Haptic Feedback in Laparoscopic Suturing: Development of A Needle Setting Training Device

Abhishek Chandra BA, Kristen Cox BSME, Alanna Carlson MS, Aidan Dulaney BS, Dasha Ignatova BS, Cody Miller BS, Paulina Swider BS, James V. Harmon MD PhD
University of Minnesota Medical School, University of Minnesota Department of Surgery

Background

- Laparoscopic suturing is a challenging skill for learners to master and educators to coach
- Instrument manipulation in a three-dimensional space with only a two-dimensional view exacerbates this challenge
- We developed a needle setting device to provide trainees an additional dimension of haptic and visual feedback in the operative field

Objective

- **Usability**
  - Device will be able to interface with many needle drivers without impeding grasper function
- **Haptic Feedback**
  - Device will allow user to appreciate the angles of tissue anatomy intraoperatively
- **Visual Feedback**
  - Device will provide stitch orientation, helping trainees set the needle perpendicular to the needle driver shaft

Device Design

Device consists of a hollow sheath, silicone tip, and slider, all 3D-printed from biocompatible PLA (polylactic acid).

A. Hollow sheath
- Encases the neck and can be attached to most industry standard needle drivers,
- Affixed to neck to prevent rotation

B. Silicone tip
- Attached to end of sheath, protecting tissue and providing haptic feedback
- Clear silicone with green reference line

C. Slider mechanism
- Retracts silicone tip along the sheath when not in use

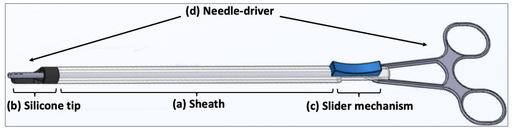


Figure 1: Needle setting device with (a) silicone tip providing haptic feedback and spatial orientation to user, (b) device sheath, (c) slider mechanism to retract and deploy the silicone tip, (d) needle driver.

Prototype Testing

- **Mechanical Integrity Evaluation**
  - Simulation-based functionality testing using FLS
  - Evaluate the force required to puncture the silicone tip and the tensile strength limit of the silicone under stretch strain (Figure 2)



Figure 2: Staff surgeon using the needle-setting device to perform standard FLS skills training tasks as part of the functionality and integrity assessment.

- **Assessment 1**
  - Suture-assist device is stabilized in the laparoscopic environment with an attached spring load
  - Participant controls a standard laparoscopic driver with 17 mm RB-1 needle and punctures the silicone tip
  - Force required to puncture the silicone is measured
    - 5 general surgery residents
    - Range of forces recorded: 1.18 - 2.81N
    - Average force resisted prior to puncture: 1.94N

- **Assessment 2**
  - Participants laparoscopically apply increasing load strain on the silicone tip
  - Maximum load force applied until the point of tearing or break is measured
  - Longitudinal dimension of the silicone attachment following application of the maximum strain force is measured. Original dimension: 12.0 mm
    - 3 general surgery residents
    - Maximal loads prior to tearing: 13.0, 17.5, 26.0N
    - Elongation: 15.1, 20.0, 28.9 mm respectively

Literature Review

- **Limited Hands-On Training**
  - Only 8% of surgical residents in a national survey reported feeling comfortable performing advanced laparoscopic procedures at the end of their training[1]
- **Laparoscopic Suturing: A Problem Area**
  - Of 91 fellowship program directors surveyed, 56% reported that surgical fellows were not proficient in laparoscopic suturing [2]
  - A national survey of 186 surgical fellows and fellowship directors identified laparoscopic suturing as the most common technical skill deficiency, with 72% reporting that an advanced skills curriculum was needed [3]
- **Focused Skills Training**
  - Simulation training has proven to be efficient and effective at developing durable skills
- **Visual and Haptic Feedback**
  - Trainees learn more quickly and perform more consistently with haptic feedback
  - A study of laparoscopic VR training found that haptics allowed superior precision in more advanced tasks [5]

Conclusion

- Preliminary findings demonstrate the device's potential viability as a training tool (Figure 3)
- Next steps include additional materials research, device testing, ergonomic enhancements, and validation studies

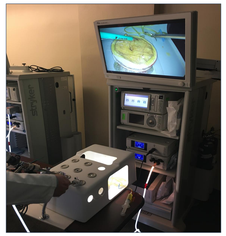


Figure 3: Needle setting device being used as a supplemental tool in laparoscopic simulation exercises for general surgery trainees at our program

Acknowledgements and References

References are available digitally via QR Code.

We would like to express our gratitude to the University of Minnesota, School of Biomedical Engineering and Brian Watschke for their support.