

Developing a 3D model of the tongue and mouth to assess pressure generation in predict bolus flow when swallowing

Project Design Specifications

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Function: JoAnne Robbins, Ph.D., Director of the UW/VA Swallowing Speech and Dining Enhancement Program (SWAL-ADE) will supervise this project concerning dysphagia, or difficulty swallowing, which affects many adults and children in the U.S. It often is a result of stroke or degenerative neurologic disease. This project will focus on developing a 3D model of the tongue and mouth that will be used to assess pressure generation within the oral cavity during swallowing. This is a third semester project, and we will concentrate on designing a mouth cavity compatible with pressure sensors (MOST device), and a stable base that will also represent the pharynx, esophagus and trachea.

Client requirements:

Our client requires a model that fulfills these requirements:

- Develop a mouth cavity with a hard palate:
 - Compatible with force sensors (MOST device)
 - That supports realistic pressure generations
- Develop a pharynx to allow for controlled bolus flow
- Programmed tongue movements that simulate various forms of dysphagia

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements:* The design should allow for full tongue movement (posterior/anterior), be compatible with sensors that are able to detect a range of pressures (MOST device), and permit realistic pressures during testing.

b. *Safety:* This model would not be in direct contact with patients; therefore, typical medically ethical issues do not need to be considered. However, the model's electrical components should be contained as to not harm the operator.

c. *Accuracy and Reliability:* Our model should mirror the physiology and anatomy of healthy and unhealthy swallowing mechanisms found in humans as accurately as possible.

- d. *Life in Service*: Our model is expected to last for many years, with continual updates to electrical components as technology advances.
- e. *Shelf Life*: Our model will need to be stable on a flat surface and portable.
- f. *Operating Environment*: The model should be able to maintain structural integrity when handled and if dropped.
- g. *Ergonomics*: Our model is not a hand-held device and so ergonomics does not apply directly.
- h. *Size*: Model should be consistent with typical human size. Mouth cavity: ~15 cm x ~15 cm.
- i. *Weight*: Model (including electronics) should not exceed 4.5 kg.
- j. *Materials*: Tongue is currently made of silicone. Hard palate and lower jaw should be constructed using a hard plastic (polycarbonate). Pharynx should be build of a rigid material. The soft palate should be constructed out of silicone.
- k. *Aesthetics, Appearance, and Finish*: Model should accurately represent the appearance of a human mouth, and allow for user visibility when running.

2. Production Characteristics

- a. *Quantity*: At least one functional prototype is needed. Design should be conscious of possible replication.
- b. *Target Product Cost*: Device costs should not exceed 500 dollars.

3. Miscellaneous

- a. *Standards and Specifications*: Model will not be in direct contact with patient; only basic safety specifications will be considered.
- b. *Customer*: Functionality is a priority to the client.
- c. *Competition*: Currently there are no devices that model the swallowing mechanisms of dysphagia.

d. *Modification for the Future*: The design should be conscious of future modifications that will benefit its performance and anatomical correctness.