Intervertebral disc prosthesis

Intervertebral Disc Prosthesis

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Introduction

One of the main problems with application of intervertebral disc prostheses concerns the surrounding ligaments. Over-extension during the operation and omission of the diurnal cycle in pre-tension are probably the main causes of ossification of the ligaments (figure 1).
Due to the osmotic properties of the natural disc, the disc shrinks under increase of load and swells under decrease of load, which results in a tension cycle.

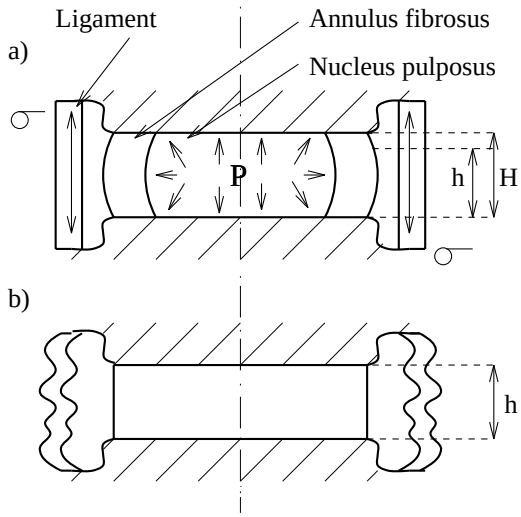

fig. 1 *Ligaments with (a), and without (b) diurnal pre-tension cycle, with P, the osmotic pressure, σ, the tensile stress, and heights H and h.*

Aim of the Project

For maintenance of the ligament function preservation of the swell-shrink cycle in the prosthesis is necessary. In this project materials are investigated which mimic this property, next to other properties needed for a prosthesis.

Design Proposal

Two lines are followed:

- Application of a hydrogel structure, with osmotic properties, as substitute of the nucleus structure, surrounded by a structure which allows an in- and outflow of water and small solutes for the swell-shrink cycle, prevents the hydrogel to get pressed out, and gives the prosthesis the appropriate stiffness and strength.
- Application of a visco-elastic compressible material which can mimic the swell-shrinking cycle by its relaxation properties. In this case no fluid in- and outflow is necessary.

In both cases the shrink capacities can be used to decrease the space needed in the ligament area during the operation.

Prototype

A prototype, with a hydrogel nucleus, surrounded with polymer fibres, is made on a winding machine. The fibres substitute the annulus structure and are positioned with plates, placed at the top and bottom sides of the hydrogel (figure 2).

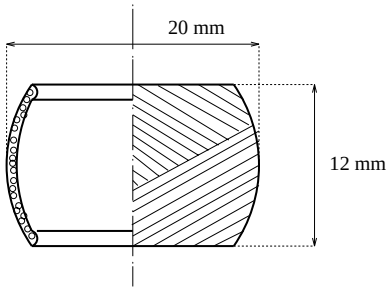

fig. 2 *Sketch of prototype.*

After attraction of water in the prototype, the osmotic pressure results in protrusion of the hydrogel through the fibre-structure (figure 3).

fig. 3 *Protrusion of hydrogel.*

Conclusion

In the natural disc the cooperation of the hydrogel and fibres takes place on a scale, with a characteristic fibre diameter of $0.1\mu - 10\mu$, in the prototype it takes place on a larger scale, with a characteristic fibre diameter $> 10\mu$, which causes the protrusion. Application of materials with better fibre-matrix bonding or application of a membrane structure in-between the former two can result in improvement.