SUBJECT SPECIFIC MODELING OF FACIAL MIMICS DERIVED FROM MRI DATA USING FEM

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Introduction

Finite Element Modeling (FEM) of facial mimics can be used to improve our knowledge about the mechanism of facial expressions, thus helping clinicians to estimate facial disfiguration and to direct function rehabilitation for involved patients. In literature, studies related to FE modeling of facial mimics aimed to estimate the outcome of maxillofacial operations [1], to simulate speech gesture [2] or to animate facial expressions in computer graphics [3]. In this work, a subject-specific model integrating the zygomaticus major (ZM) muscle and soft tissues, based on the segmentation of MRI data, was built and then FE analyses were conducted for simulating three facial mimic movements.

Methods

Geometries of different tissues (muscles, soft tissues and skull) were segmented on MRI images of a healthy subject [6] using ScanIP (Simpleware, UK). Then the geometric models were meshed in Abaqus 6.14-3 CAE. Behavior law was assigned to tissues through subroutine programs VUMAT (for muscle) or existing law in Abaqus (for soft tissues). Precisely, muscle was modeled as transversely-isotropic and hyperelastic material [4] and soft tissues were modeled as Mooney-Rivlin material using literature values [5]. In the meshed models, soft tissues contains 26585 nodes and 109098 first order tetrahedral elements; right ZM muscle contains 1549 nodes and 804 second-order tetrahedral elements; left ZM muscle contains 1443 nodes and 740 second-order tetrahedral elements. Appropriate displacements were applied on muscle according to MRI measurements. Bottom of head model was fixed as boundary condition. The interaction between muscle and surrounding tissues was defined as tie constraint. A series of FE simulations were performed for 3 selected movements: smile, pronunciation of “Pou” and pronunciation of “O”.

Results

Figure 1 shows magnitude of displacement on ZM muscle during the “O” movement and its effect on the external soft tissues. Table 1 shows the comparison between simulation and experimental displacement results of right ZM muscle in different movements. For the displacement of soft tissues, FE result is 3.3±2.2mm while MRI result is 5.3±3.4mm.

Discussion

Simulation results (either muscles or soft tissues) are lower than experimental data with a relative difference of about 22%. This could be explained by the fact that only zygomaticus major was integrated into the facial mimic simulations. However, these numerical results are in the acceptable range by comparison to the results of similar studies in literature [2], [3].

In perspectives, more muscles will be involved in order to improve the simulations of facial mimics. Thus, the coordination of facial muscle will be elucidated for a better understanding of facial mimics leading to provide objective indicators for clinical decision support.

References


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