

Mechanical behavior of iv discs stabilizes in a loaded culture system

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INTRODUCTION: Fluid flow, into and from the intervertebral disc, plays a role in vivo in the mechanics of the disc. The regulating mechanism is the pursuit for balance between the external load on the spine and the osmotic pressure in the disc. During compression, fluid is pressed out of the disc whilst fluid flows back during rest. In vivo this leads to a stable pattern, in vitro however, earlier studies show no stabilization of mechanical behavior, even if the resting time exceeded the loading time [1,2]. In this study we investigate if the mechanical behavior of intervertebral discs moves towards a stable situation if the disc is exposed to a sustained cyclic loading in a culture system.

METHODS: four lumbar spines were harvested from 4-year-old goats. One disc (L3/L4) was tested within 2 hours after death and a second disc (L2/L3) was frozen (-20C) and tested 24 hours later. The disc was thawed before testing. Each disc was tested in a disc culture system for 24 hours. This period was divided into eight cycles: a loading phase (0.2-0.8Mpa, 0.5Hz sinusoidal, 2hours) and an unloading phase (0.2Mpa, static, 1hour). The samples were tested in a disc culture system flowed with medium (+10%FBS, antibiotics, 5%CO2). Load was applied through a hydraulic mechanical testing device (Instron 8872).

RESULTS: The loss of disc height during loading is compensated during rest after three full cycles (fig1 and fig2).

The increase of stiffness of the disc, due to fluid loss in the nucleus, stabilizes after four full cycles. The stiffness of the frozen disc is approximately 30% higher (fig3).

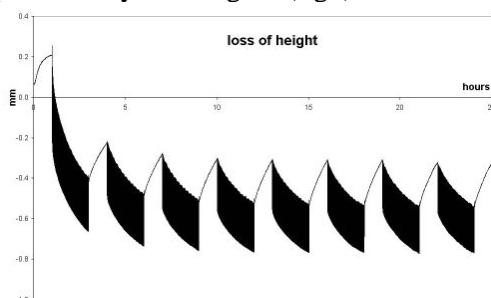


Fig. 1: Change of disc height (typical) in time.

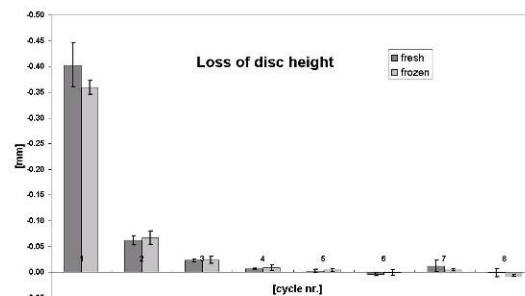


Fig. 2: Average loss of disc height per cycle.

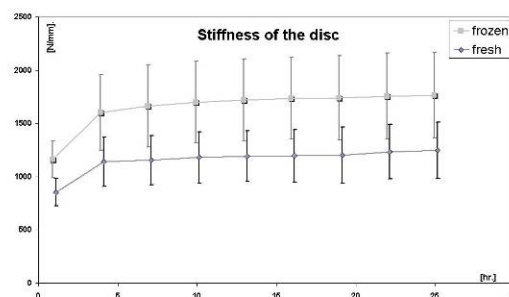


Fig.3: Change of stiffness in time.

DISCUSSION: The mechanical behavior of the disc stabilizes in four cycles but does not reach equilibrium during the loading or unloading phase. For a measurement of the mechanical properties, it is essential to cycle the system until this stable situation has been reached. The properties of the disc are then measured in its working range.

The shape of the displacement curve is not similar to curves known from the literature [3]. In vivo, the disc tends to equilibrium during the loading or unloading phase. This leads to a flattening of the displacement curve. We assume that in the present tests fluid flow in the endplate is hampered. This slows down fluid flow and equilibrium will not be reached.

Freezing of the samples appears to have influence on the stiffness of the disc but not on changes in stiffness or height. We presume that this is due to a changed stiffness of the annulus.

REFERENCES: ¹A.J. van der Veen, et al (2004) transcription of ORS2004, ² N. Dhillon, et al (2001) Spine 26-8:883-888, ³ A.R. Tyrrell et al (1985) Spine 10-2:161-164