DETERMINATION OF THE STRESSES IN BONE CEMENT AFTER KYPHOPLASTY

MSc Thesis Abstract

Mubeen Shahid

INTRODUCTION

Fractured vertebral bodies in human spine are often stabilized by Kyphoplasty. In this technique, a deflated elastic hose is first inserted into the vertebral body. By blowing it up, a hollow space is created in the vertebral body which can be filled with bone cement. The amount, distribution and elasticity of the bone cement may vary.

In the first part of this study the stresses in bone cement of various Kyphoplasty models are analyzed in order to help deciding the volume, location and number of cement injections for certain general types of vertebral body fractures by checking for minimum stresses in the affected region.

In the second part of this study, various contact conditions between cancellous bone and bone cement are simulated. The resulting stresses are compared to the stresses from the previous model that included cement and bone as ideally bonded solids.

METHOD

Within the scope of this master thesis an existing finite element model of the healthy lumbar spine was modified. A submodel of L3 vertebra was created and subsequently refined. The boundary conditions for the submodel were taken from the previous simulations of the FE model of spine.

Six types of fractures were introduced in the vertebral body L3. Different volumes and shapes were used for the cement filling. The elastic modulii of cancellous bone and bone cement as well as the stiffness of the fracture gap were varied within certain limits. The fracture type, cement volumes and cement distributions were also varied.

The following loading cases were simulated: Standing, flexion, extension, lateral bending, axial rotation and walking.

Using the probabilistic methods, 50 samples for each kind of loading were generated in which all the input parameters were varied simultaneously and randomly in order to determine their influence on stresses in cement and vertebral body, and solved for the unknown stresses.

The connection between bone cement and cancellous bone is form-lock fixing. This means that separation of two materials may occur under stresses. For the probabilistic study, rigid connection was assumed. However in the second part, i.e. parametric study, different contact conditions between cement and bone were assumed for cement filling in order to estimate the effect of contact conditions on the results. Hard contact and soft contact (linear pressure overclosure relation) were used for the further simulations.

TASKS

The master thesis includes following subtasks:

1- Familiarization with Kyphoplasty, FE model of the lumbar spine, ABAQUS/Standard, MSC Patran and OptiSLang.
2- Creation of a submodel of the L3 vertebra from the finite elements model of lumbar spine.
3- Performance of a probabilistic study for evaluating stresses in the submodel.
4- Tabular and graphical presentation of the results
6- Determining the effect of different contact conditions
7- Summarizing the comparisons of the results from both studies.

The thesis was done at the Spine Lab of Julius Wolff Institute, Charité Universität Medizin, Berlin. Dr. Ing. Antonius Rohlmann from Charité-Berlin supervised the thesis work. Prof. Dr. Klaus Hackl, Head of the Institute of General Mechanics, Ruhr University Bochum, examined the thesis.
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MSc-Engr. Mubeen Shahid e.mubeen@gmail.com