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Evaluation of a biochemical/biophysical intervertebral disc model

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Introduction

FE models have become an important tool to study load distribution in the healthy and degenerated disc (Fig 1). However, in most models, degeneration is simulated phenomenologically, but not according to matrix composition. We have developed a novel 3D disc model that accounts for pre stressing of collagen fibers due to physical principles of osmosis and is based on experimentally quantified material properties from human tissue that are dependent on matrix biochemical composition [1].

Objective

In this study, the 3D disc model is corroborated with experimental data of whole discs from literature.

Material & Methods

The disc model resembled one forth of a full disc [1]. The model distinguished between an elastic non-fibrillar solid matrix, a 3D viscoelastic collagen structure and an osmotically pressurized fluid [1,2]. The bulging and creep behavior of the 3D disc model was confronted with experiments of whole discs from the literature (radial bulging, height change and intradiscal pressure) [3,4].

During corroboration 4 adaptations to the model were explored. The fibrillar matrix was extended to incorporate smaller secondary fibril structures, e.g. minor collagen, elastin, etc. The shear stiffness (Gm) was also varied.

Results

Table 1. Results of disc deformation in comparison to Heuer et al. [4]

<table>
<thead>
<tr>
<th>Disc deformation</th>
<th>Model adaptation 3</th>
<th>Heuer et al.[4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height change</td>
<td>-0.87mm</td>
<td>- (1.00 - 1.35mm)</td>
</tr>
<tr>
<td>Radial bulging</td>
<td>0.61mm</td>
<td>(0.46 – 1.34nm)</td>
</tr>
<tr>
<td>ON 500N</td>
<td></td>
<td></td>
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<tr>
<td>Creep</td>
<td>0.1mm</td>
<td>0.1mm</td>
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<tr>
<td>500N over 900s</td>
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</tbody>
</table>

Discussion

The slight increase of Gm (1.5x) was still in in reasonable agreement with the experimental data of the confined compression experiment (Fig. 2) from Schroeder et al. [5], while 5xGm was not coherent with the exp. data.

Conclusion

The evaluated 3D disc model may now be used to explore the biomechanical implications of disc degeneration on its function and integrity as well as to explore therapeutic mechanisms for repair and regeneration.

Acknowledgment

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References: