A Computational Approach to Muscle Modeling of the Human Tongue via the Finite Element Method Along With Motion Control Correlations With MRI Tracking Data for Simple Speech Patterns

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Tongue motion control results from a complicated series of interactions between multiple tongue muscles. Surgical intervention could possibly affect speech while at the same time producing positive benefits as reduction of retro-palatal collapse. The goal of the study was to represent the tongue as a quantifiable structured geometry specifying the various muscle regions as locally varying directional fields and use this model to determine the affect of altered muscle structure on tongue motion. A quantitative computer simulation of the human tongue was constructed around a finite element model. Muscle morphology was generated from segmentation of images from the Visible Human project and MRI images. The extrinsic and intrinsic muscles were represented as directional fields at a large number of elements. Muscle contraction was produced as a stress controlled region of a locally varying directional field. A Lagrangian formulation of an Ogden hyperelastic material was used for the passive isotropic components and muscle fibers were represented by strain energy and pressure functions. Validation of the model was obtained by comparing tongue displacement or strain patterns generated with various muscle activation patterns with those obtained from tracked MRI images. Quantifiable differences in the motion of the tongue caused by alteration of specific muscle morphology or activation patterns were used to identify regions of the tongue that may be affected by surgical implants and may help in the understanding of patterns of muscle activation in the study of speech and sleep apnea.

