

Evaluation of a 3D printed silicone oral cavity cancer model for surgical simulations

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Abstract

The use of 3D models for training has been adopted in several disciplines. Its use in head and neck oncology training has however not been optimized. This study aims to evaluate the performance of a model construct of an oral cavity cancer for the purpose of surgical training.

A silicone-based tongue cancer model constructed via a 3D mold was utilized as a surgical simulator and compared with a porcine tongue model. Participants of varying training levels were asked to resect the tumors with clear margins. They were given a survey to evaluate the face and content validity of the models after. Post-ablation imaging was further used to determine the adequacy of margins amongst these participants.

Eleven Otolaryngology clinicians participated in this pilot study. Fellows and staff demonstrated a better margin clearance compared to residents (median 3.5mm vs 1.0mm) and unlike the resident group, there was no incidence of positive margins. In comparison to the porcine model, the silicone model attained a higher face (4 vs 3.6) and content validity (4.4 vs 4.1). Tumor consistency was far superior in the silicone model compared to the porcine model (4.1 vs 2.8, $p=0.0042$). The surgical simulation was overall useful for trainees to appreciate the nature of margin clearance in oral cavity cancer ablation.

This study demonstrates a cost-effective, high-fidelity tongue cancer model that can be used as an adjunct in surgical training.

Methods and Materials

3D segmentations of normal tongue were acquired from previous CT images. Tumor contours (Fig 1a) were drawn within the normal tongue, with creation of a T2 tumor; 2.0 cm x 1.8 cm with a thickness of 0.8 cm. The resulting meshes were then stretched in the anterior posterior dimension by a factor of 1.5 to mimic a stretched tongue during surgery. The 3D segmentations were used to fabricate an inverse mold (Fig 1b) using a 3D printer. This mold was filled in two stages with mixtures of silicone rubber mimicking the elastic properties of tongue and tumor.

Surgeons of varying experience were then asked to surgically resect the tumor with an appropriate margin in both the silicone and porcine models. Participants were given an anonymous survey following the training exercise to evaluate the realism of model, ‘surgical’ experience and their opinion on applicability in surgical training. A Likert scale of 1-5 (1 being strongly disagree and 5 being strongly agree) was used in the evaluation. Margin evaluation was further performed on the excised specimen and compared amongst the clinicians' experience.

Results

The average face and content validity from the survey shows overall better scores (table 1a and 1b) when comparing the silicone model to the porcine model (mean face validity: 4 vs 3.6, mean content validity: 4.4 vs 4.1). Tumor consistency was far more realistic in the silicone construct compared to the porcine model (4.1 vs 2.8, $p=0.0042$). When using a score of ≥ 4 as a cut-off for validity, the average face validity of the silicone model was considered a valid model as compared to the porcine model.

Margin analysis (Fig 2) was performed to determine if the model could reflect the clinical experience of the user. The resident cohort obtained a median closest margin at 1.0 mm (range 0-3.5 mm) with the average closest margin reported at 1.4 mm. Within this group, 1 participant obtained a positive margin while another obtained an extremely close margin at 0.1mm. In contrast, the median closest margin in the attending/fellows group measured 3.5 mm (range 1.4-4.5 mm) with the average closest margin reported at 3.0 mm. The closest margin reported within this group was 1.3 mm. These findings reflect the realistic nature of the model as a valid simulator for surgical training.

Discussion

This study demonstrates the utility of a simulation model in oral cavity ablation. Based on content validity scores, all participants felt the exercise was useful for appreciation of surgical margins. The silicone model fared better in demonstrating the nuances of intraoperative decisions to obtain clear margins. This was reinforced by improved scores in both domains regarding tumor margin assessment. Face validity of the models invariably favored the silicone model, particularly with reference to the tumor construct. This was not surprising as the ability to control the interface between the “normal” tongue and tumor allows for a subtle change in consistency that closely replicates the clinical feel during surgery. This further allows the appreciation of a submucosal extension of tumor that is often difficult to appreciate in less experienced surgeons.

An advantage of the silicone model was ability to review the participant’s surgical planes post resection in comparison to an “ideal” resection which enabled a comprehensive 3D analysis of margins especially that of the deep margins thereby allowing for feedback on the surgical ablation by each participant. Overall, this study demonstrated the utility and fidelity of a 3D silicone model as a training tool for head and neck surgery.

Table 1b

	Face validation			Content validation			Use for medical training			
	Feel of tongue model	Feel of tumour model	Incising and operating	Aids to appreciate margin	Improve surgical technique	Improve margin sampling	Ideal for med student	Ideal for residents	Ideal for fellows	Ideal for continual education
Silicone model	4	4.09	3.36	4.55	4.18	4.36	4.45	4.27	4	4.18
Porcine model	4.18	2.82	3.91	4.18	4.09	4.18	4	4.27	3.81	4.09

Table 1a

	Mean face validation	Mean content validation
Silicone model	4	4.4
Porcine model	3.6	4.1

Fig 1

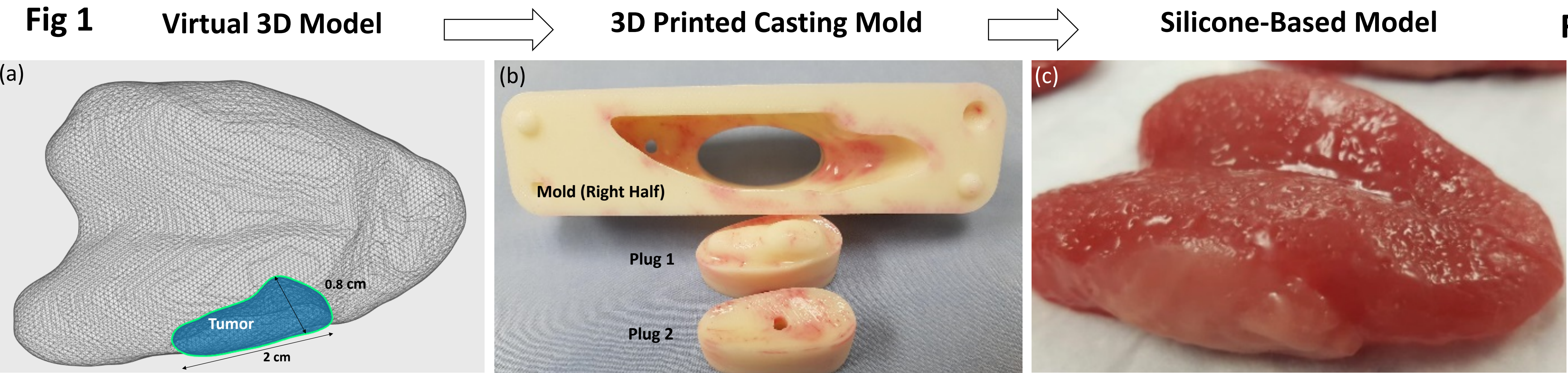


Fig 2

