

3D Printable Epistaxis Simulator for High-fidelity Procedure Training

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Background

Epistaxis is one of the most common emergencies managed by otolaryngologists, and residency trainees often are required to perform procedures during these emergencies with limited supervision.¹ As with other emergency procedural skills, there is a need to acquire competency early in training. In response to this need there has been a national movement to start simulation-based boot camps for otolaryngology residencies.²⁻³ Epistaxis management has been identified as one of the most important (top 4) procedural skills that should be included in a simulation-based boot camp.⁴ However, available task trainers are very limited. Published epistaxis simulators are limited to those that are low fidelity (e.g. repurposed CPR dummies) or high cost (e.g. cadaveric models).⁵⁻⁷ 3D printing has been used to create task trainers of various types, including one reported epistaxis trainer but the materials used are rigid plastic with limited abilities for tactile realism.⁸ No high fidelity task trainer is commercially available for use in teaching epistaxis emergency skills.

Objectives

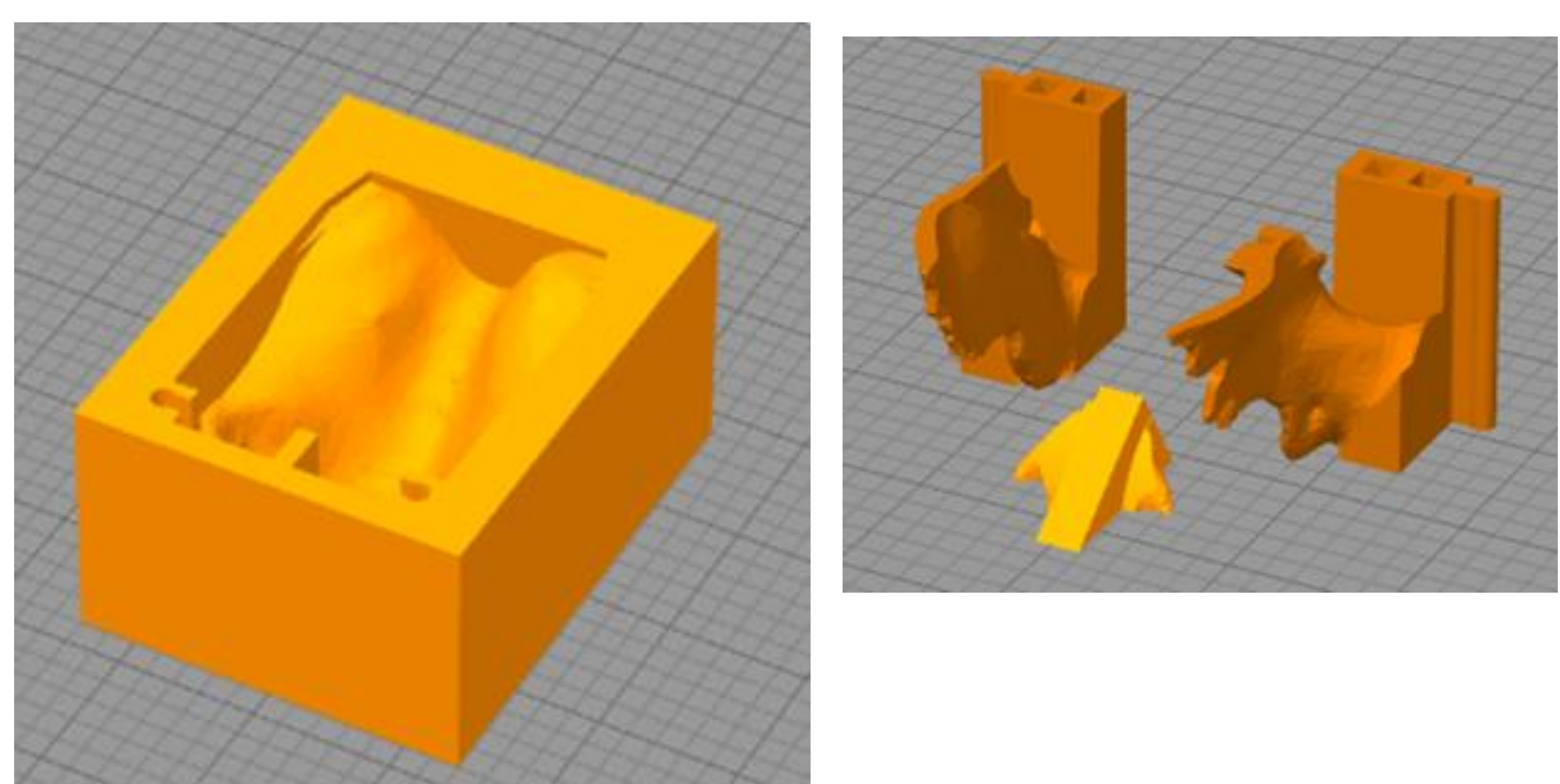
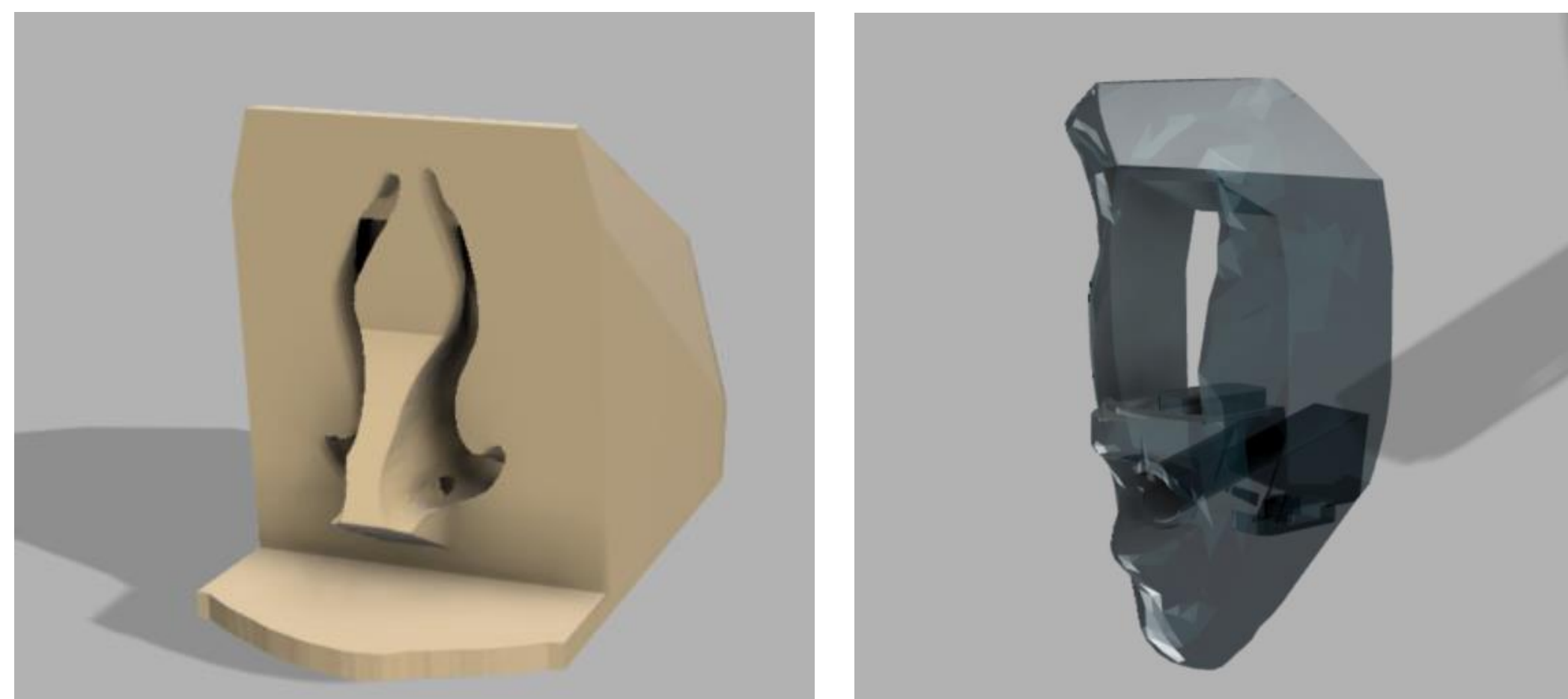
1. To create a high fidelity, low cost epistaxis simulator
2. To study the realism of the simulator with an expert validation study
3. To utilize the simulator in a pilot curriculum during simulation-based boot camp.

Simulator Development

Real patient CT data (NIH open source repository) was used to create a 3D model of the internal and external nose. Autodesk Fusion 360 design software was used to generate a multi-component model.

1. Internal nasal anatomy with channels for realistic bleeding from 3 different sites
2. Face mount with oral cavity capable of simulating bleeding from posterior nasal cavity
3. Mold cavity and inserts for creation of soft silicone external nasal anatomy

Cost of production: <\$20 per simulator when producing 5 or more



Expert Validation

Experts in epistaxis management were recruited to participate in this study. All methods were approved by the Colorado Multiple Institutional Review Board and the study was performed to the highest level of ethics for human research. Experts included twelve board-certified otolaryngologists, four 5th year otolaryngology residents, and one rhinology-specialized physician assistant.

METHODS:

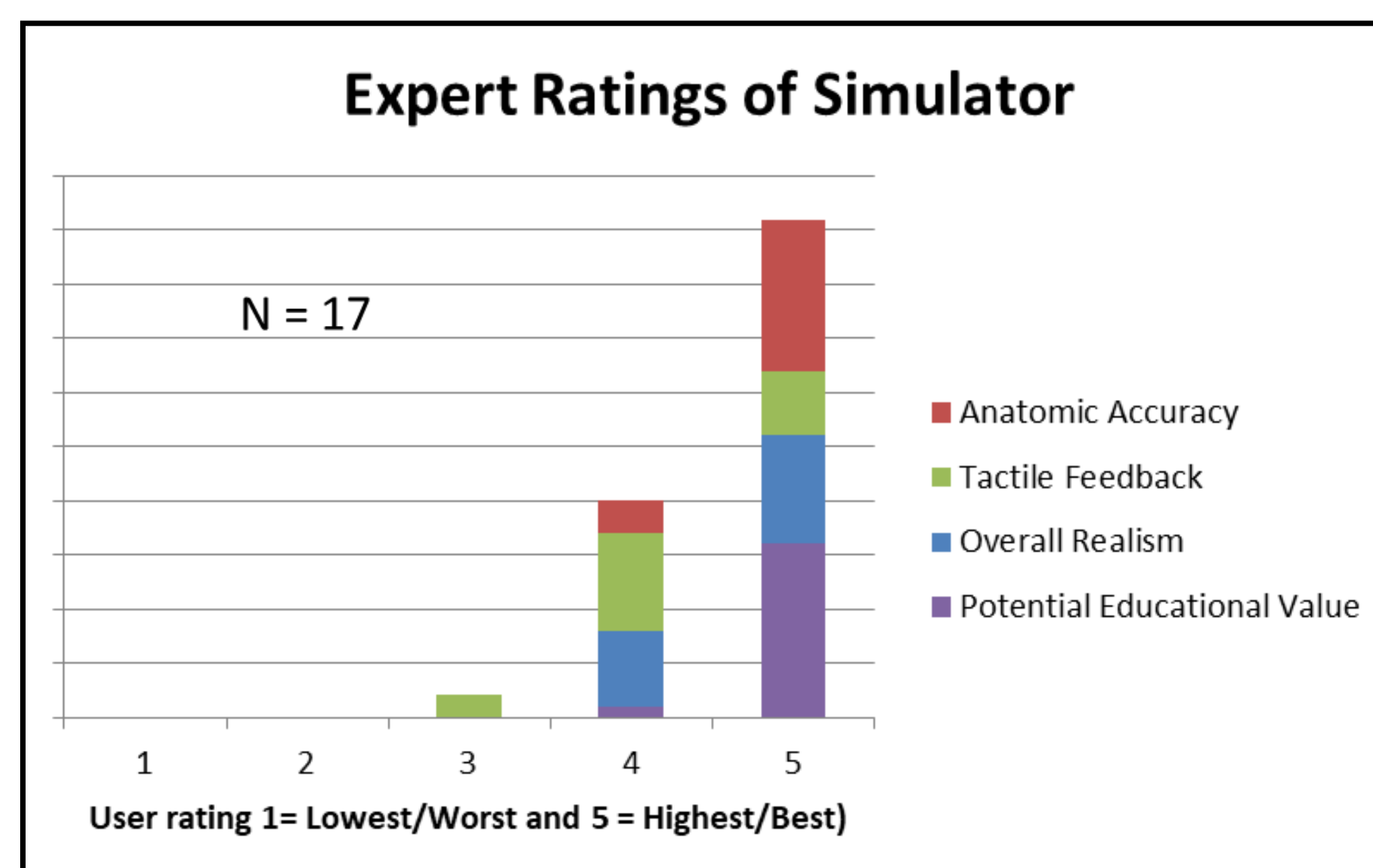
Each expert participated in a simulated epistaxis emergency and performed the following with the model:

1. Anterior rhinoscopy with evacuation of clot and identification of anterior bleeding source
2. Standard nasal packing with 8cm non-absorbable pack
3. Nasal endoscopy

Experts then evaluated the simulator on a detailed questionnaire. Questions included 5-point Likert style scoring of different attributes, as well as open-ended questions.

RESULTS:

Open ended responses were nearly-universally positive. Only critical feedback was related to tactile feedback being "a bit too stiff" by 3 participants.



Pilot Curriculum

EDUCATIONAL GOAL: To acquire the knowledge, skills, and confidence to manage basic epistaxis emergencies.

LEARNING OBJECTIVES:

1. Demonstrate the use of anterior rhinoscopy to identify the source location of an anterior epistaxis
2. Describe the initial management steps of epistaxis and the indication for nasal packing
3. Demonstrate accurate and effective placement of standard nasal packing
4. Demonstrate the use of a nasopharyngeal balloon and petroleum gauze packing in the management of refractory posterior epistaxis.
5. Develop an appropriate management plan in response to an epistaxis e-consult

CURRICULUM DESIGN:

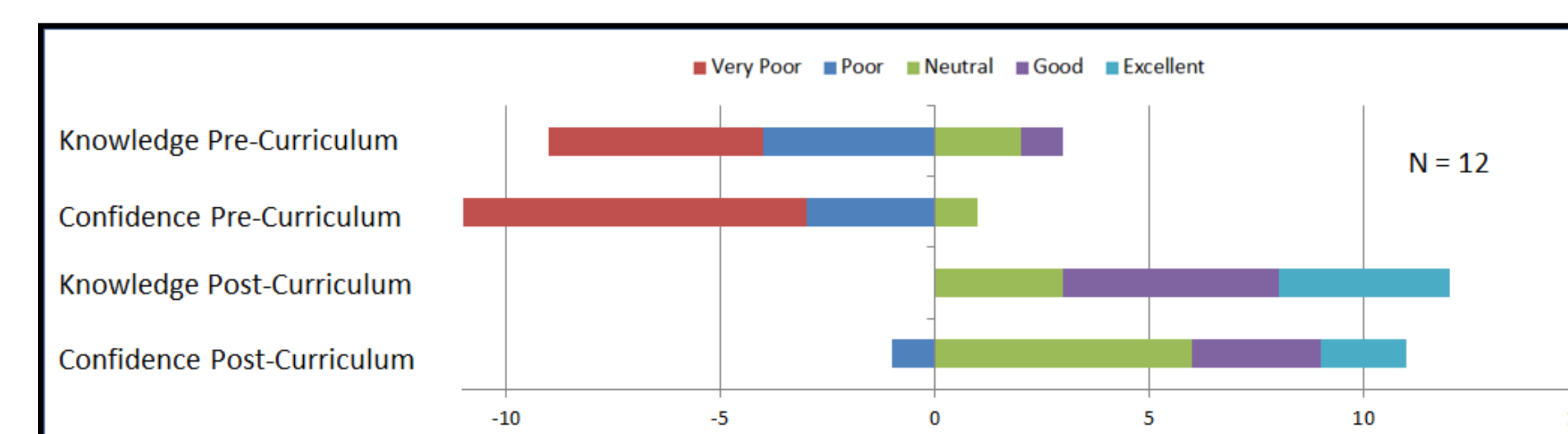
Fifty minute session with novice otolaryngology learners incorporating the following:

1. Didactic standardized presentation
 - Background knowledge
 - Anatomy
 - Clinical practice guidelines (management decision making)
2. Guided procedure simulation activity
 - Anterior rhinoscopy
 - Standard nasal packing
 - Posterior epistaxis packing (Foley balloon technique)
3. Mock Telehealth Consultation (s)

RESULTS:

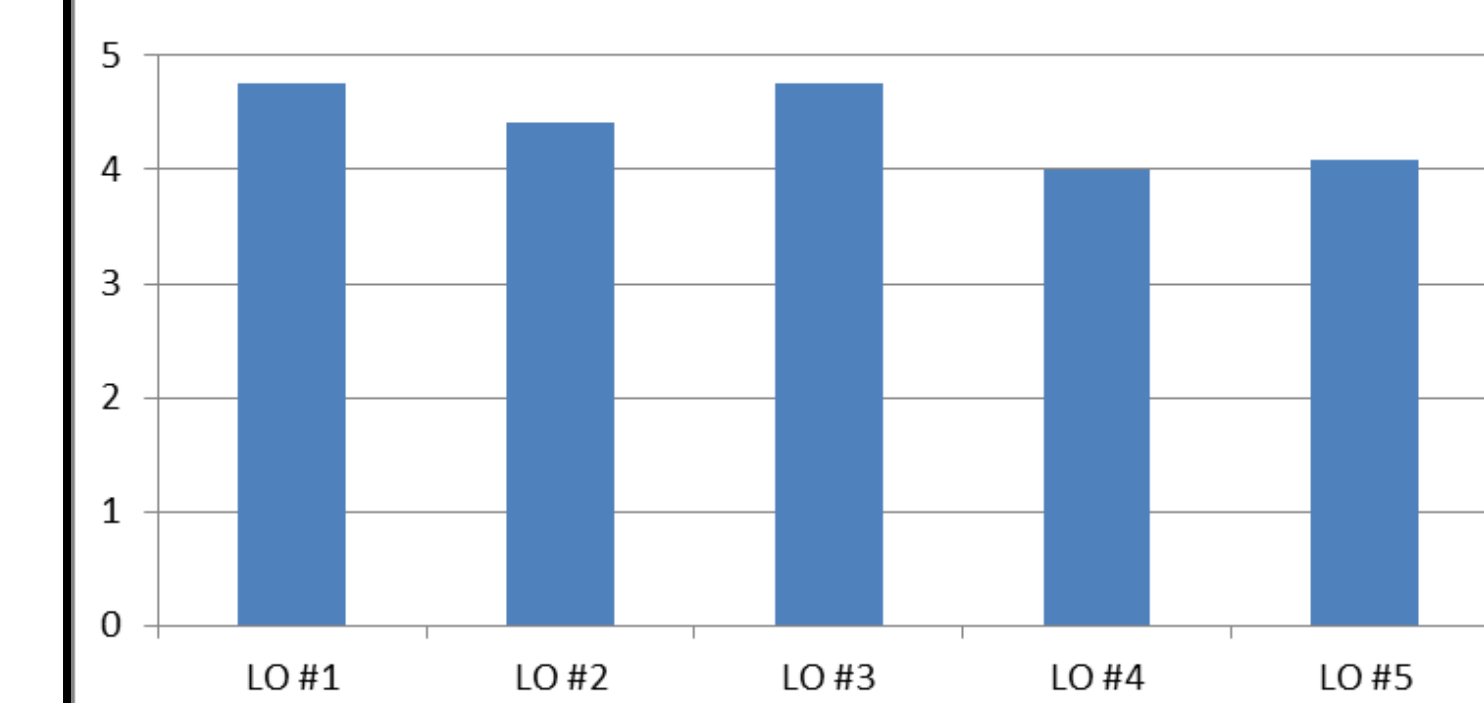
- 4 small group sessions performed (12 total participants)
- Ratings by learners (mean, 1-5):
- Overall positive experience: 4.79±0.74
 - Educational value: 4.89±0.36

Learner Self Assessment (Retrospective Pre-Post)



Preceptor Evaluations: Mastery of Learning Objective

Mean Scores (1= least, 5=most)



Conclusions

A novel 3D printable simulator was developed that is inexpensive to produce and highly can simulate epistaxis from 3 different intra-nasal locations. Expert evaluations of a novel epistaxis simulator concluded it had high fidelity and educational potential. A pilot curriculum utilizing the simulator was highly rated by novice learners, improved their self-assessed knowledge and confidence, and demonstrated achievement of learning objectives as evaluated by the session preceptor.



References

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