Abstract

**Objectives:** To validate the use of a high-fidelity phonomicrosurgical trainer. **Study Design:** A phonomicrosurgical trainer was created that uses a larynx model with multilayered vocal folds that mimic the consistency of true vocal folds. It also has adjustable hand and wrist supports for surgical ergonomics and to simulate the operating room experience.

**Methods:** Synthetic vocal folds containing lesions were placed within the phonomicrosurgical trainer. Novices and experts were instructed to remove the lesion, and novices were given four training trials. All participants' performances were measured by amount of time spent and tissue injury (microflap, superficial, deep) to the vocal fold. Statistical analysis was used to compare novices to experts. Progressive novice performance was then assessed.

**Results:** 25 novices and 6 experts participated in the study. Experts completed the excision with less total errors than novices (P = .004) and made less injury to the microflap (P = .05) and superficial tissue (P = .003). Novices improved their performance with training, making less total errors (P = .002) and superficial tissue injuries (P = .02) and spending less time for removal (P = .002) after several attempts.

**Conclusions:** The phonomicrosurgical trainer has been validated for novice surgeons. It can distinguish between experts and novices, and after training, it helped to improve novice performance.

Introduction

Phonomicrosurgery is a highly-specialized type of surgery that is used to remove vocal fold lesions and optimize voice outcomes. It requires precision and skills that are difficult to obtain during otolaryngology residency training.

In an effort to address this issue, the senior author designed a phonomicrosurgical trainer that is consistent with a true laryngeal surgery experience. It is an updated version of a previously validated laryngeal dissection module. The new trainer has adjustable hand and wrist supports for comfort and operative ergonomics, mimicking the operative experience. The vocal fold microstructure was designed with specific blends of copolymers to emulate the tissue characteristics of true vocal folds. The high-fidelity phonomicrosurgical trainer is meant to aid medical students, residents, and novice surgeons in their phonomicrosurgical training.

The objective of this study is to validate the updated, high-fidelity phonomicrosurgical trainer as a means to both discriminate between experts and novices and improve novice performance with training.

Methods

IRB exempt by the Emory University Institutional Review Board.

The phonomicrosurgical trainer (Figure I) consists of:
- A plastic laryngoscope fixed on an adjustable plastic framework
- An anatomically scaled model larynx
- Microstructural vocal folds with embedded lesions (Figures II-IV)

Subjects: Each had 4 trials to remove the subepithelial vocal fold lesion
- Twenty-five novices (20 medical students and 5 residents)
- Six experts (2 laryngology fellows and 4 attendings)

Subjects were scored on 4 technical aspects (Table I):
- Microflap injury
- Deep tissue injury
- Superficial peripheral injury
- Time

A scoring scale of 0 to 2 points was used, with 2 points given for the worst error. Deep tissue injury was scored on a scale of 0 to 1 point. The four scores were summed to obtain a total error score, from 0 (best) to 7 points (worst).

Statistical analysis was performed to determine differences between novice and expert scores and novice pre-training and post-training scores.

Results

**Table I. Error scoring scale**

<table>
<thead>
<tr>
<th>Score (points)</th>
<th>Time (min)</th>
<th>Microflap Injury (mm)</th>
<th>Superficial Peripheral Injury (mm)</th>
<th>Deep Injury (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;2</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>2-4</td>
<td>&gt;2</td>
<td>&lt;2</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>&gt;4</td>
<td>&gt;2</td>
<td>&gt;2</td>
<td>Present</td>
</tr>
</tbody>
</table>

**Table II. Wilcoxon Signed Rank Test Comparing Novice Pre-training and Post-training Error Type Scores**

<table>
<thead>
<tr>
<th>Time</th>
<th>Pre-training</th>
<th>Post-training</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>17</td>
<td>0.02</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>7</td>
<td>0.12</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>12</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Significant differences were found in total errors, injury to microflap and superficial peripheral tissue between expert and novice surgeons, supporting the internal validity of the trainer. Error type comparisons between experts and novices revealed two types without significant differences: amount of time spent and deep tissue injury. Deep tissue injury subjectively does not appear to be a valuable measure of skill difference, as it was not present in most initial novice trials.

Novice total errors, superficial peripheral injuries, and time spent were all significantly lower after training. Amount of microflap or deep tissue injury were not found to be significantly different when comparing pre-training to post-training scores. Raising a microflap is a fairly advanced technique, and it is possible the novice surgeons would require more practice with the trainer before gaining significant improvement.

Limitations of the study include the fairly low number of participants. There was also minimal variability in their origin, with most being affiliated with Emory University. This sampling reduces the generalizability of the study results.

Surgical training in phonomicrosurgery relies primarily on operating room experience and cadaveric tissue dissection laboratories. There is a need for improved surgical simulation technology that can be made readily available as part of training programs in phonomicrosurgery. This shift in educational approach aims proficiency of surgeon skill and thus improve patient outcome. The high-fidelity phonomicrosurgical trainer holds promise as a teaching and assessment device for phonomicrosurgery and merits continued study.

Conclusions

Our results demonstrate the phonomicrosurgical trainer is effective as a training device in phonomicrosurgery. It is able to distinguish between experts and novices, and after training, it helped to improve novice performance.

References

