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IN-VIVO MEASUREMENTS OF HUMAN TONGUE ELASTICITY UNDER GENERAL ANESTHESIA USING A VOLUME BASED ASPIRATION METHOD

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Treatment of locally advanced head and neck cancer, in particular tongue cancer, often results in impaired speech, swallowing, or mastication. Due to the complex structures and systems involved in oral functions, it is difficult for a clinician to predict the functional consequences after surgery or chemoradiation. Effective patient counseling and choosing the right treatment is therefore often an arduous task. Simulating the effect of treatments using biomechanical computer models can help the patient and the treating physician to understand the effects and impact of the intervention. Therefore, we are currently developing a Finite Element tongue model that can simulate these postoperative functions.

To simulate the deformations of tissue in the tongue, accurate measurements of the elastic properties are essential. Furthermore little is known regarding inter-person variability. Techniques such as magnetic resonance elastography, shear wave elastography, and ex-vivo measurements have not provided us with sufficient information yet. Recently Elahi et al. (2019) introduced a new measurement technique to estimate elasticity using a volume-based aspiration method (Figure 1). The device was slightly modified to estimate in-vivo tongue tissue stiffness (Figure 2). The method relies on an inverse Finite Element Analysis (FEA) of the aspiration experiment using the Gent hyperelastic material model. The aspirated volume over time is translated to the Young's modulus and the strain limiting factor Jm.

To test the feasibility of this technique for clinical measurements, we measured 16 healthy volunteers ten times, and subsequently estimated their Young's modulus at rest. While the inverse FEA procedure is still in development, the first identified values range from 3 to 5 kPa, with a mean standard deviation of 1.73 kPa within every subject.

However, under normal circumstances, it is hypothesized that muscle tonus will cause the tongue to be stiffer, even if the volunteers were asked to keep their tongue "at rest". In order to measure the tongue with and without muscle tonus, we have started the inclusion of 19 urology and gynecology patients scheduled for surgery under general anesthesia. In the final paper, we will present the results of both the measured elastic properties in normal circumstances and under general anesthesia.

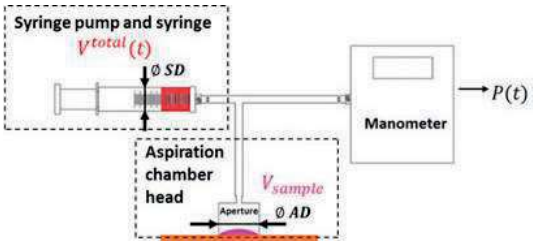

Figure 1: Schematic overview of the setup. By removing a known volume of air, a vacuum is created inside the aspiration chamber. The pressure is measured using a manometer. (Image from: Elahi et al. 2019)

Figure 2: Placement of the aspiration chamber head at the lateral side of the tongue.

References:

Elahi, S. A., N. Connesson, G. Chagnon, and Y. Payan. 2019. "In-Vivo Soft Tissues Mechanical Characterization: Volume-Based Aspiration Method Validated on Silicones." Experimental Mechanics. Retrieved (https://doi.org/10.1007/s11340-018-00440-9).