STUDY OF THE STRESS TENSOR TYMPANI MUSCLE FOR DIFFERENT CASES OF THE EARDRUM

Carolina Garbe (1), Fernanda Gentil (2), Marco Parente (1), Pedro Martins (1), Renato Natal Jorge (1)

1. IDMEC, Faculdade de Engenharia da Universidade do Porto, Portugal
2. IDMEC, Faculdade de Engenharia da Universidade do Porto, Portugal.
Clínica ORL-Dr. Eurico Almeida, Widex, ESTSP

Introduction

The middle ear contains three ossicles: malleus, incus and stapes. The movement of the ossicles can be enhanced by two muscles, the muscle of the stapes (stapedius muscle) and the muscle of the malleus (tensor tympani). These muscles contract in response to loud sounds, reducing sound transmission to the inner ear. The objective of this paper is to analyze the stress tensor tympani muscle from a study of different types of existing eardrum through the use of a computer model of the tympano/ossicular chain.

Methods

The digital geometric model of the tympano-ossicular chain, was utilized [Gentil et al., 2010], and the eardrum was adapted [Garbe, 2010] based on the dimensions described in the literature [Paço, 2003]. The *pars tensa* of the eardrum was considered to be divided into three layers according to their anatomy. The central layer is predominantly responsible of the stiffness of the eardrum, with radial and circular fibers. It is known that there are three different cases according to the distribution of circular fibers [Paço, 2003] (table 1 and figure 1).

	Description
Case 1	Eardrum with a circular band of fibers that surrounds all quadrants equally
Case 2	Eardrum with a circular band of fibers that decreases in thickness in posteriors quadrants
Case 3	Eardrum without a range of circular fibers in the posterior/superior quadrant

Table 1.Description of cases.

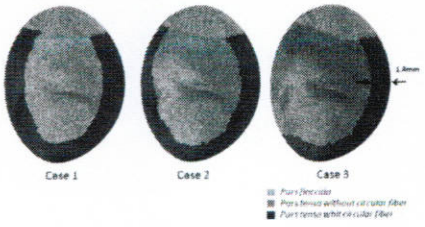

Figure 1. External face of eardrum - pars flaccida and pars tensa for case 1, case 2 and case 3.

The properties of the eardrum were set according to their anatomy. For the *pars tensa* different properties for each layer were used. The central layer properties were characterized by different types of fibers distribution.
Related to the boundary conditions, the eardrum is attached to simulate the tympanic sulcus. The malleus is attached by superior, lateral and anterior ligaments and the tensor tympanic muscle; the incus by the superior and posterior ligaments; the stapes by stapedius muscle and the annular ligament.

Results and conclusions

Simulations were carried out applying a uniform sound pressure level of 105 dB SPL in the eardrum.
This paper analyzed the results of the tensions of the tensor tympani muscle to different simulations performed with the different existing eardrums. We can observe that the highest levels of tension of tensor tympani muscle occur in the model case 3, then for the case 2 and finally in case 1.

Acknowledgement

The authors would like to thank the Ministério da Ciência, Tecnologia e Ensino Superior – Fundacão para a Ciência e a Tecnologia, Portugal, through the exchange of reference SFRH/BD/74731/2010 and de project "Estudo bio-computacional do zumbido" (PTDC/SAU-BEB/104992/2008).

References

Garbe C, Gentil F, Parente M, Martins P, Natal Jorge RM, Ferreira, A.: Development of Computational Model to Analyze the Influence of Fiber Direction in the Tympanic Membrane. 6 International Conference on Technology and Medical Sciences. Porto. 2010.

Gentil F, Parente M, Martins P, Garbe C, Natal Jorge R, Tavares J, Ferreira A: The influence of the mechanical behaviour of the middle ear ligaments: a finite element analysis, in Part H: Journal of Engineering in Medicine. 2010, vol 225, pp 68–76.

Paço J: Doenças do Tímpano, LIDEL Edições Técnicas Ltda. 2003, vol. 1, pp 57-65.