Surgical Instruments for Robotic Microsurgery

Computer Integrated Surgery II
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Introduction

- Micro-scale surgery requires a very technically advanced skill set, including high hand-eye coordination and little-to-no hand tremor.
- To improve microsurgical procedures, such as vein suturing, we have developed tools for the REMS, a cooperatively-controlled surgical robot that reduces tremor when operating.
- Our goal is to design effective needle holders and validate the use of the REMS by comparing the free-hand and robot-assisted results of the procedure.

The Problem

- For microsurgeries requiring a high level of precision and accuracy, hand tremor can be detrimental to the quality of the procedure.
- Master-slave robots (ie. the DaVinci system) have difficulty operating is small workspaces, making them unsuitable for microsurgeries.
- Among currently available surgical robots, there is no system other than the REMS that provides steady-hand admittance control for general microsurgeries.

- Ideal components of an integrated needle holder:
  - ❑ Jaws that close over a wide area, not only at tip
  - ❑ Rigidly attached to the force sensor on REMS
  - ❑ Locking mechanism to keep jaws closed
  - ❑ Quick-release tool attachment unit
  - ❑ Light weight, ergonomically natural, and safe

The Solution

- An adapter for professional needle drivers was constructed
- Custom made needle holders were designed using CAD tools, rapid prototyped, and manufactured in machine shop.
- Pilot studies with six medical students and one attending physician in which manual and robot-assisted vein anastomoses were performed to validate the use of the REMS for microvascular procedures.

Figure 4: Adapter for needle drivers, apart and attached to the REMS.

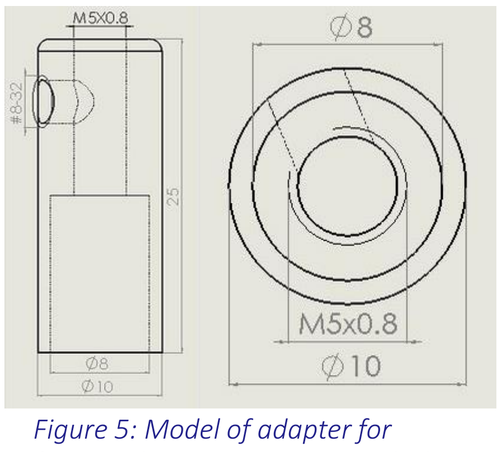

Figure 5: Model of adapter for forceps shown in Figure 4. Both the top and side holes were threaded for the corresponding screws.

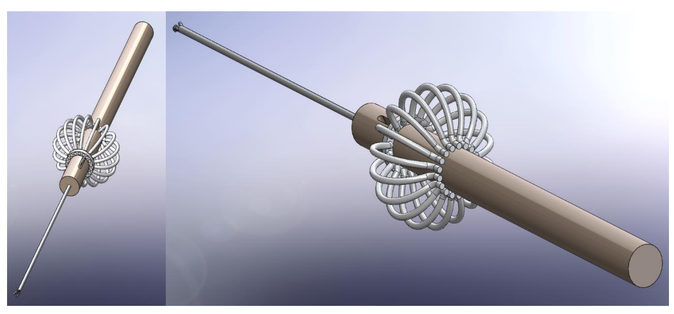

Figure 6: Original design for custom needle drivers. Modeled after the deformable mesh grip design from the Eye Robot tool.

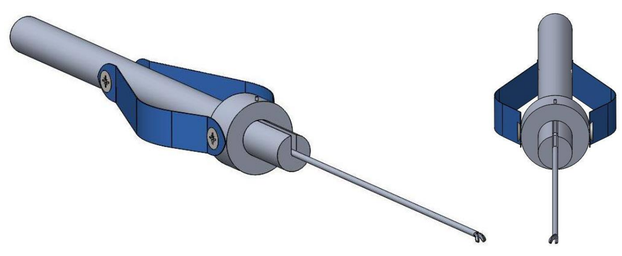

Figure 7: Model of the custom made needle drivers, shown in different views.

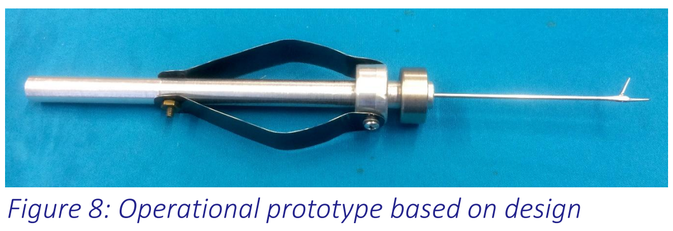

Figure 8: Operational prototype based on design shown in Figure 7. Simplified after difficulty constructing original design, shown in Figure 6.

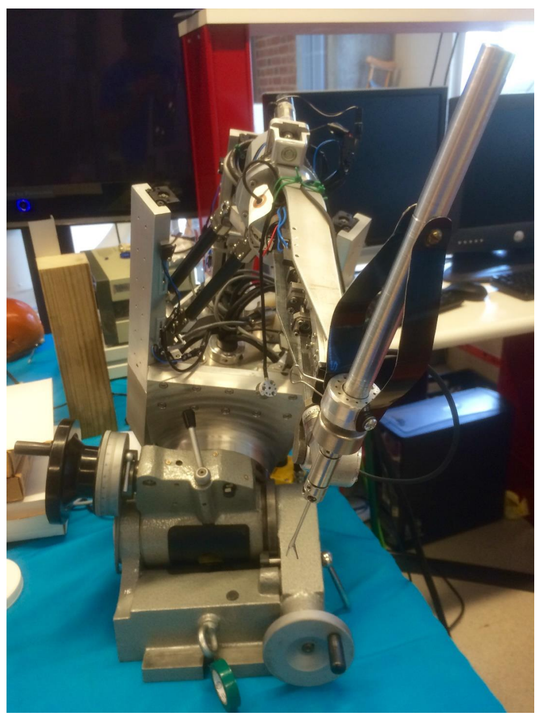

Figure 1: Robotic ENT Microsurgery System (REMS), shown with an attached needle holder prototype.

Figure 2: Chicken thigh model of free flap using ischiatic neurovascular bundle

Figure 3: Desired end result. Partial anastomosis with three sutures.

Outcomes and Results

- Manual and robot-assisted procedures were evaluated based on procedure time, tremor, tissue handling, and quality of results.
- Trials were recorded using a built-in microscope camera and shared with Allen Feng and Dr. Richmon for quantitative evaluation using OSATS scores.
- Though quantitative analysis is incomplete, robot assisted trials show overall better quality and take less time than manual due to tremor reduction.
- We verified that our custom prototype integrates well with the REMS and have scheduled test runs with our medical advisors.

Future Work

- Analyze results from validation study and submit a paper for publication.
- Conduct trials with the custom prototype.
- Integrate locking mechanisms and quick-release capability into later prototypes.
- Optimize prototypes and REMS movement algorithms and conduct *in vivo* trials.

Lessons Learned

- Methods for design and construction of prototypes for medical devices
- Optimize and simplify designs based on physical constraints prior to constructing and implementing.

Credits

- We worked together for the majority of the tasks, namely manufacturing the custom tool and conducting the trials for the validation study.
- Pranav performed REMS software tasks
- Zaid produced CAD models (Figures 5-7)

Support by and Acknowledgements

- This project was made possible with support from Kevin Olds, Marcin Balicki, Allen Feng, Dr. Taylor, and Dr. Richmon, and the medical students who agreed to be a part of the validation study.
- Thank you to the rest of the CIS class for encouragement and positive feedback.