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A COMPARATIVE STUDY BETWEEN EARDRUM PERFORATIONS AND MYRINGOSCLEROSIS

***F. Gentil[1], R.M. Natal Jorge[2], A.J.M. Ferreira[3], M.P.L. Parente[4], P.A.L.S. Martins[5], and E. Almeida[6]**

[1] FEUP, ESTSP, Widex
Av. Boavista 117 6º Porto
fgentil@clix.pt

[2] IDMEC, FEUP
R. Dr. Roberto Frias, Porto
rnatal@fe.up.pt

[3] INEGI, FEUP
R. Dr. Roberto Frias, Porto
ferreira@fe.up.pt

[4] IDMEC, FEUP
R. Dr. Roberto Frias, Porto
mparente@fe.up.pt

[5] IDMEC, FEUP
R. Dr. Roberto Frias, Porto
palsm@fe.up.pt

[6] Clin. ORL Dr.-E. Almeida
Av. Boavista 117 6º Porto
clinicaorlea@telepac.pt

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ABSTRACT

The eardrum receives vibrations travelling through the external ear and transfers them through the ossicles (malleus, incus and stapes) to the inner ear. However, it can suffer several damages, which can result in hearing loss. Most children have otitis media that usually go away, often resolved either on their own or with antibiotic treatment, but some cases are more complicated. Fluid builds up in the middle ear and stays there for months. Perhaps the child's hearing gets noticeably worse. Or maybe the ear infection disappears, but comes back. In these cases a surgical procedure called a myringotomy with tube insertion to drain out fluid from the middle ear is needed. The main benefit is that myringotomy with tube insertion restores hearing and reduces the frequency of ear infections, however, as with all surgeries; myringotomy carries a risk of complications. One of them can result in myringosclerosis or permanent perforation of the eardrum (Figure 1) [1]. Myringosclerosis looks like a white patch on the eardrum. It is a formation of dense connective tissue. A pure tone audiogram helps to quantify and classify any conductive hearing loss.

The aim of the present study was to evaluate the effects of myringosclerosis and eardrum perforations from a biomechanical point of view.

In this work, a finite element modeling 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 discretized by tetrahedral elements. Linear elements model the ligaments and the muscles. Hyperelastic behaviour of the ligaments was taken into account [2] using the Yeoh model.

The strain-energy function ψ [3] for the Yeoh model can be written in the form:

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

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

In this work the mechanical properties available in the literature were considered [4].

Figure 1: Right ear – Anteroinferior perforation with two myringosclerosis plaques (anteromalleolar and retromalleolar).

The connection between ossicles is 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.

For this purposes, static and dynamic studies were done, using the ABAQUS program.

Considering a 2 Pa acoustic pressure, applied in the eardrum, the obtained results for different region of myringosclerosis, are compared with the results of different sizes of eardrum perforation and the normal eardrum. The great value obtained for the stapes footplate displacement was 1.32E-8 m for a frequency of 441 Hz.

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