SUBJECT SPECIFIC FACIAL MIMICS SIMULATION DERIVED FROM MRI

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Introduction

Comprehension of facial mimics mechanism and functional consequences of facial surgery planning is of great interest in clinical diagnosis and treatment of facial disfigurement patients. Some studies aimed to simulate facial expressions or motions due to muscle contraction using biomechanical models ranging from basic model to advanced muscle constitutive model [Hung, 2009]. However, these models are based on generic geometries and there is a lack of experimental data for the numerical simulation as well as for the model validation in a clinical context. The objective of our present study was to perform facial mimics simulation using subject specific data derived from MRI technique.

Methods

MRI Data Acquisitions

A muscle-specific 3Tesla MRI protocol (3DFSPGR Sagittal T1 sequence, FOV=24x24mm², slice thickness = 1.6mm, acquisition time = 7 seconds) was developed at the CHU Amiens to acquire anatomical images of the facial soft tissues (fat and skin) and the zygomaticus major (ZM) muscle at 4 different positions (neutral, smile, pronunciation of sound “O”, pronunciation of sound “Pou”) of a healthy subject (female, 24 yo, 1.5 m, 57 kg).

Subject Specific Geometrical Segmentation, Reconstruction and Meshing

The 3D facial soft tissue (fat, skin and ZM muscles) were segmented, reconstructed, meshed and smoothed using the ScanIP module, Abaqus 6.9, and our Python-based specific procedure [Dao et al., 2011].

Finite Element Simulations of Facial Mimics

The simulations of 3 facial motions (Smile, “O” sound, and “Pou” sound) resulting from ZM muscle contraction were performed using the FEBio code [Maas, 2012]. The ZM muscle is modelled as a transversely isotropic hyperelastic material (full activation level, muscle along-fiber orientation) [Maas, 2012]. Other soft tissues such as skin and fat layer were modelled as one-layer isotropic and hyperelastic material using Mooney-Rivlin mechanical law. Appropriate boundary conditions were applied.

Results

The lengthening process of the ZM muscle to perform the pronunciation of sound “Pou” is illustrated in Fig. 1. As compared to MRI-based experimental data, the maximal absolute displacement deviation is ranging from 0.87 mm to 1.94 mm for all simulated positions. The FE simulations of the “neutral”, “smile” and “O” motions are presented in Fig. 2.

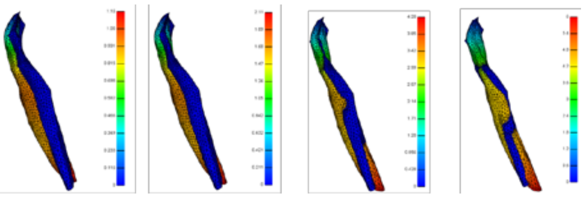

Figure 1: ZM muscle lengthening during the pronunciation of sound “Pou”: the final IRM-based geometry of the ZM muscle is in blue color; color map represents the displacement map (in mm)

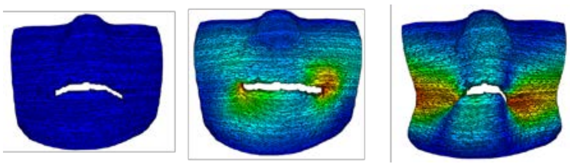

Figure 2: Facial simulation at 3 positions: neutral (left), smile (middle) and “O” (right)

Discussion

MRI-based experimental data were used to evaluate the FE simulation results of facial muscle mechanism. Other facial muscles will be investigated to have a more complete model leading to the simulation of muscle coordination mechanism of facial mimics.

Such study will be of interest for defining objective criterias to evaluate the facial disfigurement patients and to perform the functional rehabilitation.

References

Hung *et al*, WAS, E & T. 54:134-138, 2009

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