EXPERIMENTAL MEASURMENTS OF THE LUMBAR SPINE STIFFNESS

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Abstract: The purpose of the presented study was the experimental measurement of the lumbar spine stiffness and the range of the motion. During experimental measurement was observed deflection of lumbar spine segment due to moment of flexion. From measured data was determinate a stiffness of spine segment. In the Laboratory of Biomechanics was developed a new type of total intervertebral disc replacement and results obtained from this experimental measurement was used for design of this replacement.

Introduction

One common cause of low lumbar back pain is degenerative disc disease. A physiological intervertebral disc has several functions in the axial system. Each disc is attached to the vertebra above and below and serves as a connector and a spacer. Surgical treatment of back pain becomes more common in medical practice. There are two surgical methods in treating back pain (when replacing intervertebral disc): spinal fusion and artificial discs. Disadvantage of the fusion is decrease of mobility in dependence on the increasing of adjacent vertebrae and discs load. Next none of currently available artificial intervertebral discs does respect all properties of natural disc (no shock absorption, no bending and torsion stiffness). Therefore surgeons came with a demand to develop a new artificial disc, which would respect all physiological properties of intervertebral disc.

The goal of this work is experimental measurements of lumbar spine stiffness and range of motion. Results of these experimental measurements are used as an input data for creating a new artificial disc which is developed in Laboratory of Human Biomechanics.

Materials and Methods

For developing a new artificial intervertebral disc is necessary know physiological properties of lumbar spine. Determination of these physiological properties, namely answer of lumbar spine segment to mechanical loading is goal of this project.

To verification of experimental technique was used lumbar spine of pigs. Measured sample was three lumbar vertebrae composed by three vertebral body and two intervertebral discs. All muscles were removed but all ligaments were preserved. Measurements were carried out of the fresh motion segments.

Experimental measurements were carried out in Laboratory of Human Biomechanics on the test system MTS 858.2 MiniBionix, where is possible axial loading and moment of force at the same time. Own measurement were carried out in special measurement device, where loading is possible in two axes (Figure1).

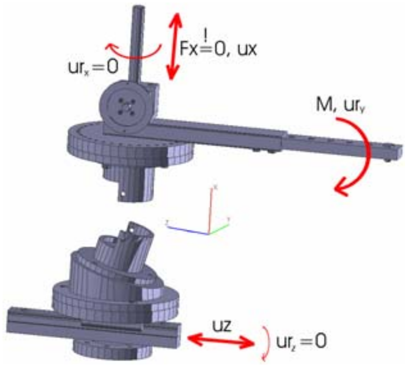

Figure 1: Special measurement device

Measurement device was designed so as to additional moment didn't affect. It was ensure by condition that F_x must be zero and free movement in the Z axis (Figure 1). That way were motion segments loaded by "pure" bending moment only and angular displacement was written by the sensor.

All measured motion segments were loaded in the four direction: flexion, extension, right lateral bending and left lateral bending. Experimental measurements were carried out for each of ten specimens.

$$k = \frac{M_C}{\varphi} \qquad \left[\frac{N.m}{\deg}\right] \qquad (1)$$

Resulting stiffness were determinate by using the equation (1), where M_c is a general moment and φ is an angle of the motion.

Results

The apparatus described in this paper was capable of applying continuous and bi-directional pure moments to multi-segment spine specimens in a highly reducible fashion (Figure1).

Curves were determined for the two directions of loading (Figure 2) and (Figure 3.). Three spine specimens were tested for each of these two motions. Maximal ranges of the motion were 17.9 ± 2.3° for flexion, 18.1 ± 1.8° for extension.

ISSN: 1727-1983

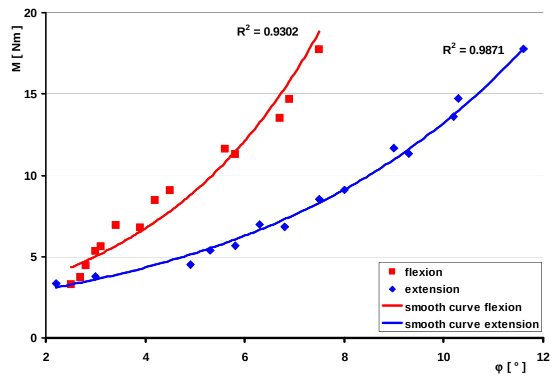

Figure 2: Graph of motion in flexion and extension

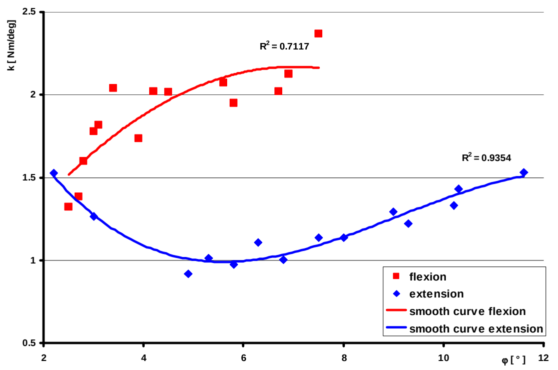

Figure 3: Graph of stiffness in flexion and extension

Discussion

The goal of this work is experimental measurements of the lumbar spine stiffness and range of motion. Our cadaveric model simulated physiological loading of lumbar spine. Although this may not represent a truly physiologic model, it represents the most real function of the lumbar spine.

Conclusions

The apparatus described in this paper applies pure moment loads to multi-segment lumbar spine specimens continuously and bi-directionally about the natural position. The advantage of this approach is that it permits the analysis of the behaviour of the spine within the neutral zone region. The apparatus has been designed to minimize the off-axis moment, however small additional moment influenced our results.

In this experiment was carried out verification of experimental technique that is highly reproducible and objective. Nevertheless results obtained from presented experimental measurements didn't statistically relevant therefore project is still in progress.

Acknowledgement

The research is supported by the Czech Science Foundation: "Research of biocompatible materials that are useable for production of new type of total intervertebral disc replacement", No. 106/05/2174.

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