ON THE PROBLEMS OF NUMERICAL AND EXPERIMENTAL INVESTIGATION OF THE BIOMECHANICAL SYSTEMS

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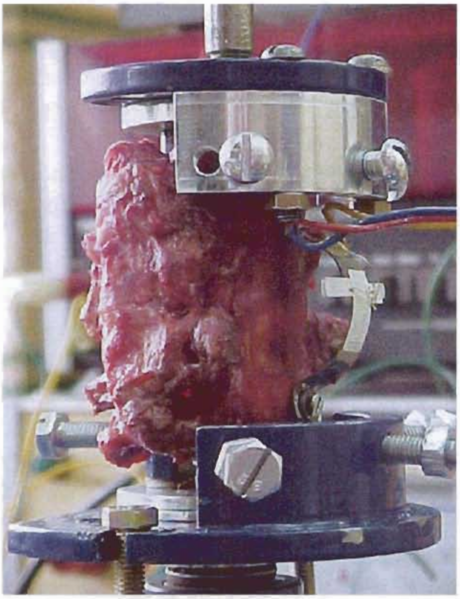

Fig 1. Experimental rig with lumbar spine segment

This paper describes selected biomechanical problems which have been investigated recently in the Department of Automatics and Biomechanics chaired by the autor. Our research is mainly concentrated on finite element analysis (FEM) of muscles-skeletal systems. At the beginning we analysed dynamical properties of the human vertebral column with implants [1, 2]. The mentioned works are aimed to build finite element models of lumbar spine sections with implants and to investigate static and dynamics properties of such biomechanical system [3, 4, 5]. The finite element model includes different forces magnitude acting in different directions. Stresses and displacements obtained from computations are validated by comparison with the data obtained from the experiment. The experimental rig has been designed and built [1]. The human lumbar and cervical spine segments are taken from cadavers and tested on the experimental rig [10, 11] (Fig. 1). After analysis of computations and experimental data one can conclude that numerical model is build properly and it might be used for further implant designing and testing.

Another example of applying FEM in biomechanics is investigation of implants used in ischaemic heart disease therapy [6, 7, 12]. Coronary artery disease is a leading cause of morbidity and mortality in the world. Severe reduction in the circulation to the heart may cause infarction that can lead to death. Symptoms and health risks of coronary artery stenosis may be treated medically by modifying risk factors or by adducing medications. When medical treatment is not effective or is not appropriate, coronary angioplasty (PTCA) or coronary artery bypass grafting (CABG) are considered. Coronary angioplasty is a minimally-invasive procedure in which a catheter

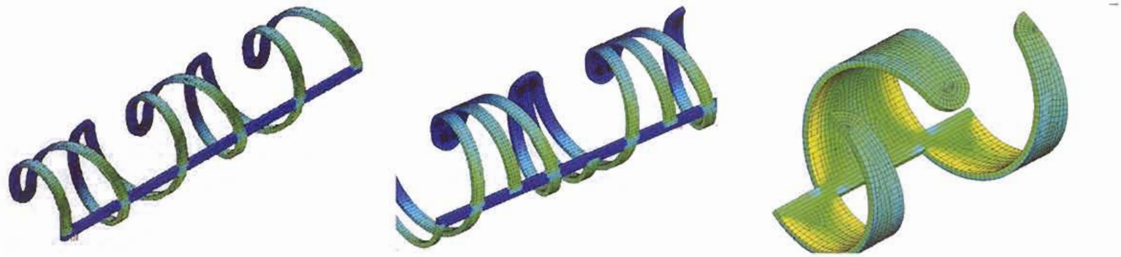

Fig 2. Finite Element Models of STENTS

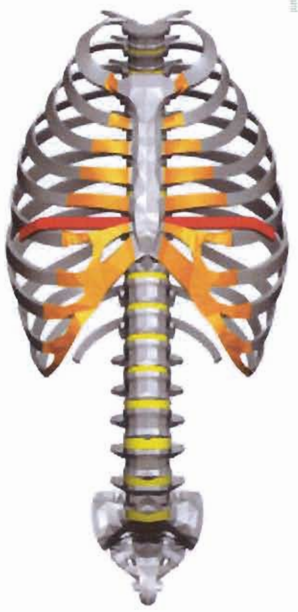

Fig. 3 Thorax model with Nuss implant

with an inflatable balloon at the tip is inserted into the lumen of the artery and inflated, dilating the area of blockage. However restenosis following angioplasty is common. Approximately 15 to 20% of stented arteries restenose. Implant called Stent were developed to address the problem of restenosis FEM models of stents are developed and investigated (Fig. 2). Computational analysis of various type of stents are carried out. Achieved data give us clear directions - how to build a new, better coronary implant.

The new biomechanical problem, we are working on, is the thorax finite element model. The thorax model is developed in order to perform more details investigation of the human rib cage responses and injuries subjected to impact loads [8, 9]. Two thorax models are considered, first model is designed to investigate stress distribution in a healthy human rib cage. The second one is a numerical model of a chest after Nuss pectus excavatum repair procedure (Fig. 3). The Nuss implant is left in a human organism for two or even more years. It can happen that during such a long period of time a patient may participate in a road accident. Therefore, an investigation of a rib cage responses to impact loads is carried out. Pectus excavatum, or a funnel chest, is one of the most common major congenital anomalies, occurring in approximately one in every 400 births. The FEM models are established with impact velocities ranging between 5 - 9 m/s and impactor masses of 23 kg. Comparison of stress distribution in skeleton parts for these two cases is expected to be useful for an appropriate further implants design. Careful analysis of our computation leads to the following conclusions: in the model with implant a fracture of the 5-th rib will appear faster and it is caused by a smaller force, and the implant may damage lungs or heart. It is easy to recognize that stress distribution is violated by the implant and in the health thorax ribs (1-7) transfer a large majority of the load. Comparing results of displacements one can conclude that the sternum displacement in the model with implant is smaller. However, it can be an illusion since the implant causes faster fracture of the 5-th rib, and the thorax stiffness becomes weaker.

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