Nucleus pulposus (NP)

- β-Mangostin Attenuates TET2-Mediated DNA Demethylation of Prkcg in the Prevention of Intervertebral Disc Degeneration
- Lumbar disc herniation modelling: a review of ex-vivo mechanical models and a comparison with clinical data
- 17beta-estradiol maintains extracellular matrix homeostasis of nucleus pulposus cells by activating p70 S6K1 signaling pathway
- Dynamic behavior of the nucleus pulposus within the intervertebral disc loading: a systematic review and meta-analysis exploring the concept of dynamic disc model
- Bioactive Therapies for Degenerative Disc Disease: Microenvironmental Foundations of Disease
- Brachyury-Activated Fucoidan Hydrogel Microspheres Rejuvenate Degenerative Intervertebral Discs Microenvironment
- The relationship between biomechanical factors and intervertebral disc degeneration: a review
- RTA 408 attenuates TBHP-Induced apoptosis in nucleus pulposus cells via Nrf2/ARE and NF-kappaB signaling pathways: in vitro and in vivo evidence for mitigating rats' intervertebral disc degeneration

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The NP is a gelatinous structure, composed primarily of type II collagen, large aggregating proteoglycans, and a low concentration of chondrocytes. The NP can retain large amounts of water to provide resistance to compression.

It is the remnant of the notochord.

It functions to distribute hydraulic pressure in all directions within each disc under compressive loads.

The nucleus pulposus is a loose, fibrous network suspended in mucoprotein gel that is sealed by the annulus fibrosus and needs to be well-hydrated in order to maintain its strength and softness, and serve as the major carrier of the body's axial load.

The nucleus pulposus consists of chondrocyte-like cells, collagen fibrils, and proteoglycan aggrecans that aggregate through hyaluronic chains. Attached to each aggrecan molecule are the glycosaminoglycan (GAG) chains of chondroitin sulfate and keratan sulfate.

Aggrecan is negatively charged, allowing the nucleus pulposus to attract water molecules. The amount of water and glycosaminoglycans decreases with age and degeneration.

The capacity for endogenous regeneration in the NP is limited due to the low cellularity and poor nutrient and vascular supply. Towards restoring the NP, a number of biomaterials have been explored for cell delivery. These materials must support the NP cell phenotype while promoting the elaboration of an NP-like extracellular matrix in the shortest possible time. Previous work with chondrocytes and mesenchymal stem cells demonstrated that hydrogels based on hyaluronic acid (HA) are effective at promoting matrix production and the development of functional material properties. However, this material has not been evaluated in the context of NP cells. Therefore, to test this material for NP regeneration, bovine NP cells were encapsulated in 1%w/vol HA hydrogels at either a low seeding density (20×10(6)cellsml(-1)) or a high seeding density (60×10(6)cellsml(-1)), and constructs were cultured over an 8week period. These NP cell-laden HA hydrogels showed functional matrix

accumulation, with increasing matrix content and mechanical properties with time in culture at both seeding densities. Furthermore, encapsulated cells showed NP-specific gene expression profiles that were significantly higher than expanded NP cells prior to encapsulation, suggesting a restoration of phenotype. Interestingly, these levels were higher at the lower seeding density compared to the higher seeding density. These findings support the use of HA-based hydrogels for NP tissue engineering and cellular therapies directed at restoration or replacement of the endogenous NP [1].

Disc herniation

Disc herniation

Replacement

Nucleus replacement technologies are a minimally invasive alternative to spinal fusion and total disc replacement that have the potential to reduce pain and restore motion for patients with degenerative disc disease. Finite element modeling can be used to determine the biomechanics associated with nucleus replacement technologies.

A study focuses on a new nucleus replacement device designed as a conforming silicone implant with an internal void. A validated finite element model of the human lumbar L3-L4 motion segment was developed and used to investigate the influence of the nucleus replacement device on spine biomechanics. In addition, the effect of device design changes on biomechanics was determined. A 3D, L3-L4 finite element model was constructed from medical imaging data. Models were created with the normal intact nucleus, the nucleus replacement device, and a solid silicone implant. Probabilistic analysis was performed on the normal model to provide quantitative validation metrics. Sensitivity analysis was performed on the silicone Shore A durometer of the device. Models were loaded under axial compression followed by flexion/extension, lateral bending, or axial rotation. Compressive displacement, endplate stresses, reaction moment, and annulus stresses were determined and compared between the different models. The novel nucleus replacement device resulted in similar compressive displacement, endplate stress, and annulus stress and slightly higher reaction moment compared with the normal nucleus. The solid implant resulted in decreased displacement, increased endplate stress, decreased annulus stress, and decreased reaction moment compared with the novel device. With increasing silicone durometer, compressive displacement decreased, endplate stress increased, reaction moment increased, and annulus stress decreased. Finite element analysis was used to show that the novel nucleus replacement device results in similar biomechanics compared with the normal intact nucleus [2].

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Kim DH, Martin JT, Elliott DM, Smith LJ, Mauck RL. Phenotypic stability, matrix elaboration and functional maturation of nucleus pulposus cells encapsulated in photocrosslinkable hyaluronic acid hydrogels. Acta Biomater. 2015 Jan 15;12:21-9. doi: 10.1016/j.actbio.2014.10.030. Epub 2014 Oct 29. PubMed PMID: 25448344; PubMed Central PMCID: PMC4274233.
2)
Coogan JS, Francis WL, Eliason TD, Bredbenner TL, Stemper BD, Yoganandan N, Pintar FA, Nicolella DP. Finite Element Study of a Lumbar Intervertebral Disc Nucleus Replacement Device. Front Bioeng Biotechnol. 2016 Dec 1;4:93. PubMed PMID: 27990418.