Towards a three-dimensional software model of the oral cavity for tongue surgery planning

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Purpose: Tongue resections, consequent to a cancerous tumour, can cause strong impairments of the patients' ability to speak, even when followed by a reconstruction. Though the biomechanical properties of the flap used for tongue reconstruction impact its mobility, they are not considered as critical factors for their choice, the priority being given to their volume and bulk. We are currently exploring the contribution of a biomechanical model of the oral cavity in the planning of tongue resection surgeries.

Methods and Materials: We exploit a 3D biomechanical model of the tongue (finite element modelling), in which major tongue muscles, either extrinsic or extrinsic, are represented implemented. This model is inserted in the oral cavity including jaw, palate, pharyngeal walls, as well as the hyoid bone. Two common tongue excisions with reconstruction are modelled: a hemiglossectomy and an enlarged mouth floor resection. The impact of the flap mechanical properties on tongue mobility and the production of vowels \i, a, u\ are evaluated in the absence of any compensatory strategy.

Results: First simulations revealed a high desymmetrisation of the tongue movements after a hemiglossectomy, resulting on a deviation more or less pronounced of the tongue apex on the flap or healthy tissues side according to the vowels simulated. The impact of the flap choice was non negligible on the tongue's kinematics, essential for speech production, a rigid flap leading to slower motion. For the mouth floor resection, the nature of the flap had a strong impact on tongue movements, especially on protraction, a high stiffness flap facilitating strongly the advancement of the tongue in the oral cavity.

Conclusion: First results showed an important impact of the flap's nature on tongue mobility in terms of tongue position, shaping and kinematics, dependent on the kind of exeresis. They were globally in agreement with observations usually made on patients, leading to think this model could be of a significant improvement in planning tongue surgery systems. Further improvements would model include algorithmic aspects aiming at a significant decrease of the computation time and mesh matching methods to design patient specific oral cavity models, allowing a more complete evaluation of the model.