A COMPARATIVE STUDY OF MYRINGOSCLEROSIS

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Introduction

Anatomically, the ear is divided into three parts (external, middle, and inner ear). The eardrum divides external from middle ear and can develop some pathology. The majority of the eardrum is composed by *pars tensa* being the *s*uperior area known as *pars flaccida*. Myringosclerosis (formation of dense connective tissue in the eardrum) is a common sequel of the ventilation tube insertion used for the treatment of the media otitis with effusion. It can affect tympanometric evaluation by decreasing mobility of the eardrum. However, usually, it is not associated with hearing loss.

Methods

In this work, a finite element modelling of the middle ear, based in imagiology, was made. The model includes the eardrum, ossicles (malleus, incus and stapes), ligaments and muscles. The eardrum was discretized by hexahedral solid elements and the ossicles were descritized by tetrahedral elements. Linear elements model the ligaments and the muscles.

Hyperelastic behaviour of the ligaments was taken into account using the Yeoh model.

The strain-energy function ψ [Holzapfel, 2000] for the Yeoh model can be written in the form:

$$\psi = c_1 (I_1 - 3) + c_2 (I_1 - 3)^2 + c_3 (I_1 - 3)^3 \qquad (1)$$

where c_1, c_2 e c_3 are the material constants that must satisfy certain restrictions [Martins, 2006].

For the ossicles, the elastic properties available in the literature were considered [Prendergast, 1999].

The connection between ossicles was done using contact formulation, which can be interpreted as a simulation of the capsular ligaments.

Boundaries of the finite element model include tympanic annulus, the connection between the stapes footplate and the cochlea, and the connection of suspensory ligaments and muscles to the temporal bone.

In the present work, static and dynamic studies were done, using the ABAQUS program.

Figure 1: Eardrum with myringosclerosis.

Results

Considering a level sound pressure of 100 dB SPL, the obtained results for different regions of myringosclerosis are compared with the results of normal eardrum. The greatest value obtained for the stapes footplate displacement was 1.32E-8 m and it corresponds to a frequency of 441 Hz.

Discussion

The aim of this study was to evaluate the effects of myringosclerosis according the quadrants where it can occur. We can conclude that there are not significant differences of the movement of the stapes.

References

PALS Martins *et al.*, A Comparative Study of Several Material Models for Prediction of Hyperelastic Properties: Application to Silicone-Rubber and Soft Tissues, **42**:135-147, 2006.

G.A. Holzapfel, *Nonlinear solid mechanics*, John Wiley & sons, Ltd., New York, 2000.

PJ Prendergast *et al.*, "Vibro-acoustic modeling of the outer and middle ear using the finite element method", *Audiol Neurootol*, **4**:185-191, 1999.

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