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MODEL-BASED SIMULATIONS OF THE INSERTION OF TENSOR THREADS IN PATIENT-SPECIFIC FACE: A PROOF OF CONCEPT

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1. Introduction

Facial paralysis is associated with the loss of motricity of facial muscles, inducing face sagging under the effect of gravity, with aesthetic and functional consequences. In order to compensate for the sagging, surgeons have proposed a clinical procedure consisting of inserting and anchoring biodegradable tensor threads under the skin of the face, in order to restore tension to the sagging areas. This study allowed the realization of a proof of concept of a software tool that uses simulations with a Finite Element (FE) biomechanical model of the face [1] in order for the surgeons to (1) predict the behavior of the face after addition of tensor threads and (2) visualize preoperatively in real-time the postoperative aesthetic appearance of the patient's face using reduced order models (ROM) [2].

2. Materials and Methods

Patient-specific FE face models are generated by registrating a reference Face model using the Elastix library (fig. 1).

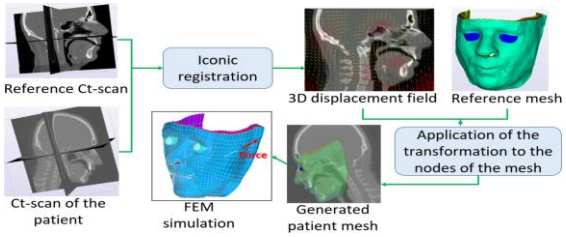

Figure 1: Patient-specific mesh generation

The mesh is composed of four layers, which represent skin, dermis, hypodermis and muscles, modeled by hyperelastic materials. An FE replica of the thread is inserted in the third layer of the FE face model and contacts between thread (that includes a set of hollow cones) and facial tissue are modeled. Nodal forces are then applied at the tip of the thread to simulate its traction (fig. 1) and the lifting of facial tissue. A ROM is then built from a set of selected FE simulations of the impact of the applied force on the facial tissue shape, using the StaticRomBuilder software of Ansys®.

3. Results

A interactive software has been developed using the CamiTK library (camitk.imag.fr), in order for the clinician to (1) build the patient-specific biomechanical face model, (2) insert the tensor thread (position and rotation) in the model, (3) generate the corresponding ROM and (4) test and display in real-time the shape of the face resulting from tractions with the tensor threads (fig. 2).

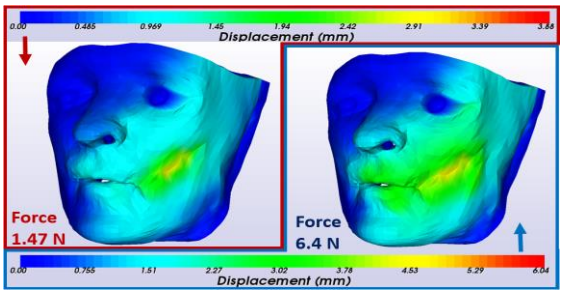

Figure 2: Simulated face appearance after tensile wire traction of two forces imposed by the user.

4. Discussion and Conclusions

We have demonstrated the feasibility of a software that allows surgeons to evaluate for each patient the extent to which the position of the threads can compensate for facial lifting.

5. References

1. Nazari, M. A. et al. (2011). Shaping by stiffening: a modeling study for lips. Motor control, 15(1), 141-16
2. Cueto, E., & Chinesta, F. (2014). Real time simulation for computational surgery: a review. Advanced Modeling and Simulation in Engineering Sciences, 1(1), 1-18