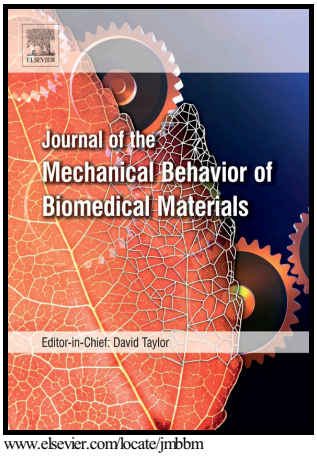
A comparative study of mechanical properties of fresh and frozen-thawed porcine intervertebral discs in a bioreactor environment

M. Azarnoosh, M. Stoffel, V. Quack, M. Betsch, B. Rath, M. Tingart, B. Markert



www.elsevier.com/locate/jmbbm

PII: S1751-6161(16)30435-0
DOI: http://dx.doi.org/10.1016/j.jmbbm.2016.12.010
Reference: JMBBM2157

To appear in: *Journal of the Mechanical Behavior of Biomedical Materials*

Received date: 24 August 2016
Revised date: 12 December 2016
Accepted date: 16 December 2016

Cite this article as: M. Azarnoosh, M. Stoffel, V. Quack, M. Betsch, B. Rath, M. Tingart and B. Markert, A comparative study of mechanical properties of fresh and frozen-thawed porcine intervertebral discs in a bioreactor environment *Journal of the Mechanical Behavior of Biomedical Materials* http://dx.doi.org/10.1016/j.jmbbm.2016.12.010

A comparative study of mechanical properties of fresh and frozen-thawed porcine intervertebral discs in a bioreactor environment

M. Azarnoosh[a,*], M. Stoffel[a], V. Quack[b], M. Betsch[b], B. Rath[b], M. Tingart[b], B. Markert[a,c]

[a] *RWTH Aachen University, Institute of General Mechanics, Templergraben 64, 52062 Aachen, Germany*
[b] *Orthopaedic Clinic of Aachen University Medical Center, Pauwelsstraße 30, 52074 Aachen, Germany*
[c] *Faculty of Engineering and Science, University of Agder, Televeien 9, 4879 Grimstad, Norway*

Abstract

Limited availability of fresh intervertebral discs (IVDs) necessitates the use of frozen-thawed samples in biomechanical investigations. Several authors have reported the mechanical properties of frozen-thawed IVDs, but few studies have investigated the effects of storage temperature and cooling rate. The validity and reliability of the applied freezing-thawing procedures are still relatively unknown. The study aims to compare the mechanical responses of fresh porcine IVDs and porcine IVDs, which were frozen at different freezing temperatures with a controlled-rate cooling process and then thawed. The specimens were obtained from pigs aged 6 months. A total of 18 functional spine units (FSUs) were taken from seven porcine lumbar spines (L1-L6). The specimens were then split into three groups. The first group was tested fresh immediately and the other two groups were frozen at the same cooling rate and stored at -20° C and -80° C, respectively, before testing. The period of storage ranged between 12 and 43 days. The frozen specimens were thawed for 9 hours at room temperature before the tests. A special IVD bioreactor, which maintained the realistic behaviour of IVDs under various loading conditions, was developed. The analysis of variance (ANOVA) was used to determine if the observed results were statistically significant. The results indicated that frozen storage at -20° C decreases the comprehensive stiffness. In contrast, freezing to -80° C did not seem to have any effect on the mechanical properties of IVDs. No significant differences in outcome were observed for the samples, which had different spine levels. The study confirmed the reliability and usability of frozen-thawed samples stored at -80° C for biomechanical investigations.

Keywords: porcine intervertebral disc, freezing temperature, fresh, thawed, periodic cyclic loading, bioreactor

*Corresponding author. Tel.: +49 (0) 241 80 94602; fax: +49 (0) 241 80 92231.
Email address: azarnoosh@iam.rwth-aachen.de (M. Azarnoosh)