ADJUSTMENT OF PROSTHETIC SOCKET USING FINITE ELEMENT ANALYSIS

Agata Mrozek (1)

1. *Institute of Applied Mechanics, Poznan University of Technology, Poland*

Introduction

Additive manufacturing techniques found a wide range of applications in the area of prosthetics. These technologies enabled the manufacturing of prostheses adapted individually to the patient's anatomy. The prosthetic socket is the component of the prosthetic appliances which enable to attach residual limb to the prosthesis The interface pressure between the residual limb and prosthetic socket has a significant effect on quality of users' life. Due to the individual anatomical shape, it requires a high level of customization [1-2].

The finite element analysis delivered tools which enabled to evaluate the interface pressure between the residual limb and prosthetic socket and validate the socket shape. This will allow to speed-up the design process of prosthetic socket.

Methods

The finite element model consists of three components: residual limb, bone and prosthetic socket. Hyperelastic behaviour of residual limbs soft tissues were defined using generalized Mooney-Rivlin Solid strain energy function [3].

In this study, the donning procedure of press-fit sockets was simulated. During the first step of analysis, the value of the displacement vector applied to the socket ensures that this component is appropriately positioned.

In the second step of the analysis, following simulation of the donning procedure, the loads correspond to the loading conditions during selected activities and different gait phase were applied.

Volume changes in the residual limb are considered as essential factor which significantly affects limb-socket interface pressure. The analyses were conducted for two assumed level of changes: 5% and 10 %.

Results

The obtained results allow for a detailed analysis of the interface between prosthetic socket and residual limb and evaluation of the durability of socket during various activities.

The highest values of the contact pressure after donning procedure were observed in the spots, specially designed in order to obtain the press fit socket. Nevertheless maximum value of contact pressure was lower than defined pain threshold.

The obtained results enable to indicate the area of residuum-socket interface which have to be corrected. For example, as shown in Figure 1, during the stance phase, the highest value of the contact pressure, 31.5 kPa, was observed at the distal tip of the residuum which is sensitive area.

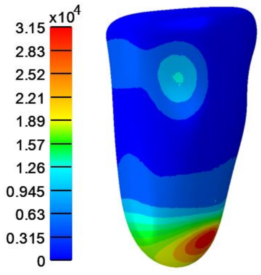

Figure 1: Contact pressure during the stance phase (expressed in [Pa]) – residual limb

For the residual limbs after the increase in their volume, the highest values of contact pressure were observed for the upper edges of the socket sliding on the residuum surface. The observed changes have also a significant impact on the obtained value of contact pressure. Increase of 10% in the volume of residuum, results in increase in the value of maximum contact pressure equal to 80% (Fig. 2).

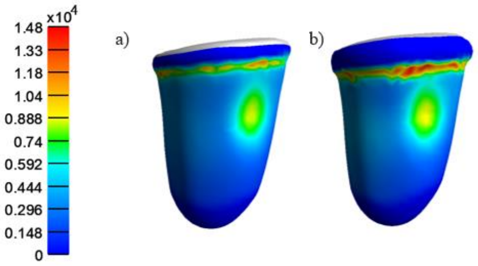

Figure 2: Contact pressure after donning procedure (expressed in [Pa]) for different value of relative volume change: a) 5%, b) 10%.

Discussion

The finite element analysis delivered tools which enabled to evaluate the interface pressure between the residual limb and prosthetic socket and validate the socket shape. This allows to speed-up the design process of prosthetic socket. Evaluation of prosthetic socket design using finite element analysis enable comparative assessment of wide range of socket design and their optimization.

References

1. Steer J.W. et al, Prosthet Orthot Int, 45(2):138-146, 2021.
2. Lacroix D. et al, Ann Biomed Eng, 39:2972, 2011.
3. Portnoy S. et al, Ann Biomed Eng , 37:2583, 2009.