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

SIMULATION OF PROCEED® SURGICAL MESH APPLIED TO VENTRAL HERNIA REPAIR

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Key Words: *Membrane, Biomechanics, Implants, Finite Element Modelling, Experiments.*

Laparoscopic treatment of hernia is quite common medical technique. However, a significant number of recurrences of the illness takes place [1], in particular, in the case of incisional hernias. This fact indicates the necessity of the assessment of the hernia repair persistence. For this, a definition of mechanical models of implanted meshes and their analyses are required. The paper deals with mathematical modelling and analysis of surgical meshes applied within the treatment of hernia.

In the present research, Proceed® implant is considered. The system is subjected to short-time dynamic pressure load, similar to post-operative cough naturally occurring in human abdomen. Thus, the mesh can be modelled by description of its elastic behaviour only. As the implant is made of knitted orthotropic material, the dense net model is applied to the material modelling (see e.g., [2,3]) of the surgical mesh. Two moduli of elasticity represent the mechanical properties of the analysed mesh, E_1 = 50 N/mm and E_2 = 7.4 N/mm.

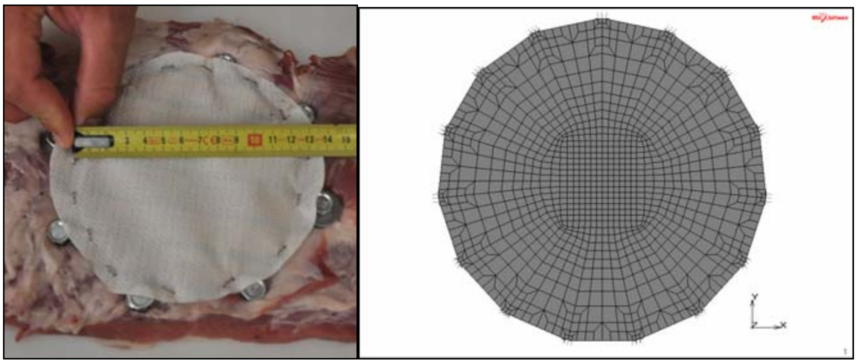

Fig. 1. a) physical model of operated hernia; b) finite element model of implanted mesh

The model refers to a clinical case of 5cm of hernia operated by Proceed implant fixed by 15 joints every 3cm around the orifice. The simulations of the implanted mesh are performed by means of the Finite Element Method. The implant is modelled as a membrane structure supported by visco-elastic springs [4]. Elastic foundation representing the abdominal wall are also included (see e.g., [2]).

The finite element simulations are compared with the experiments performed on the physical models of hernia prepared with the use of porcine abdominal tissues, which supports the implant membrane. The model geometry and the displacement of the implant undergoing the cough pressure are presented in Fig.1. The pressure load grows within 0.1s until the extreme value and then goes down until 0 within next 0.1s. In the study the maximum value of the pressure equal to 43,34 kPa has been applied in the experiment and simulation. Total simulation time was 2s. The appropriate Rayleigh damping parameters were included in the model. The calculated and experimental values of the membrane deflection are compared in Fig. 2.

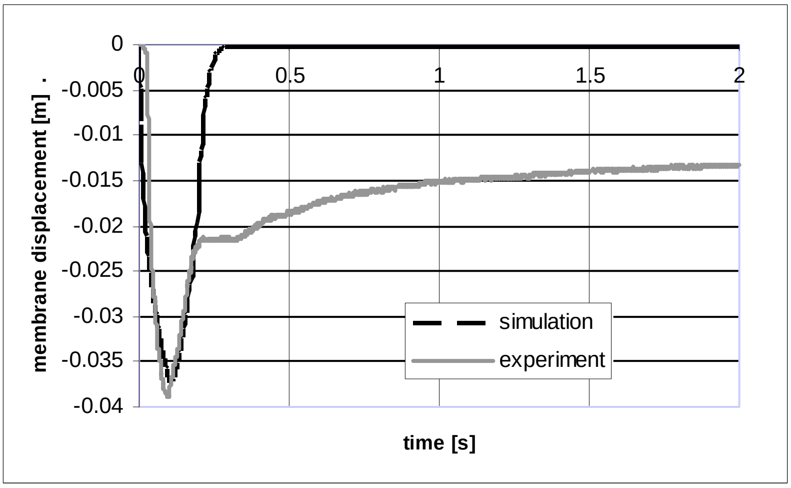

Fig. 2. Implant model displacement undergoing cough pressure; simulation versus experiment

The good accordance of calculated and experimental results assures the model accuracy. The forces in joints can be calculated and compared with the tissue-implant joints strength and thus to estimate the hernia repair persistence. The proposed model and it finite element implementation and simulation can be applied drawing hints in planning the surgery with the use of Proceed implant.

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