INVESTIGATION OF DIFFERENT HYDROGELS FOR NUCLEUS REPLACEMENT – A BIOMECHANICAL STUDY

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Introduction

Hydrogels are considered promising for disc regeneration strategies. However, it is currently unknown whether the destruction of the natural interface between nucleus and surrounding structures caused by nucleotomy and an inadequate annulus closure diminishes the mechanical competence of the disc.
To clarify these mechanisms and to evaluate whether hydrogels are able to restore the biomechanical behaviour of the disc a combined *in vivo* and *in vitro* and approach was used.

Methods

To consider physiological loading conditions *in vitro*, the intradiscal pressure was first measured in 3 sheep over 24 hours *in vivo*. Average measured intradiscal pressure was ~0.75 MPa during day and ~0.5 MPa during night which corresponds to an axial force of 130 and 58 N, respectively.
Two different loading protocols were performed *in vitro*: (1) an axial compressive stiffness test and (2) an axial compressive test of 3 loading cycles each consisting of 15 minutes at 130 N and 30 minutes at 58 N. The tests were performed on 24 ovine motion segments (16×L2-L3, 8×L4-L5).
Four different states were investigated: (i) INTACT, (ii) DEF-NUC: Nucleus tissue was removed and subsequently re-implanted and (iii-iv) two different hydrogels as nucleus replacements: DDAHA (Anika Therapeutics, Abano Therme, Italy) and iGG-MA (3 B's Research Group, University of Minho, Portugal).
During the test, the axial displacement and the nucleus pressure were recorded.

Results

In the stiffness test (1), the load-deformation-curves of all tested segments showed a nonlinear behavior characterized by a toe-region at the beginning of loading. This was followed by a progressive region and ended with an almost linear response.
→ **No significant differences were observed between the different testing groups.**

In the compression test (2) INTACT showed a typical creep response with a steady loss of specimen height under the constant diurnal load of 130 N. The night load only led to a slight recovery. Two intervals of night load did not compensate for the loss of height resulting from two intervals of diurnal load. Intact ovine discs caused a nucleus pressure of ~0.3 MPa without any external load. The application of 130 and 58 N initially caused the desired nucleus pressures of 0.75 and 0.5 MPa, respectively. During the diurnal load, the pressure slightly decreased by ~3%, while it remained almost constant during the night load.
→ **DEF-NUC, DDAHA and iGG-MA increased the height-loss** (maximal for DEF-NUC: ~33%) and **decreased the fluid pressurization** (maximal for DEF-NUC: ~26%) compared to INTACT.

Discussion

The re-implantation of the natural nucleus, assumed as being the ideal implant, was not able to restore the mechanical function of the disc. This may be due to (i) a damaged natural interface between nucleus and surrounding structures, (ii) an inadequate annulus sealant and (iii) a destroyed collagen-proteoglycan compound making up the native nucleus tissue. Therefore, hydrogels that mimic the mechanical behaviour of the native nucleus may still fail in restoring the disc height and fluid pressurization when neglecting the disturbed structural interrelations.

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