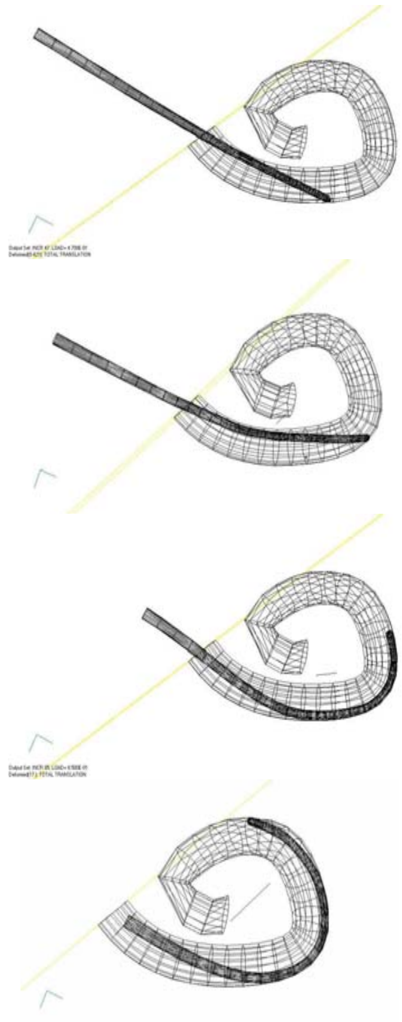
Medical Case Study (Monash University, Australia – Development of a 3D FEM for Evaluating Insertion Trajectories of Electrode Arrays, Contact Stresses and Associated Damage in the Human Cochlea)



Graded Stiffness Array Tip at Approximately 8mm, 11mm, 14mm and 25mm from the Round Window

Monash University (www.monash.edu.au) of Melbourne, Australia used a 3D finite element analysis in this study to model the insertion of the single wire (uniform stiffness), the Nucleus standard straight (graded stiffness) and the Contour electrode arrays with different stiffness properties into cochlear scala tympani (ST). The results show the predicted trajectories and contact stresses exerted by the electrode arrays, from which the propensity of damage can be compared with results of published experimental studies. The present work overcomes limitations of the previous 2D finite element analysis, which was unable to predict out-of-plane trajectories and contact pressures on the basilar membrane.

The electrode array (EA) sliding along the spiral cochlear wall involved large displacements. Therefore NEi Nastran's nonlinear solution was used to solve the problem. The results of the 3D model were found to be consistent with experimental findings.

Results of the model have shown that the graded stiffness array is least likely to cause damage to delicate regions within the scala tympani compared with the Contour and the uniform stiffness electrode arrays. The results have also demonstrated that stiffness properties of EA strongly influence the insertion trajectories and contact stresses which can be associated with damage to the cochlear structures. The degree of damage appears to vary in experimental studies with severe damage reported in some cases, while others were more successful with little or no damage observed. Hence a comprehensive investigation should include other factors such as variation in insertion techniques (angle of entry, applied rotation of EA and the practice of slight withdrawal partway through the insertion when resistance is felt), and variations in the geometry of the ST caused by local regions with non-uniform undulations. This 3D FEM is useful for investigating these factors to achieve optimal insertion techniques which take into consideration geometrical characteristics of individual cochleas. The 3D FEM will also assist in future research on development of improved EA designs with the use of new materials to gain better control of the final placement of the EA.

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