

Can the Biomechanical Disc Function Be Restored by a Collagen Matrix Nucleus Replacement

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INTRODUCTION: The goal of a nucleus replacement is to restore the origin disc height and motion. Recently, it has been shown that rebuilding the nucleus by seeding autologous cells inside the intervertebral disc (IVD) is capable to enhance anatomical integrity, which also preserves vital structures maintaining nutrition transport and metabolism¹. In this study, we investigated whether implantation of the new tissue engineered nucleus implant into a spinal segment after a nucleotomy is able to restore disc height and flexibility.

METHODS: The implant basically consists of condensed collagen type-I matrix. For clinical use, this matrix will be used for reinforcing and supporting the culturing of nucleus cells. In order to evaluate the biomechanical performance of the collagen, the collagen matrix was concentrated with barium sulfate for x-ray purposes but no cells were seeded (Fig.1a). The in vitro testing was performed on six bovine lumbar functional spinal units (FSU), aging between 5 and 6 months. In each specimen an oblique incision was performed from a right lateral approach. Through this access the nucleus was removed and replaced by a collagen-type-I matrix (Fig.1b). Proper application of the implant was controlled by radiographic visualization.

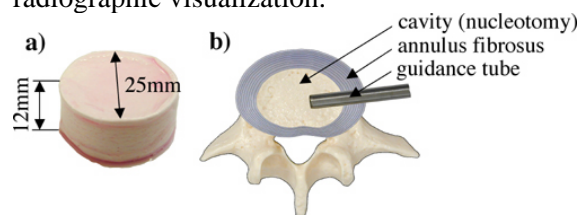


Fig.1: a) collagen matrix, b) implantation.

Spinal segment flexibility was assessed using a custom-built spine tester². Unconstrained pure moments of $\pm 7.5\text{Nm}$ were applied in axial rotation, flexion/extension and lateral bending. For each tested stage (intact, nucleotomy, and with implant) flexibility and height measurements were performed. The 3rd load cycle was evaluated to determine the range of motion (ROM) and neutral zone (NZ) in each direction. Paired t-test was employed. In order

not to lose significance the p-values were not adjusted for multiple testing.

RESULTS: Removal of the nucleus reduced disc height by $0.88 \pm 0.37\text{mm}$ in respect to intact stage. In contrast, implantation of the vital nucleus replacement increased the disc height by $0.15 \pm 0.4\text{mm}$ compared to intact stage. The average flexibility of the intact specimens was $7.9 \pm 4.3^\circ$ ROM and $3.0 \pm 2.3^\circ$ NZ in flexion/extension. Nucleotomy caused a significant loss of stability and resulted in $10.0 \pm 4.7^\circ$ ROM and $3.5 \pm 2.2^\circ$ NZ ($p < 0.05$). Application of the implant significantly stabilized FSUs to a ROM and NZ of $7.6 \pm 2.0^\circ$ and $1.4 \pm 0.3^\circ$, respectively ($p < 0.05$). There was no statistical difference between the stability provided by the implant and the intact stage. Similar trends were found in lateral bending and axial rotation compared to flexion/extension. However, implant extrusions have been observed in three of six cases.

DISCUSSION & CONCLUSIONS: Artificial and tissue engineered nucleus replacement has been of great interest for orthopaedic and neurosurgeons. Early treatment of disc degeneration or IVD prolapse are intended to be the main indications for tissue engineered nucleus replacement. The results of this study reflect the principal efficacy of vital nucleus replacement to restore disc height and to provide stability to intervertebral discs. However, from a biomechanical point of view the challenge is to employ an appropriate annulus fibrosus sealing method, which is capable to keep the nucleus implant in place over a long-time period. Securing the nucleus implant inside the IVD will be considered as an objective for future biomechanical studies.

REFERENCES:

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