Dynamic study of the middle ear using a total ossicular replacement prosthesis

Fernanda Gentil[*], Marco Marques[†], Marco Parente[†], Carla Santos[†], Renato Natal Jorge[†]

[*]Instituto de Engenharia Mecânica (IDMEC - FEUP)
Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal
Clínica ORL – Dr. Eurico Almeida e Escola Superior de Tecnologia da Saúde do Porto
fernanda.fgnanda@gmail.com

[†]Instituto de Engenharia Mecânica (IDMEC - FEUP)
marco.costa.marques@gmail.com; mparente@fe.up.pt; fsantos.carla@gmail.com; rnatal@fe.up.pt

ABSTRACT

Among the many existing hearing problems, there are those that need to be corrected through the replacement of the ossicles of the middle ear with a prosthesis. The type of the prosthesis used in the rehabilitation of the middle ear, total ossicular replacement prosthesis (TORP) or a partial ossicular replacement prosthesis (PORP) depends of the level of the ossicular impairment [1,2]. In the present study, the behavior of the middle ear with a TORP, is analyzed. Using a finite element model, a dynamic study of the middle ear was made. Models were created with a cartilage in the membrane-prosthesis interface of different diameters (4 mm and 5 mm) and thicknesses (0.3 mm and 0.7 mm) and considering 0º and 10º as angles between the TORP and the stapes footplate. The mechanical properties of the tragal cartilage were obtained in the literature according to Wen [3]. The material of the TORP is characterized as being titanium grade 2. The displacements values were obtained at the umbo and stapes footplate, for a sound pressure level of 80 dB SPL applied at the tympanic membrane. The results were compared with the healthy middle ear model [4]. The usage of this model aims to achieve a set of techniques that promotes the best possible performance of prostheses in the middle ear. The present study allows to conclude that the rehabilitation of the middle ear with TORP type prosthesis can lead to the best results when used with 4 mm diameter cartilages, and a thickness of 0.3 mm, with an angle of 0º between the TORP and the stapes footplate.

Keywords: biomechanics; finite element method; middle ear; TORP.

REFERENCES

[1] R.J. Wiet and R.M. Wiet, Experience-driven ossiculoplasty, *Operative Techniques in Otolaryngology-Head and Neck Surgery*, vol. 21, **3**, 211–216 (2010).

[2] B.A. Neff, F.M. Rizer, A.G. Schuring, W.H. Lippy, "Tympano-Ossiculoplasty Utilizing the Spiggle and Theis Titanium Total Ossicular Replacement Prosthesis", *The Laryngoscope*, Vol. 113, **9**, 1525–1529 (2003).

[3] Y.H. Wen, L.P. Hsu, P.R. Chen, C.F. Lee, Design Optimization of Cartilage Myringoplasty using Finite Element Analysis, *Tzu Chi Medical Journal*, Vol. 18, **5**, 370–377 (2006).

[4] F. Gentil, C. Garbe, M. Parente, P. Martins, C. Santos, E. Almeida, R.N. Jorge, "The biomechanical effects of stapes replacement by prostheses on the tympano-ossicular chain", *International Journal for Numerical Methods in Biomedical Engineering*, doi: 10.1002/cnm.2664, Jul 14. 2014.