disc [3].

The loading protocol:

• Axial compressive load of 2kN on the top of the disc (figure 2) [1].

Results

The model of the degenerated disc (figure 3, right) does not fit the experimental data from Adams et al (figure 4, right) [1].

Figure 2. Disc model showing the sagittal path along which the compressive stress is measured.

Figure 3. Stress profiles from numerical computation. Healthy disc (left) and degenerated disc (right).

Little differences in the mechanical behavior between healthy and degenerated disc can be observed (Figure 3).

Discussion

The OVED model has been equipped with biochemical data of a grade 3 degenerated disc. The predicted mechanical behavior of the grade 3 disc is very close to the predicted behaviour of a healthy disc. The discrepancy with experimental data (Figure 4) may be due to difficulties in interpretation of the measurements, the uncertainty about the grade of degeneration of the discs or modelling issues.

References