11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Finite element study of healthy, pathological and surgical lumbar spine biomechanics.

A. Calvo-Echenique[1], J. Cegoñino[1], L. Bances[2] and A. Perez del Palomar[1]

[1] Group of Biomaterials (GBM)
Aragon Institute of Engineering Research (I3A)
Universidad de Zaragoza, Spain
acecheni@unizar.es
[2] Department of Neurosurgery
Hospital Clínico Universitario Lozano Blesa de Zaragoza (Spain)

Key Words: *Lumbar, intervertebral disc, degeneration, ageing, arthrodesis, cage.*

INTRODUCTION

Lumbar pain is one of the most common problems of population. Far too often it is caused by ageing and degeneration of intervertebral discs (IVD). Fusion techniques, as arthrodesis, were the first surgeries used to avoid lumbar pathologies. However, arthrodesis reduced dramatically the spine movement[1]. So the aim of this work was to study numerically how different pathologies affect lumbar spine biomechanics. Different intervertebral disc cages insertion (arthoplasty[2]) were analysed and compared with healthy and pathological results.

MATERIALS AND METHODS

First of all, a new finite element model was created from CT images and validated with experimental data from literature[3]. After the validation, the degeneration and ageing process was simulated and compared with healthy lumbar biomechanics.

Arthrodesis and arthroplasty surgical techniques were numerically simulated. For arthrodesis simulation a screw fixation FE model was created and inserted in the FE lumbar model. The cages, which were implemented to simulate the arthroplasty, were OLYS[4] and NEOLIF-PLIF[5]. They were inserted in L4-L5 segment and were simulated with and without posterior screw fixation (Figure 1).

In order to prove the properly work of cage implant, different cyclic loads were simulated and compared wiht the healthy one[6].

Figure 1. Finite element models.

A) Healthy lumbar spine.

B) Arthrodesis.

C) Cage implant+ screw fixation.

D) Cage implant

RESULTS AND DISCUSSION

At it is known, disc degeneration causes a loss of water content in the disc, a reduction in its height and an increase in stresses. On the other hand, ageing produced a reduction in water and proteoglycans content which cause similar effects. Thus, the purpose of the surgical techniques is to avoid pain and maintain disc height.

The variables chosen to analyse the lumbar biomechanical behaviour were range of motion (ROM) and maximal and minimal stresses in the intervertebral discs.

In our simulation surgical techniques with screw fixation achieved disc decompression releasing the pain. However, it also removed the physiological motion of the pathological segment. For these reasons, the adjacent segment showed an increase in stresses, which could produce the progression of the degeneration. It has been seen that prostheses surgeries without posterior fixation can restore the pathologic segment motion in a 60-80% range. In this study both commercial cages have been compared. Therefore, it would be possible to choose the best prosthesis geometry, in order to substitute the damaged intervertebral disc.

CONCLUSION

The goal of this work was to simulate a new surgical technique which eliminates posterior screw fixation and reproduces healthy biomechanics.

We have concluded that the insertion of an intervertebral prosthesis without using posterior fixation maintains the physiological movement of the lumbar spine minimizing the stresses in the adjacent segments. This effect would decelerate the degeneration progress that has been observed in these surgeries. We also proved that the long term effects are lower without posterior fixation.

ACKNOWLEDGEMENTS

We want to express our gratitude to Prof. Vicente Calatayud and Dr. Luciano Bances for their medical support.

REFERENCES

[1] E.Guerado et al. Spinal arthrodesis. Basic science. *Rev. Esp. Cir. Ortop. Traumatol.* 227-244, 2012
[2] Shin-Hao Chen et al. Biomechanical comparison between lumbar disc arthroplasty and fusion. *Medical Engineering & Physics* 244-253, 2009
[3] Yabo Guan et al. Moment-rotation responses of the human lumbosacral spinal column.
[4] http://www.scient-x.com
[5] NEOLIF-PLIF de BIOMET spine
[6] H. Schmidt et al. Response analysis of the lumbar spine during regular daily activities – A finite element analysis. *Journal of Biomechanics*, 1849-1856, 2010