Assessing the Use of a Model in Transnasal Endoscopy Training

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***Abstract*— Currently, clinicians are trained to perform the transnasal endoscopy procedure through practice on human volunteers. The use of a training model could eliminate the pain and discomfort that arises during current training methods. In this pilot study, clinicians tested a model for training of transnasal endoscopy and evaluated it based on effectiveness of the user feedback, anatomical correctness of the structures, and its potential educational efficacy. Preliminary evaluations of the model support its potential as an effective training tool. A more extensive study can be implemented to gauge the effectiveness of training with the model before making a commitment to commercial production of this training model.**

I. Introduction

Clinicians use transnasal endoscopy to observe and evaluate the health of the vocal cords, larynx, pharynx, and nasal structures. In the procedure, a flexible endoscope is inserted into the nose and maneuvered through the nasal passage towards the vocal cords. If the clinician lacks fine motor control with the scope, he or she may cause pain. Using the endoscope's controls, the clinician maneuvers the tip through the nasal passage between the turbinates. After the nasal cavity, the scope is pointed downwards illuminating the upper regions of the throat, including the tongue base and vocal cords.

Since few medical conferences offer training, clinicians are trained for transnasal endoscopy by colleagues. This training uses human volunteers, imposing unnecessary risk and pain. An inexperienced endoscopist may accidentally touch sensitive regions such as the posterior pharyngeal wall or tongue base, which can cause choking and/or a gag reflex. Similarly, excessive force or a rapid pressure change on the turbinates causes sharp pain in the nasal passage.

A survey of 15 skilled speech pathologists claimed they performed between 20 and 50 procedures before being competent and comfortable. The human subjects for these trials were composed of mostly other clinicians, volunteers or patients. A physical training model would allow professionals to be trained without the risks associated with using human subjects. Flexibility and convenience of training are also improved by using a model since supervision and human subjects are not required.

There is a previous basis for the use of models in training for medical procedures. Starting in the 1970s, a simulator known today as SIM man has enhanced medical education, allowing students to learn procedures and their complications on a simulator rather than a living human [1]. Borrowing the same idea of the SIM man, a model of the nasal passageway and the larynx would assist in transnasal endoscopy training. Although a physical model does not simulate the anatomy of every patient, basic procedural skills and enhanced hand/eye coordination can be attained prior to performing procedures on human subjects.

II. Methods

We fabricated a model to be used for transnasal endoscopy training. The model has structures with anatomically correct sizes and shapes, based on CT data from a healthy patient. In addition, the model provides feedback to the user when one of two mistakes is made: exerting excessive pressure on the turbinates or making contact with the tongue base or posterior pharyngeal wall. A pilot study with 4 medical personnel was executed to evaluate the model's capability to improve transnasal endoscopy training. Figure 1 shows a clinician performing a trial with the model. A questionnaire, with a 1 (poor) - 10 (great) rating scale for each question, was developed to gather information about the user's experience with the procedure and their anatomical critique and opinion on the educational efficacy of our model.

Fig. 1. Clinician performing trial endoscopy with the training model.

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III. Results

Due to poor motivation only 4 medical personnel returned surveys. These 4 surveys were filled out by: 2 clinicians with 5 or more years of procedural experience, 1 clinician with moderate experience (less than 5 years), and a medical student with limited experience. Based on preliminary findings, we discovered greater experience decreased anxiety levels while performing a transnasal endoscopy on patients. The clinicians rated the previous training they received as satisfactory, but were supportive of our model as a training tool. The student commented that the model was very interesting and was a great learning experience. Although all of the clinicians thought the model has potential for training future clinicians, they expressed necessary improvements in the morphology of the vocal cords, tongue base, posterior pharyngeal wall, and turbinates to increase its training value. The vocal cords were repeatedly commented on as an area to focus on for structural revision and better pigmentation selection. Besides morphology and pigmentation, experienced clinicians desired an overall improvement of the tissue compliance to better simulate tactile sensation of performing the procedure on a live individual.

IV. Discussion

Since only a small number of trials were documented, a more extensive study should be conducted. A more useful future study would entail higher number of documented trials. In this study, a higher number of experienced clinicians can provide insight into anatomical correctness and tactile sensation of the model. Meanwhile more student feedback can give more insight on potential educational efficacy. This study would still survey clinicians on the model's similarity to a real person, the effectiveness of the feedback mechanisms, and the model's educational potential to improve transnasal endoscopy training. However, a future study including long-term follow-up on performance and pace of learning for those training with or without the model could provide significant support for its educational efficacy.

V. Conclusions

The preliminary feedback evaluating the model as a training tool for transnasal endoscopy supports the use of this approach as an effective training method to preclude procedures on living people by young clinicians. Although the feedback was supportive, a small sample pool limited our ability to assess its teaching credibility. The model needs additional testing and evaluation to examine the potential interest in marketability of our training model as a commercial product. For the training model to reach a commercially acceptable state, manufacturing must be taken to a more advanced level. The current latex coating of the passageways inside the head should be replaced with a more durable polymeric material that would more accurately mimic the compliance of human tissue and eliminate latex associated health risks. Furthermore, rapid prototyped molds could be created ensuring high quality repeatable production of structures inside the cavities. Many clinicians are trained in transnasal endoscopy due to the multi-disciplinary nature of the procedure. Therefore the high frequency of training for the procedure would create a large market for a training model with the previously mentioned improvements.

Appendix

Five appendices are attached to this report. Appendix A is a product design specification sheet for the prototype. Appendix B provides technical information about construction and sensor function of the model. Appendix C shows the schematics for the two user-feedback circuits. Appendix D is the questionnaire that was filled out by clinicians to evaluate the model in the pilot study. The final appendix, E, is the budget used for construction of the training model.

Acknowledgment

The authors would like to acknowledge the following people for their support and guidance: Brian Petty, Professor Willis Tompkins, Professor Thomas Yen, and Professor John Webster.

References

[1] Cooper, J.B. and Taqueti, V.R. (2004). A brief history of the development of mannequin simulators for clinical education and training. *Qual. Saf. Health Care* 13;i11-i18.

[2] Measurement Specialties, Inc. (2009). http://www.meas-spec.com/downloads/LDT1_028K.pdf

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Problem Statement:
To train clinicians to perform transnasal endoscopy of the larynx, a model with realistic and anatomically correct structures of the nasal passages and larynx must be developed. Currently, training is conducted on human subjects in the form of volunteers and/or patients.

Client Requirements:

- Anatomically correct model of nasal passages and larynx
- Materials should have a compliance similar to living tissue
- Costs less than $3000
- Force against a turbinate is painful, touching the larynx causes choking, touching the tongue base causes gagging. Feedback to the user would be helpful if contact with these structures is made.

1. Physical and Operational Characteristics

a. Performance requirements: Needs to accurately simulate environment and obstacles involved in transnasal endoscopy. Simulate a real face as best as possible.

b. *Safety*: The model must contain non-toxic materials. The materials included may not damage the endoscope.

c. *Accuracy and Reliability*: The model must be anatomically correct for training purposes. The model should be durable.

d. *Life in Service*: 5 years

e. *Shelf Life*: No specific requirements by client, but to be determined by materials used.

f. *Operating Environment*: Office / classroom (non-sterile).

g. *Ergonomics*: Should be small enough to place on a table or desktop.

h. *Size*: Accurate in terms of anatomy.

i. *Weight*: 25 pounds so it's light enough for one person to move by hand.

j. *Materials*: Non-toxic materials.

k. *Aesthetics, Appearance, and Finish*: The outer surface should look like a face. The inner structures should be the same color and shape as the living structures.

2. Production Characteristics

a. *Quantity*: One.

b. *Target Product Cost*: Less than $3000.

3. Miscellaneous

a. *Standards and Specifications*: Model should comply with anthropometric data.

b. *Customer*: Voice pathologists and other medical professionals working with transnasal endoscopy and its training.

c. *Patient-related concerns*: Any material allergies such as latex need to be taken into concern. The scope needs to be cleaned after use with the model since it is not sterile.

d. *Competition*: Existing commercial larynx models and human subjects (volunteers and/or patients).

APPENDIX B: TECHNICAL INFORMATION

A. User Feedback System

The piezoelectric sensors in the prototype are piezoelectric films (Fig. B-1) from Measurement Specialties, Inc. The company donated approximately 120 films to the project.

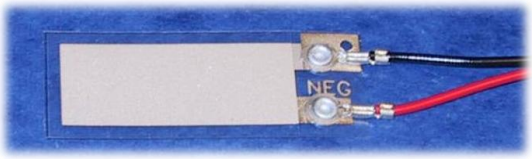


Fig. B-1. Piezoelectric film used to construct sensors for training model. [2]

Appendix C shows the circuit schematics for the feedback systems that use these sensors to identify mistakes made by the model user and give them auditory and visual feedback when mistakes occur. Fig. B-2, below, is a block diagram that shows the sequence of events occurring to produce user feedback.

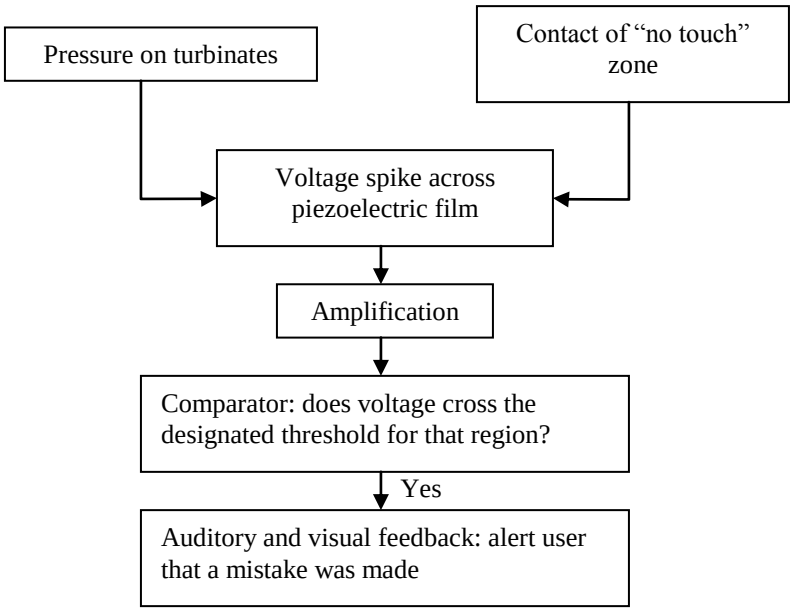


Fig. B-2. Block diagram of sequence of events involved in user feedback from the model.

B. Anatomical Structures

Anatomical structures were scaled to match the sizes and shapes of the throat and nasal passageways of a random healthy patient. CT data from the head and neck in that patient was used to create a 3D computer model of the patient's regions of interest. Cross-sections were obtained from the computer model and used to create the foam cross-section slices that stacked up to form the passageways inside the model.

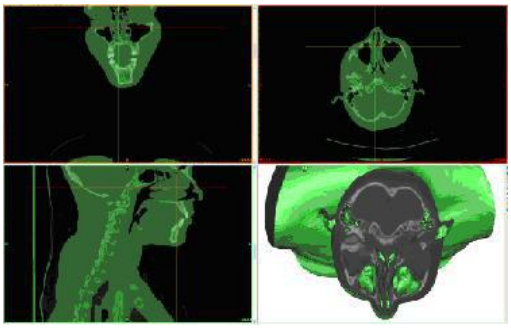
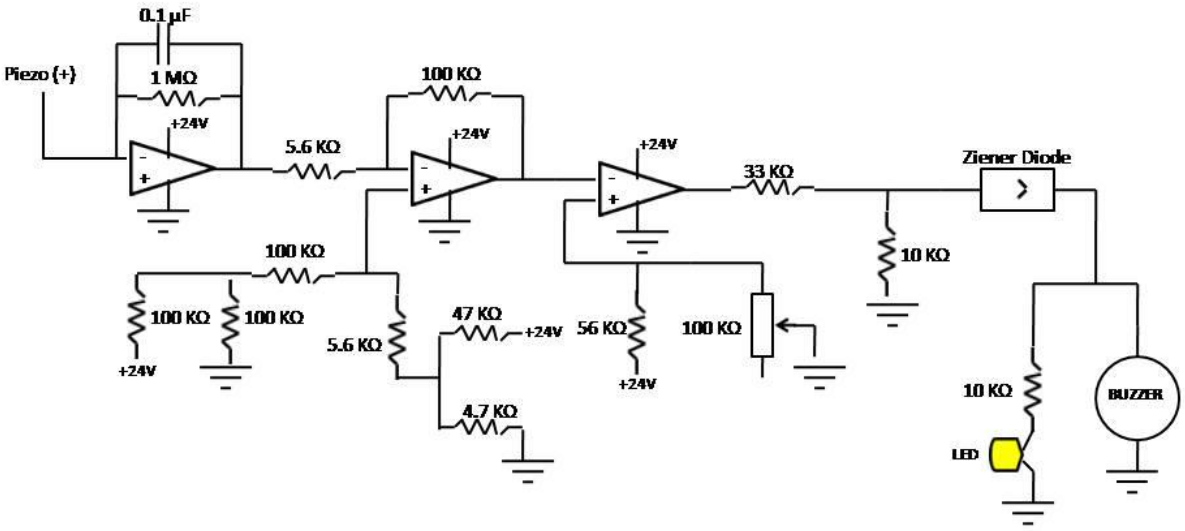
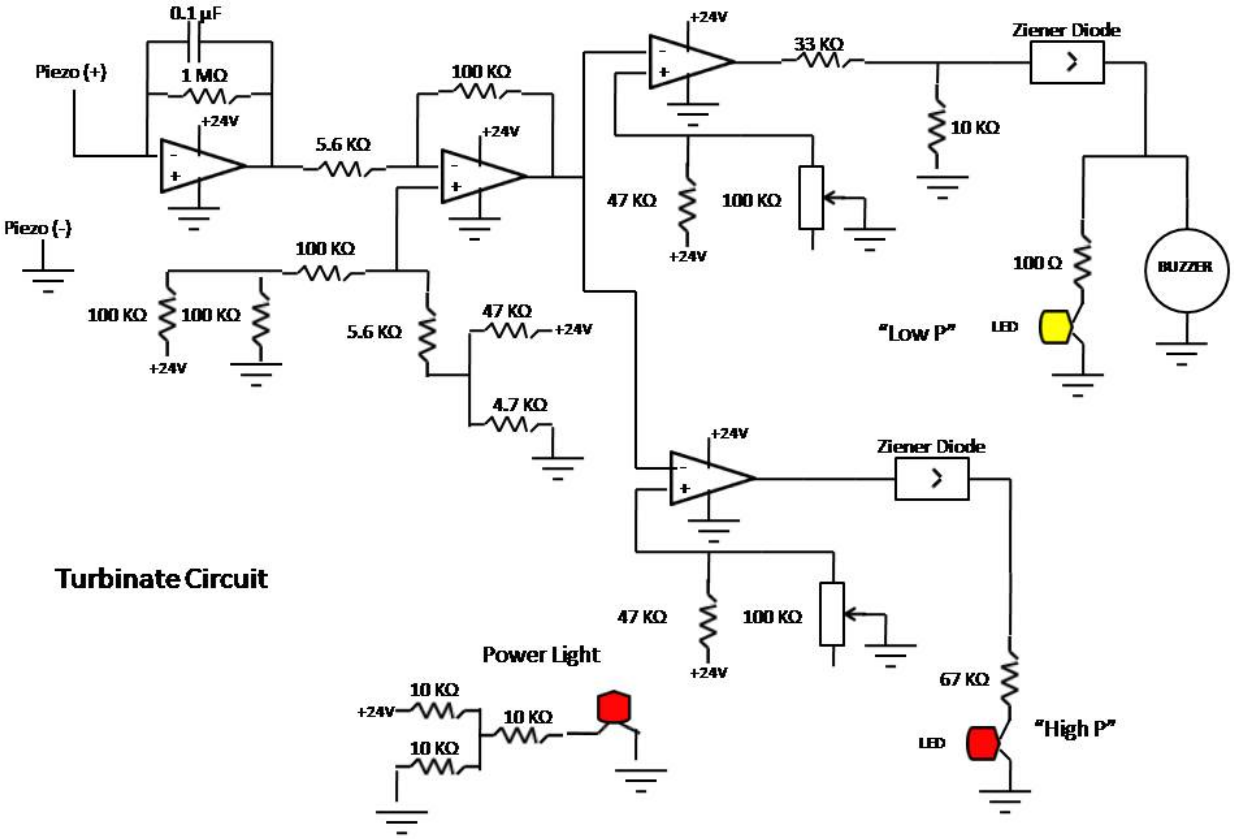


Fig. B-3. A snapshot of the computer model that was used to create anatomically correct structures inside the training model.



No Touch Circuit



Turbinate Circuit

APPENDIX D: QUESTIONNAIRE

Transnasal Endoscopy Model Feedback Form – Please return

User Background- BEFORE using model

How would you rate your **experience level** with the transnasal endoscopy procedure?

(Never performed before) (Med Student/ In Training) (Professional <5yrs) (Professional 5+ yrs)

How would you rate your **mood/ comfort level** with performing this procedure on a **living patient**?

(Anxious) 0 1 2 3 4 5 6 7 8 9 10 (Calm/ Confident)

What was your mode of training while learning this procedure? **(Circle all that apply)**

A. Never done this before (skip sub-questions) B. Practice on other medical personnel
C. Volunteers from the public D. Went directly to patients
E. Other (***please explain***)…

How would you rate your **mood/ comfort level** when you were **first training**?

0 1 2 3 4 5 6 7 8 9 10
(Anxious) (Calm/ Confident)

How would you rate your **mode of training** for **practicing and gaining confidence**?

0 1 2 3 4 5 6 7 8 9 10
(Anxious) (Calm/ Confident)

Performing a transnasal endoscopy – AFTER using model

How would you rate the **realistic compliance and tactile sensation** from the model?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

How would you rate the anatomical correctness of the **turbinates**?

*Morphology?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

*Pigmentation?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

How would you rate the anatomical correctness of the **posterior pharyngeal wall**?

*Morphology?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

*Pigmentation?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

How would you rate the anatomical correctness of the **tongue base**?

*Morphology?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

*Pigmentation?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

How would you rate the anatomical correctness of the **vocal cords**?

*Morphology?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

*Pigmentation?

(Poor) 0 1 2 3 4 5 6 7 8 9 10 (Great)

OVER →

General Use

Did you find the model **easy to set up and use**?

(not at all) 0 1 2 3 4 5 6 7 8 9 10 (definitely)

Did you find using this model helpful **for practicing and gaining confidence**?
(not at all) 0 1 2 3 4 5 6 7 8 9 10 (definitely)

How would you rate your **mood/ comfort level** while using the **model**?
(very anxious) 0 1 2 3 4 5 6 7 8 9 10 (very calm)

Comments:

Do you prefer the **auditory or visual** feedback? *AUDITORY (buzzers) / VISUAL (lights)*

Comments:

Is the model **self-explanatory**, without the need for additional instructions? *YES / NO*

Comments:

What **changes** would you make to this model, and why? **(Please mention at least one)**

Thank you for your time and help! Please make sure this form is returned.

APPENDIX E: BUDGET FOR CONSTRUCTION OF TRAINING MODEL

Material	Cost ($)
Latex	3.29
Nano glue	5.97
Polystyrene foam	7.35
LED holders	1.49
Project box	3.69
LEDs	10.55
Op amps	7.00
Diodes	4.00
Resistors	11.25
Mannequin head	25.00
Piezoelectric film	44.00
Wooden box	30.00
Head tilter	5.95
Buzzers	11.07
Power supply	20.00
Foam cutter	10.00
Total	200.61