NUMERICAL MODELLING OF THE BREAST RECONSTRUCTION USING SILICONE GEL-FILLED IMPLANTS

Bruno Areias (1), António André (1), Ana Margarida Teixeira (1), Sofia Brandão (2), Pedro Martins (1,3)

1. INEGI, Portugal; 2. CESPU, Portugal; 3. ARAID, Spain

Introduction

In the last two decades, the number of women undergoing breast implant procedures, used in aesthetic, oncologic and risk reducing surgery has exponentially increased [1].

Breast reconstruction allows to reestablish breast shape and volume, restoring the patient's body image, the sense of femininity as well as improving the overall quality of life [2]. These artificial devices can be implanted under the breast tissue (subglandular) or the chest muscle (retropectoral) [3].

The breast implant procedure continues to improve, over time, but changes in breast behavior after augmentation have not been fully investigated, mainly by using of finite element methods. In this study, the authors pretend to apply the finite element method to investigate the static and dynamic behavior of the breast with and without implant, therefore it is possible to select materials which can lead to a more natural breast.

Methods

The numerical work of the human breast incorporates the ribs, pectoral muscles, adipose and fibroglandular tissues and skin (see Figure 1). The breast implant (silicone implant) was also included in the finite element model to investigate the effects of the breast augmentation surgery. In total, the mesh is composed by 565 576 nodes and 525 036 elements, from which 224 272 element of the type C3D8H (linear fully integrated hybrid element) type and 300 764 elements of type C3D8 (linear fully integrated element). The geometry of the breast model was obtained through a set of MRI images (from 1 patient). The images were segmented using the Mimics software (v19.0.0.347, Materialise) in order to obtain the geometry. The Software Abaqus Standard [4] was used in order to conduct all numerical analysis. The boundary condition applied to the model was the fixation of the rib, being then extracted the natural frequencies and the corresponding vibration modes. The mechanical properties of the tissues and implant were based on the literature.

Discussion

Natural breast augmentation is a surgical procedure that utilizes fat stored in the body to increase the breasts size through fat transfer surgery. They have advantages in comparison with the silicone or saline implants in relation to the biocompatibility and cost-effective [5]. However, this procedure has the disadvantage that can lead to radiological images which can be confused with breast cancer and are less permanent as fat can be absorbed. The use of non-natural implants (silicone and saline implants) lead to a change of the tissue behavior which is a disadvantage of the procedure. With this numerical study, the authors intend to investigate new materials and configurations to improve the natural feel and reduce the tendency to ripple in the silicone implant.

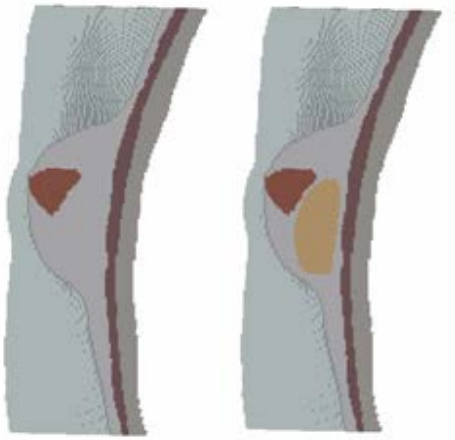

Figure 1: Cross section view of the finite element model - human breast with (right) and without silicone implant (left).

References

1. Marra, Antonio et al., Cancer Treatment Reviews, 84: 101963, 2020.
2. Cooper, D. et al., Plast Reconstr Surg Glob Open, 9:e3614, 2021.
3. Amisha and Bijal, Indian J Radiol Imaging, 26:216–225, 2016.
4. Dassault Systemes, ABAQUS analysis user's guide, 2016.
5. Yalcin Bayram et al., Arch Plast Surg., 46:498–510, 2019.

Acknowledgements

The authors gratefully acknowledge funding from FCT, Portugal, MCTES, FSE and EU under project MImBI - PTDC/EME-APL/29875/2017 financed through FEDER and FCT. This work was supported by FCT, through INEGI, under LAETA, project UIDB/50022/2020.