Seminar Presentation:
Tremor Reduction Assessment in Microlaryngeal Surgery

Team

Jasmine (Sue Min) Cho
scho72@jhu.edu

Mentors
Dr. Russell Taylor (rht@jhu.edu),
Balazs Vagvolgyi (balazs@jhu.edu),
Dr. Francis Creighton (francis.creighton@jhmi.edu),
Dr. Deepa Galayia (gdeepa1@jhmi.edu),
Dr. Ioan Lina (ilina1@jhmi.edu)

Project Overview

- Goal: Perform user study to assess the degree of tremor reduction in robotic microlaryngeal surgical procedures on cadaveric phantoms

Experimental Apparatus

Surgical Tool Tracking Software

User Study

Data Analysis
(Tremor Reduction Assessment)

Paper Selection and Why

Robotic Microlaryngeal Phonosurgery: Testing of a "Steady-Hand" Microsurgery Platform

Lee M. Akst, MD; Kevin C. Olds, PhD; Marcin Balicki, PhD; Preetham Chalasani; Russell H. Taylor, PhD

Problem Statement

- Currently, robotic surgery is not being regularly translated into microlareangeal phonosurgical procedures
- A novel robotic ear, nose, and throat microsurgery system (REMS) has been developed but further preclinical investigation of this “steady hand” microsurgery platform is necessary for evaluation of surgical performance and usefulness

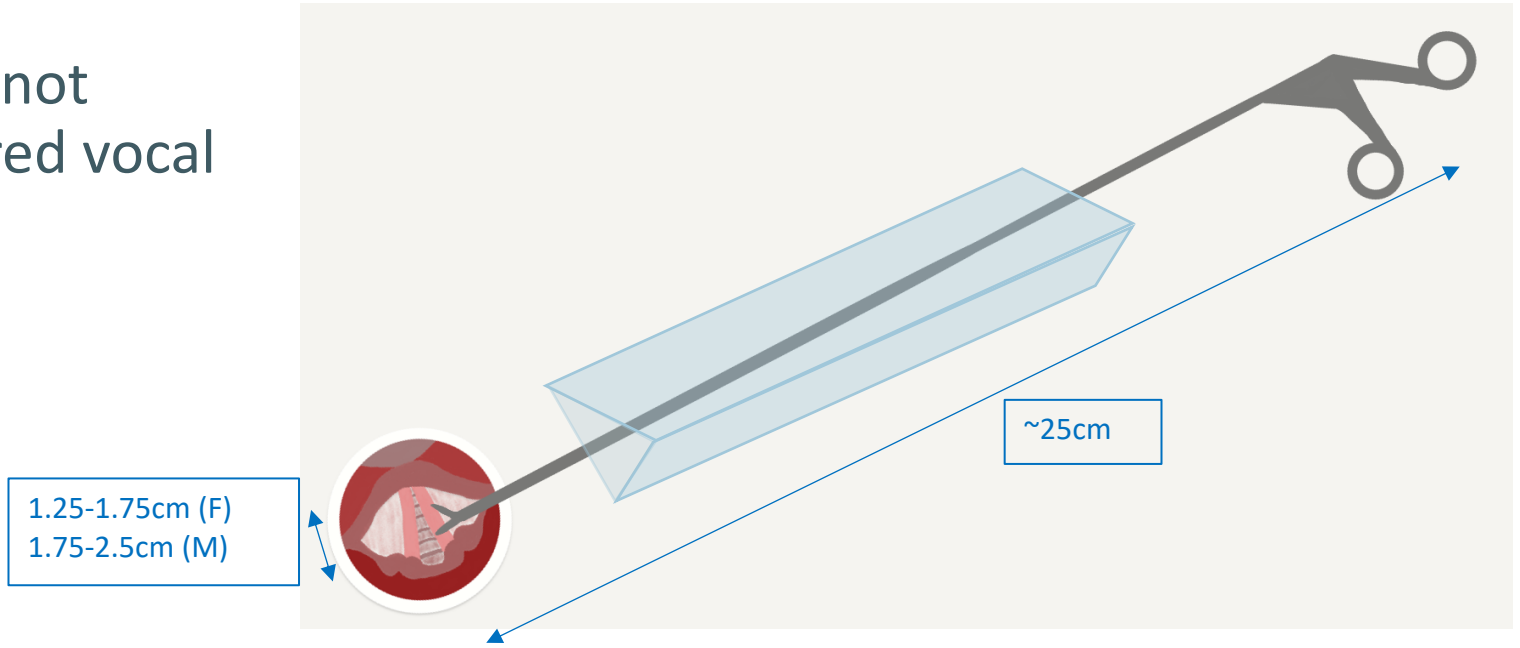
Key Results and Significance

- REMS improved precision of simulated phonosurgery compared to unaided, manual performance
  - Objective improvement in surgical precision over manual surgery during performance of a simulated phonosurgery task
  - Participants found the REMS easy to use, felt that their surgical performance was improved by the REMS, and expressed a desire to use the REMS in their clinical practice

→ Provided further preclinical investigation of this novel robotic "steady hand" microsurgery platform, REMS

Background

- Microlaryngeal phonosurgery
  - Better maintain, restore, or enhance the human voice
  - Imprecise surgery (i.e. with hand tremor) can lead to suboptimal voice outcomes
  - Current treatments cannot effectively restore scarred vocal folds



Background

- Development of a novel robotic ear, nose, and throat microsurgery system (REMS)
- Its ability to improve surgical precision has been demonstrated in a preliminary study

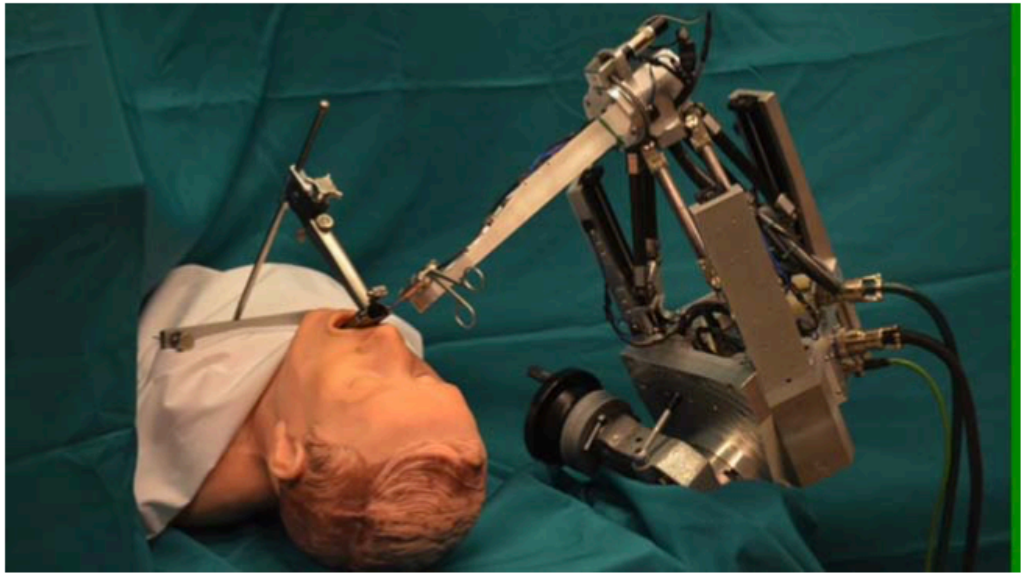


Fig. 1. The robotic ear, nose, and throat microsurgery system (REMS) set-up for microlaryngeal surgery.

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Experiment

- Simulated Phonosurgery
  - Used modified 25cm laryngeal forceps with its tip holding a 0.4mm diameter needle
  - Participants were asked to move the needle through a spiral groove
  - To measure fail time (the time the needle contacted the spiral sides) an establishment of an electrical circuit was made.

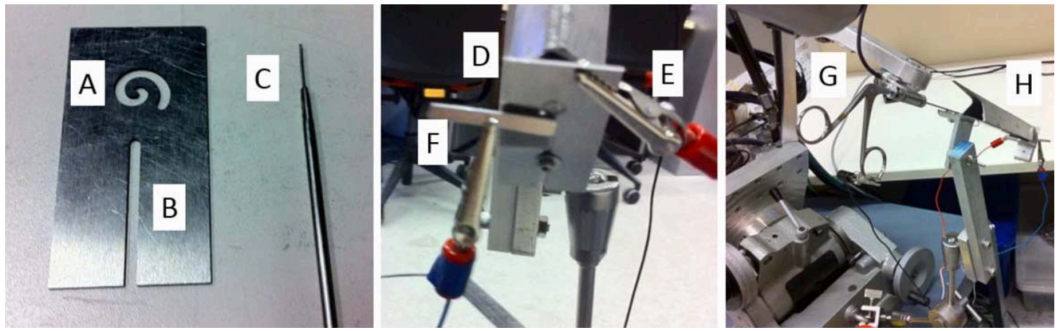

Fig. 2. The experimental setup. The spiral (A), mounting slot to allow positioning of the spiral at the end of the laryngoscope (B), and microlaryngeal needle tip (C) are shown on the left. The middle image demonstrates a view of the spiral target (D) mounted at the end of a laryngoscope with both failure electrode (E) and success electrode (F) attached. On the right, the REMS grasping arm (G) is used to hold the modified microlaryngeal needle within the laryngoscope (H). Edge of the 400-mm microscope can be seen in the upper left corner.

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Experiment

- Four different spiral targets used: 2.5mm spiral for a practice session to allow familiarity with the surgical task, and 2mm, 1.5 mm, and 1.2mm spirals

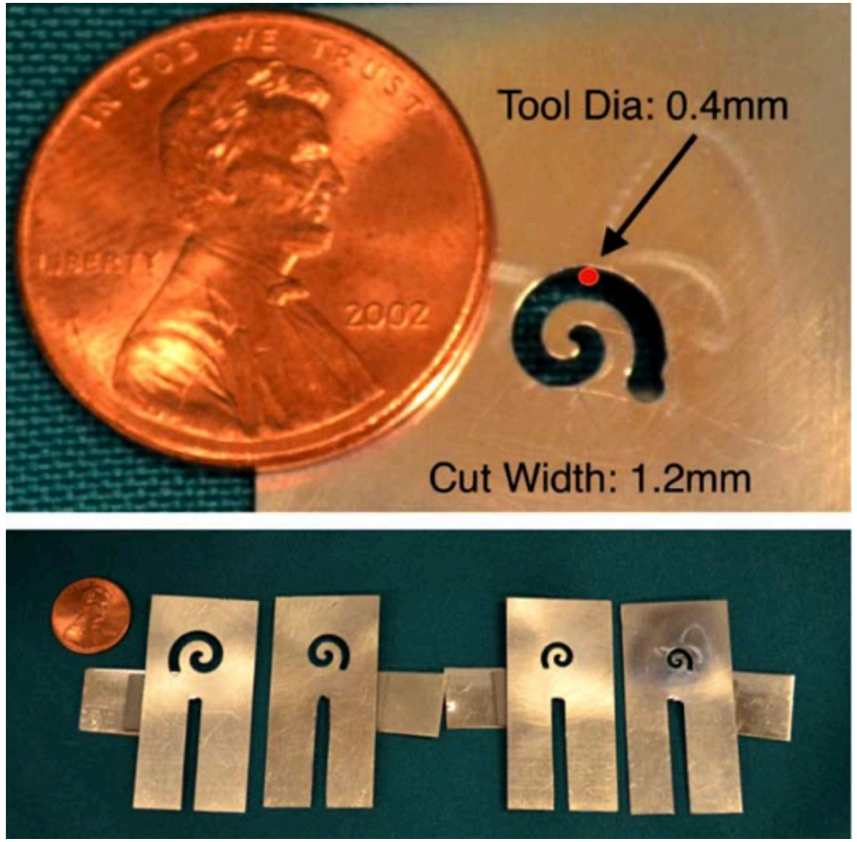

Fig. 3. The spirals, shown next to a penny. From left to right, the width of the spiral channels are 2.5 mm, 2.0 mm, 1.5 mm, and 1.2 mm, respectively. The 0.4-mm diameter of the microlaryngeal needle is represented by the red dot in the upper image.

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Data Collection

- Participants were given a practice session with the 2.5mm spiral to familiarize them with the robot and the surgical tasks
- Participants were asked to navigate the instrument through the spiral as quickly as possible without touching the sides
- Whenever the instrument made a contact with the spiral's sides, a buzzer sounded
- Five trials for each of the 2mm, 1.5mm, and 1.2mm spiral targets, both with and without the REMS

Statistical Analysis

- Mean fail time was calculated over five trials with each combination of spiral size and the robotic vs. manual performance for each participant
- Paired analysis was performed, comparing the participants' fail times with the REMS to manual fail times
- Statistical significance was assigned to results at a $P<.05$ level

Descriptive Analysis

- Participants were asked to provide feedback on the REMS using a survey form after experiment

Results

TABLE II.
Fail Times Across All Participants for Each Condition.

	All Three Spirals	2.0 mm	1.5 mm	1.2 mm
Manual fail time	0.769 ± 0.568	0.549 ± 0.545	0.890 ± 0.518	0.868 ± 0.634
Robot fail time	0.284 ± 0.584	0.156 ± 0.226	0.075 ± 0.099	0.621 ± 0.923
P value	.003	.019	.002	.52

Data are presented in seconds as mean ± standard deviation with statistical comparison.

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Results – Descriptive Feedback

TABLE III.
Subjective Feedback on Uses of the REMS Platform in Simulated Phonosurgery.

	Participant								
	1	2	3	4	5	6	7	8	9
Manual or robot first	M	R	M	R	M	R	M	R	M
Experience	6	6	4	2	3	6	3	7	7
Specialty	L	L	L	N/A	N/A	HN	N/A	HN	O
Left or right handed	Right	Right	Right	Right	Right	Right	Right	Right	Right
Used robot before	Y	Y	N	N	Y	Y	Y	Y	N
Experiment fair representation	4	5	4	3	5	5	3	3	3
Skill without robot	2	3	3	3	2	2	2	2	3
Skill with robot	5	5	5	4	5	5	3	4	4
Robot ease of use	5	5	4	3	5	4	3	4	4
Robot aid in real use	5	5	5	4	5	4	4	5	5
Better if bimanual?	Y	Y	Y	Y	Y	Y	Y	Y	Y
Would use it clinically?	Y	Y	Y	Y	Y	Y	Y	Y	Y

Experience is quantified by: 1 = medical student, 2 = junior resident, 3 = senior resident, 4 = fellow, 5 = attending <5 years, 6 = attending 6–10 years, 7 = attending >10 years. Subspecialty is quantified by: L = laryngology, HN = head and neck, O = other. Residents are marked N/A as they do not have a subspecialty yet. N = no; N/A = not applicable; M = manual; R = robot; REMS = robotic ear nose and throat microsurgery system; Y = yes.

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Paper Assessment

- Pros
  - Novel approach to use simulated phonosurgery tasks for objective evaluation on improvement in surgical precision using REMS over manual surgery
  - Crossover comparative study of surgical performance
  - Descriptive analysis of surgeon feedback
- Cons
  - Experiments based on simulated phonosurgery tasks
  - Indirect measurement of tremor

→ “Further feasibility studies and preclinical testing is needed for eventual clinical use of REMS system”

Relevance

- The Galen robot is a next generation research system of the robotic ear, nose, and throat microsurgery system (REMS)
- Will be conducting user study with microlaryngeal surgery tasks on cadaveric phantoms
- Will be using vision-based surgical tool tracking for tremor reduction assessment

Conclusion

- Paper was a great resource for the project:
  - Explains motivation, experimental setup, comparative study of surgical performance, and descriptive analysis of surgeon feedback
  - I will continue to refer to this paper in the future (especially when writing academic paper with surgeons)

References

- Akst, Lee M., et al. “Robotic Microlaryngeal Phonosurgery: Testing of a ‘Steady-Hand’ Microsurgery Platform.” The Laryngoscope, vol. 128, no. 1, 2017, pp. 126–132., doi:10.1002/lary.26621.

Thank you