# Quantitative Evaluation of Phonomicrosurgical Manipulation Using a Magnetic Motion Tracking System

Chen, Ting, et al. "Quantitative evaluation of phonomicrosurgical manipulations using a magnetic motion tracking system." *The Laryngoscope*124.9 (2014): 2107-2113.

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## Reasoning for paper selection

Phonomicrosurgery is defined as a highly specialized surgery to improve voice (phonosurgery) using microsurgical techniques and highly magnified views (microsurgery) in order to provide microscopic detail. For our study, we hope to investigate a specific type of this surgery called the laryngeal surgery. Laryngeal diseases affect millions of people in the world. Vocal cords specifically, play a significant role in one's ability to communicate. Due to the delicate nature of vocal cords, a very careful and accurate surgical approach is necessary to preserve or restore normal vibratory functions in the cords.

The Robotic Ear nose and throat Microsurgery System (REMS) is a robotic system for enhancing surgical precision that is currently under development at Johns Hopkins University. The REMS is cooperatively controlled, meaning that the surgeon and robot hold the surgical tool together, and the robot senses the surgeon's intent through a force sensor at the end of the robot arm, and moves to comply. The primary intent of the REMS is to help surgeons overcome hand tremor and fatigue by providing tremor cancelling and enhanced stability for high-precision work.

For our study we wish to study soft tissue manipulation using robotic assistance. More specifically, we wish to use the GALEN robot system. We wish to use animal larynx models to mimic human vocal cords, and injecting them with a model "cyst." Our goal is to simulate a cyst removal operation both manually and through robotic assistance. In order to do so, we will recruit subjects such as surgical experts, medical students, residents, and undergraduate students. However, our plan for the study was to videotape the operational trials from the subjects and then subjectively analyzing the video to come up with performance metrics with and without the robot.

This paper was chosen since it provides both subjective and objective analyses of a modeled phonomicrosurgery. The team, Chen et al., investigated performance of a simple surgical task (which mimicked a phonomicrosurgery) of both surgical experts and non-experts. They developed a quantitative approach to analyze surgical performance. Specifically, they developed a magnetic-based phonomicrosurgery instrument tracking system. Their study is extremely insightful for us as we approach setting up our experimental analyses parameters.

## Summary of Problem

The problem is briefly described in the section above. However, vocal cords are extremely delicate, and as a result, they require a very careful and accurate surgical approach. A successful surgical procedure would require a surgeon to maintain very smooth motion and minimize tremor as much as possible. Additionally, surgeons would have to ensure the least amount of damage possible to healthy tissue surrounding their region of operation. Other factors surgeons

consider when evaluating a successful laparoscopic surgery include: compact and continuous spatial motion of the tip of an instrument, smooth motion, good depth perception, a good sense of orientation, and coordination of two hands.

In order to be the best as possible in these respects, traditionally surgeons are trained in an apprentice style approach where they observe and perform procedures on patients under expert supervision. The problem that exists is that there is no real objective evaluation and feedback provision to surgeons. A good approach to objectively analyze surgical performance would significantly improve surgical education as it would provide more concrete feedback. Additionally, using the objective metrics, simulation training systems could be put in place which would help surgeons in training develop better skills.

## Key Result and Significance

By using a magnetic-based phonomicrosurgery instrument tracking system, the team was able to analyze surgical performance of experts and novices. They found differences in kinematic parameters between the two subject groups. In the dominant hand, experts demonstrated better motion smoothness than novices along the horizontal axis. In the non-dominant hand, experts had better motion smoothness than novices in all three axes, reduced path lengths, and better depth perceptions. Experts overall demonstrated better operational quality than novices. The significance of this study is that the team was able to differentiate between expert and novice surgeons by using the kinematic parameters they derived from the magnetic-based motion tracking.

## Necessary Background and Experiment

*Material and Methods*

For the experiment, the team used a phonomicrosurgery simulation bench which consisted of 1) a laryngeal dissection frame, 2) a floor-stand microscope, 3) right turn triangle forceps and upturned laryngeal microscissors, and 4) a surgeon's chair.

For the motion tracking system, the team used a peripheral component interconnect (PCI) bus-based direct current magnetic position and orientation tracking system, microBIRD to track the path of the tip of the surgical instruments within the surgical field. The microBIRD's sensors were attached to the tip of the instruments and was measured the strength of in the applied magnetic fields.

The simulation task for the experiment required making vertical cuts similar to microflap technique used in laryngeal microsurgery. The paper had 3mm x 3mm square grids and a centered circle of 25 mm in diameter. The simulation task is pictured in **figure 1.0** below.

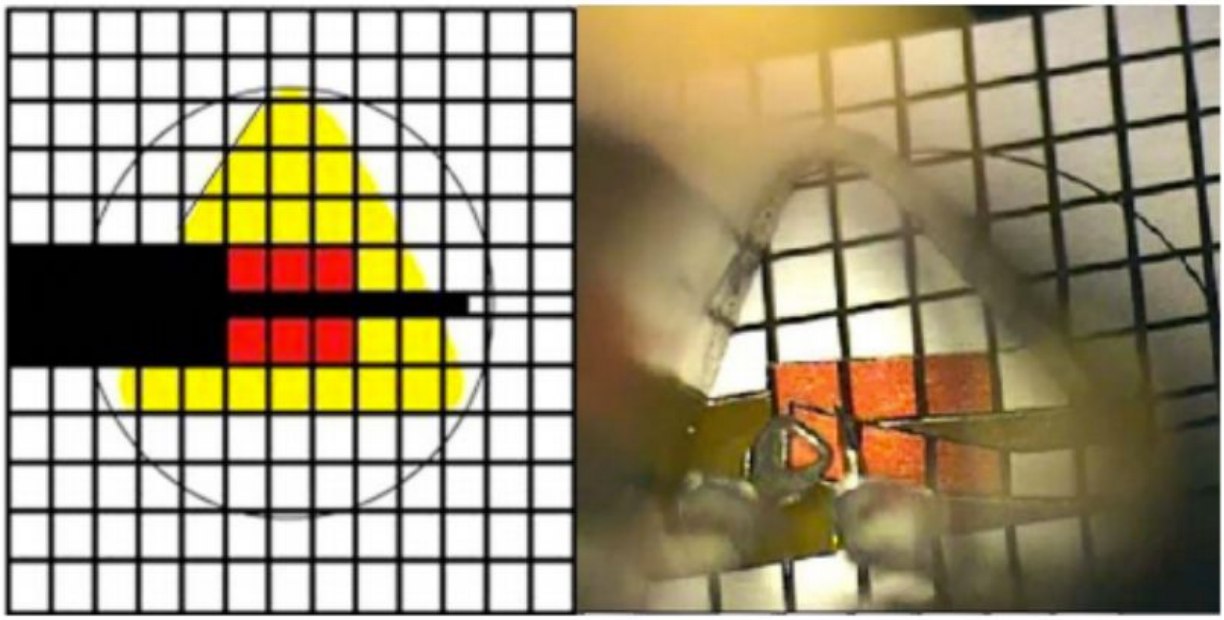

**Figure 1.0. Vertial cutting task grid (left) and task shown through the viewpoint of the microscope (right).**

The quality of operation was evaluated through scoring based on the ratio of the area being cut off to the standard square area.

## Theory

The team seeked to evaluate the use of a magnetic tracking system to characterize surgical skill. They hypothesized that their developed magnetic tracking system would successfully differentiate between experts and novices. As a result, they would be able to develop objective evaluation methods to quantify surgical skill, which would in turn provide valuable feedback to surgeons to enhance training. The team developed certain parameters to do this.

**Motion Smoothness:** This parameter characterizes the overall smoothness of the instrument's movement. It is based off of the measure of jerk, or the instantaneous change in acceleration. It is represented by this equation:

$$S = \frac{1}{T}\sqrt{\frac{1}{2}\int_0^T j^2 dt}$$

The higher the S value, the more significant the tremor is.

**Path length (P) :** This parameter measures the total distance travelled by the tip of the instrument. A shorter path equates to a more skillful surgical maneuver. It is represented by this equation:

$$p = \sum_{0}^{T} \sqrt{(dx)^2 + (dy)^2 + (dz)^2}$$

**Depth Perception (D) :** This parameter measures the total distance travelled by the tip of the instrument along the instrument's own axis.It is represented by this equation:

$$D = |(x_1 - x_2) \cdot \cos(42^\circ) - (Z_1 - Z_2) \cdot \sin(42^\circ)|$$

**Quality (Q):** This parameter was measured as the difference in area between the standard grid square and the area of the square after a cut is made. A lower score indicates a higher quality, as it implies that the operator cut more precisely along the vertical grid lines. It is represented by this equation:

$$Q = \sum_{k=1}^{n} (A - A_k)/n * A$$

## My Assessment (Relevance, possible next steps)

This study presents an insightful look at objectively analyzing surgical procedures in a phonomicrosurgery. The team developed a novel approach to use magnetic fields to measure the movement of the tip of an instrument during a surgical procedure and provide quantitative feedback which would aid surgeons in training to better improve their performances in simulated settings since they would have concrete metrics they could compare themselves to. A possible next step would be to actually do a simulated surgery on soft tissue (what we are trying to accomplish). If we could integrate an objective measure in our study, it would make our final deliverable much more crisp.

## Conclusions

When working with phonomicrosurgeries, there is a need to remove lesions without damaging surrounding healthy tissue. As a result, the margin of success is narrow, and these kinds of surgeries thus require a high demand in surgical skill. The only way to amend and develop skill is by being provided actionable feedback. Chen et al.'s study has come up with a way to quantitatively provide feedback for surgeons in training to better develop their skills.

## References


Chen, Ting, et al. "Quantitative evaluation of phonomicrosurgical manipulations using a magnetic motion tracking system." *The Laryngoscope*124.9 (2014): 2107-2113.

Zambricki, Elizabeth A., et al. "Phonomicrosurgery simulation: A low‐cost teaching model using easily accessible materials." *The Laryngoscope* 126.11 (2016): 2528-2533.

Garrett CG, Ossoff RH. Phonomicrosurgery II: surgical techniques. Otolaryngol Clin North Am 2000;33:1063–1070.

Cohen SM, Kim J, Roy N, Asche C, Courey M. The impact of laryngeal disorders on work-related dysfunction. Laryngoscope 2012;122:1589–1594

Branski RC, Cukier-Blaj S, Pusic A, et al. Measuring quality of life in dysphonic patients: a systematic review of content development in patientreported outcome measures. J Voice 2008;24:193–198.

Smith R, Marres H, de Jong F. The relation of vocal fold lesions and voice quality to voice handicap and psychosomatic well-being. J Voice 2012;26: 466–470.