15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-71

NUMERICAL SIMULATIONS OF BONE REMODELLING AFTER NUCLEOTOMY

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Keywords: lumbar spine, nucleotomy, finite element analysis, bone remodelling

Summary: Nucleotomy is a frequently used surgical treatment of lumbar disc herniation. The clinical outcome varies from 30% to almost 100% good/very good results, depending on authors and studies. In recent years, great efforts have thus been made to understand the impact of this surgery on lumbar spine biomechanics. However, possible responses of the bony structures due to instabilities have been usually disregarded. This work aims to shed light on bone adaption after nucleotomy with special focus on the role of collagen fibres in the annulus fibrosus.

A finite element model of a L4-L5 functional spinal unit (FSU) was developed. An adaptative bone remodelling process was initiated in the intact FSU from a uniform vertebral bone mineral density (BMD) according to Huiskes law. After reaching the equilibrium, a nucleotomy was performed removing the whole nucleus pulposus. The effect of different loading scenarios combining pure compression and flexion-extension was studied. To investigate the role of collagen fibres, all simulations were run with and without annular fibres.

The distribution of BMD inside the vertebral bodies was highly dependent on the loading conditions; denser bone was found in the anterior part of the endplates and in the cortical shell when flexion was considered compared to pure compression. After nucleotomy the bone was highly resorbed in the central part of the endplates and the underlying cancellous bone. In contrast, the cortical shells became denser. Furthermore, the absence of fibres provoked a change in load sharing between annulus and nucleus in the intact model leading to higher BMD in the outer part of the vertebral body and the posterior elements and lower BMD in the body core. However, this influence was not seen after nucleotomy.

In this study, the changes after nucleotomy have been shown to be comparable to those previously seen in clinical studies. The annular fibres had a mechanical influence on the bony structures of an intact FSU but, in contrast to our expectations, not after nucleotomy. In the present simulations only the bone remodelling was considered. In future simulations, the healing potential of the nucleotomized intervertebral disc will be also taken into account.