EX VIVO SIMULATION AS A TRAINING TOOL IN TRANSORAL ROBOTIC SURGERY

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Abstract

Objective: To evaluate the training capacities of an ex vivo simulator for transoral robotic posterior hemiglossectomy. **Study design**: Prospective observational study. **Methods**: We describe the creation of a transoral robotic surgery (TORS) simulator using porcine tongue in a modified airway mannequin. Twenty-nine surgeons performed transoral robotic posterior hemiglossectomy using the simulator; the 20 resident subjects completed 6 trials each, and the 5 fellows and 4 attendings completed 2 trials each. Surgical video was recorded for each trial and was blindly rated using the Global Evaluative Assessment of Robotic Skill (GEARS), a validated instrument for assessing robotic surgical skill. **Results**: Attending surgeons were faster and demonstrated greater technical skill than fellows or residents (p = 0.004). Resident completion time decreased with each subsequent trial, becoming significantly faster by the 5th trial (430s to 332s, p = 0.02). GEARS scores increased with each trial and were significantly higher by the 4th trial (14.7 to 19.4, p = 0.008). Overall, subjects rated the realism and training value of the TORS simulator highly. **Conclusions**: We have described the design and demonstrated the face, content and construct validity of an ex vivo simulator for transoral robotic posterior hemiglossectomy. Our results support the value of ex vivo simulation for training in transoral robotic surgery.

Introduction

The body of literature addressing the role of simulation-based surgical training has grown dramatically over the last decade.[1] With increasing use of TORS, attention has turned to training Otolaryngologists in robotic surgical techniques. Most training paradigms center on available virtual simulators. However, these virtual simulators do little to provide procedure-specific skills like tissue manipulation or dissection using electrocautery. Prior studies have shown the learning curve for TORS to be approximately 20 cases.[2] Thus, most novice TORS surgeons are largely reaching the 20-case benchmark while operating on live patients. The objective of this study was to develop and validate an ex vivo simulator for transoral robotic surgery and to evaluate its training capacities.

Methods and Materials

A TORS simulator was created using porcine tongue in a modified airway mannequin (**Figures 1 & 2**).[3] A 5mm cube of porcine skin was dyed red and embedded in the dorsal tongue to simulate a tumor. Twenty-nine surgeons performed transoral robotic posterior hemiglossectomy using the simulator; the 20 resident subjects completed 6 trials each, and the 5 fellows and 4 attendings completed 2 trials each. Surgical video was recorded for each trial and was blindly rated using GEARS (**Figure 3**). Trial duration, GEARS scores and margins were compared between subjects. After completing the simulation, all subjects completed a questionnaire to assess simulator realism (face validity) and training value (content validity) using a Likert-like scale.

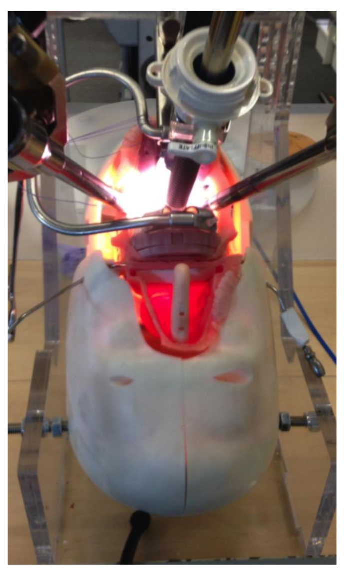

Figure 1. TORS simulator

Figure 2. Endoscopic view of simulator

Depth perception				
1	2	3	4	5
Constantly overshoots target, wide swings, slow to correct		Some overshooting or missing of target, but quick to correct		Accurately directs instruments in the correct plane to target
Bimanual dexterity				
1	2	3	4	5
Uses only one hand, ignores nondominant hand, poor coordination		Uses both hands, but does not optimize interaction between hands		Expertly uses both hands in a complementary way to provide best exposure
Efficiency				
1	2	3	4	5
Inefficient efforts; many uncertain movements; constantly changing focus or persisting without progress		Slow, but planned movements are reasonably organized		Confident, efficient and safe conduct, maintains focus on task, fluid progression
Force sensitivity				
1	2	3	4	5
Rough moves, tears tissue, injures nearby structures, poor control, frequent suture breakage		Handles tissues reasonably well, minor trauma to adjacent tissue, rare suture breakage		Applies appropriate tension, negligible injury to adjacent structures, no suture breakage
Autonomy				
1	2	3	4	5
Unable to complete entire task, even with verbal guidance		Able to complete task safely with moderate guidance		Able to complete task independently without prompting
Robotic control				
1	2	3	4	5
Consistently does not optimize view, hand position, or repeated collisions even with guidance		View is sometimes not optimal. Occasionally needs to relocate arms. Occasional collisions and obstruction of assistant.		Controls camera and hand position optimally and independently. Minimal collisions or obstruction of assistant

Figure 3. GEARS domains with descriptors

Results

Mean trial duration decreased and technical skill, measured by GEARS, increased with higher level of training (**Table 1**). Overall, residents obtained adequate tumor margins in just 50% of trials compared to 90% for attending surgeons (p =0.02). Over the course of 6 trials, resident subjects demonstrated significant improvement in speed, technical skill and margin status. Subjects increased in speed from a mean trial duration of 430 seconds to 336 seconds (p = 0.02) (**Figure 4**). Mean GEARS score increased from 14.7 to 20.1 (p < 0.001) (**Figure 5**). Over 6 trials, the fraction of subjects that obtained adequate tumor margins increased from 35% to 100% (p < 0.001). Subjects rated the TORS simulator highly both in terms of its realism (mean 4.5 out of 5) and its value as a training tool (mean 4.7 out of 5).

	Resident	Fellow	Attending	p-value
Trial duration (s)	417.5±24.9	266.6±14.1	223.2±16.9	0.004
GEARS (6-30)	15.8±0.7	21.9±0.9	24.4±0.6	0.0002
Negative margins	42.3%	66.7%	90.0%	0.021

Table 1. Comparison of resident, fellow and attending surgeon performance in simulated TORS.

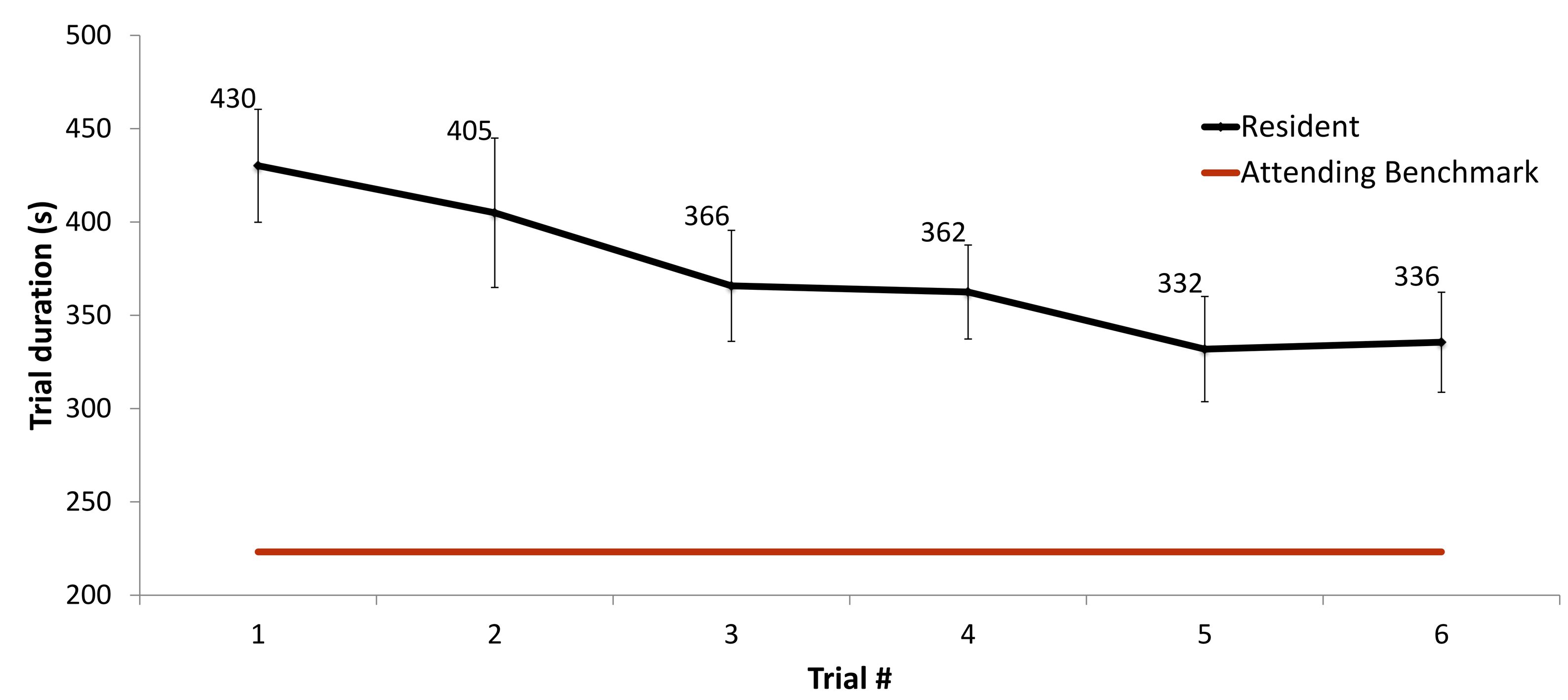

Figure 4. Mean resident trial duration over 6 trials compared to attending surgeon benchmark performance.

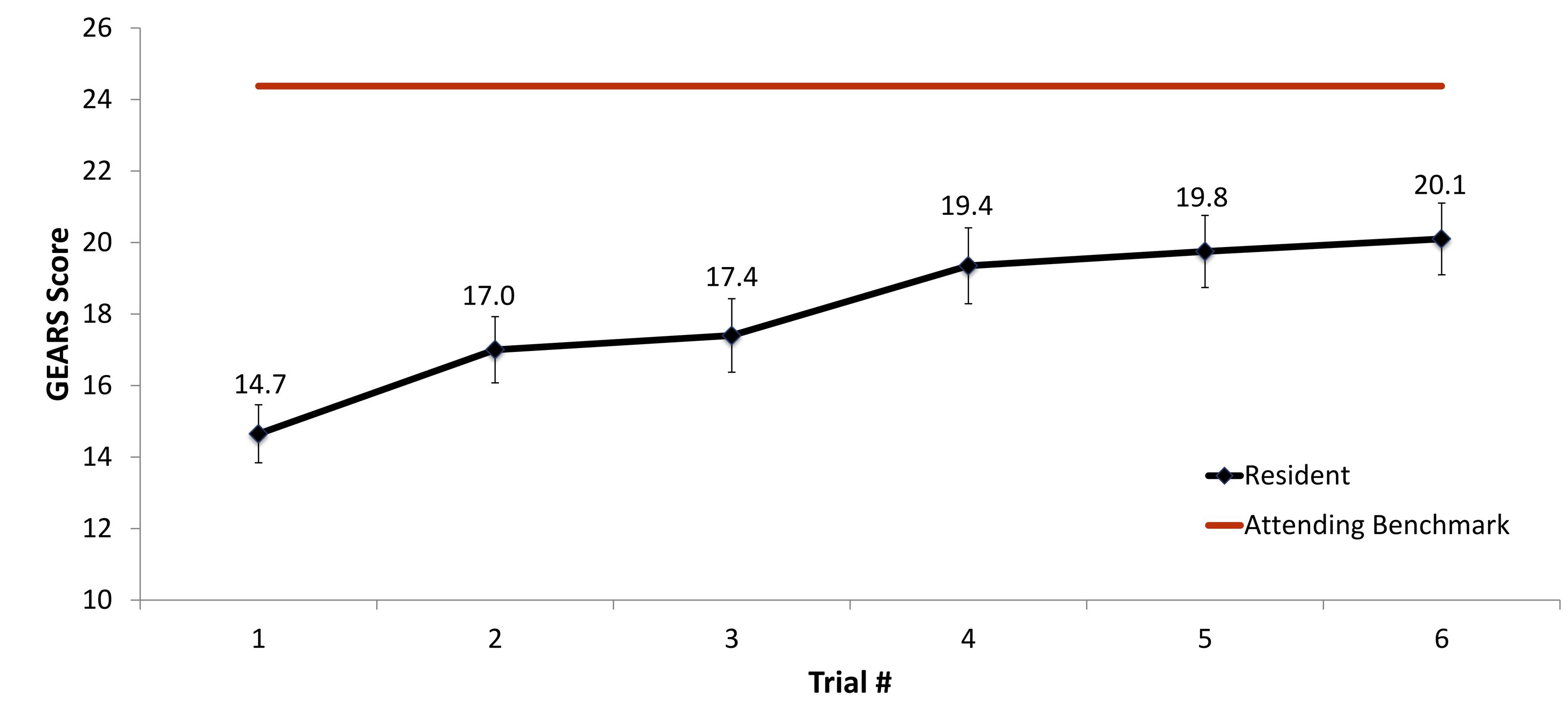

Figure . Mean resident GEARS scores over 6 trials compared to attending surgeon benchmark performance.

Discussion

To evaluate the training benefits of an ex vivo TORS simulator, we first demonstrated the face, content and construct validity of an ex vivo simulator for transoral robotic posterior hemiglossectomy. Subjects rated the simulator highly in terms of its realism (face validity) and training value (content validity). To evaluate the construct validity of the simulator, we compared speed and technical skill between subjects by level of prior TORS experience. Attending surgeons (most experienced) outperformed fellows and residents (least experienced) in speed, technical skill and margin status (p<0.01).

Over the course of 6 trials, resident subjects demonstrated statistically significant improvement in speed, technical skill and ability to achieve adequate margins. Resident speed and technical skill approached, but did not reach the performance benchmarks set by attending surgeons (**Figures 4 and 5**). This finding is consistent with the generally accepted learning curve of 20 cases for transoral robotic surgery. These results clearly demonstrate the training value of an ex-vivo simulator using a cohort of 20 residents with minimal prior TORS experience.

While ex vivo simulation is promising as an adjunct to virtual simulation and cadaveric training in TORS, there are some limitations to the TORS simulator. While subjects with prior live TORS experience were faster and more technically skilled using the simulator, the degree to which the reverse is true (skill acquired using the simulator translates into skill in live TORS) requires further study. Additionally, while every attempt was made to create a high-fidelity simulator that was as realistic as possible, some limitations exist. The simulator lacks much of the anatomic detail that is routinely encountered in live surgery. The pharynx of the simulator is constructed from synthetic materials and thus cannot be dissected with electrocautery.

Conclusions

We have described the design and demonstrated the face, content and construct validity of an ex vivo simulator for transoral robotic posterior hemiglossectomy. Our results support the value of ex vivo simulation for training in transoral robotic surgery.

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Disclosures

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