A model of early degenerated disc


Published: 01/01/2011

Document Version
Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:
- A submitted manuscript is the author's version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

Citation for published version (APA):
A model of early degenerated disc
M.M. van Rijsbergen, A.C.T. Vrancken, V.M.P. Barthelemy, J.M. Huyghe, K. Ito

Introduction
Our fiber reinforced osmoporoviscoelastic (FR-OPVE) micromechanical cartilaginous tissue model based on constituent content and their material properties could capture the normal mechanical behavior of both nucleus pulposus and annulus fibrosus tissues of a normal intervertebral disc (IVD) (Fig 1) [1].

Aim: Investigate if orientation of the collagen network in an early degenereted disc can be assumed to be similar to healthy discs in order to model their tissue mechanical behavior using a multi-scale model of the disc.

Approach
Tissue from human Pfirrmann grade III discs (Fig 2) were previously mechanically tested (tensile and confined compression) and their constituent contents biochemically determined (table 1) [2]. Assuming no change in collagen fiber orientation to that of a healthy disc (grade 1), the constituent material properties will be calculated by fitting the FR-OPVE tissue model to the mechanical test results. Goodness-of-fit to the experimental data as well as reasonable constituent material properties will be evaluated.

Table 1: Biochemical content of human Pfirrmann grade III discs.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Grade III</th>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade IV</th>
<th>Grade V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water [% WW]</td>
<td>74.99 (3.54)</td>
<td>85.09 (3.54)</td>
<td>79.04 (3.54)</td>
<td>71.36 (3.54)</td>
<td>60.61 (3.54)</td>
</tr>
<tr>
<td>GAG [μg/mg DW]</td>
<td>60.61 (16.56)</td>
<td>72.89 (16.56)</td>
<td>65.87 (16.56)</td>
<td>48.24 (16.56)</td>
<td>37.89 (16.56)</td>
</tr>
<tr>
<td>FCD [mEq/ml]</td>
<td>9.00 (0.12)</td>
<td>10.28 (0.12)</td>
<td>11.56 (0.12)</td>
<td>12.84 (0.12)</td>
<td>14.12 (0.12)</td>
</tr>
<tr>
<td>Collagen [μg/mg DW]</td>
<td>168.49 (68.67)</td>
<td>174.89 (68.67)</td>
<td>181.28 (68.67)</td>
<td>187.67 (68.67)</td>
<td>194.06 (68.67)</td>
</tr>
</tbody>
</table>

Fig 1: Comparison of experimental and FE simulation reaction force from confined compression of nucleus tissue.

Fig 2. Lumbar intervertebral discs sectioned in the mid-sagittal plane, (A) Grade 1 disc; (B) Grade 2 disc; (C) Grade 3, showing moderate degenerative changes; (D) Grade 4 disc, showing serve degenerative changes.

Preliminary results
In a previous study [2], by only accounting for the altered biochemical contents of grade 3 discs, no good fit could be obtained between experimental and numerical data (Fig 3). However, these results were biased by incomplete biochemical data.

Further work
• Redo the fit between experimental data and FR-OPVE model using the complete biochemical dataset, assuming similar collagen network orientation as in a healthy IVD (in progress).

• If no acceptable fit between experimental and numerical data can be obtained, orientation of the collagen network in grade III disc will be measured (MRI or microscopy). The outcome of these measurements will be integrated in the model and the fit redone.

“The research leading to these results has received funding from the European Union Seventh Framework Program (FP7/2007-2013) under grant agreement n” 269909.”

References: