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Pre-Meeting Activities: Thursday, MARCH 14, 2019

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Automated Assessment of Surgical Knot Tying

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### Funding Source for My Research Project

<table>
<thead>
<tr>
<th>Potential Funding Sources</th>
<th>Check all that apply</th>
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<tbody>
<tr>
<td>1 Sim center operational funds</td>
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<td>2 Intramural grant</td>
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<td>3 Clinical Departmental funds</td>
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<td>4 Hospital operations</td>
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<td>5 School of Medicine</td>
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<td>Other</td>
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Fundamental surgical skills:

- **Knot tying**
  - Core component of basic surgical skills curricula
  - Practiced deliberately prior to operating room
- **Respect for tissue**
  - Ability to control applied forces when manipulating tissue
  - Important role in knot tying

Mastery of these skills:

- Potential to decrease OR time and improve patient safety
Current knot tying models for assessment:

- Ability to measure efficiency and errors
- Do not address respect for tissue
- Ignores how learners interact with tissue
- May reinforce incorrect habits
Our aim:

• To develop a low cost knot tying simulator to collect objective, automated metrics of target tissue displacement as a proxy for tissue handling
Introduction

Our aim:
• To develop a low cost knot tying simulator to collect objective, automated metrics of target tissue displacement as a proxy for tissue handling

Our hypothesis:
• This novel assessment tool would discriminate between various levels of surgical performance based on displacement
Knot Tying Board Development

- Multi-institutional collaboration
- 100 hours, $70
- Designed to resemble current knot tying simulators
- Joystick potentiometers transmit displacement data to Excel spreadsheet
Data Collection

• Participants:
  - Juniors (26) = PGY 1&2; Seniors (14) = PGY 3-5; Surgical Faculty (7)
• Baseline data collected
  - Handedness, working hand, preferred knot tying approach
• Participants tied 4 knots
  - 2x 2-handed
  - 2x 1-handed
• No information given re: metrics collected
• Instructed to tie knots as they normally would
Knot metrics collected:

• Time (sec)
• Maximum vertical displacement (cm)
• Maximum horizontal displacement (cm)
Results

<table>
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<tr>
<th></th>
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<th>Seniors</th>
<th>Juniors</th>
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<tr>
<td>1-handed knots</td>
<td>n=7</td>
<td>n=14</td>
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<td>2-handed knots</td>
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</table>

Knot Time

Max Vertical Displacement

1-handed knots  2-handed knots
Results

- **Attendings**
  - 1-handed knots
  - 2-handed knots

- **Seniors**
  - 1-handed knots
  - 2-handed knots

- **Juniors**
  - 1-handed knots
  - 2-handed knots

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**Knot Time**

- **p = 0.04**

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**Max Vertical Displacement**

- **p = 0.01**
Results

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<td>p&lt;0.01</td>
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**Knot Time**

**Max Vertical Displacement**
Results

Knot Time

Max Vertical Displacement

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</table>

p<0.01

p=0.21

1-handed knots
2-handed knots
Results

Knot Time

- 1-handed knots
- 2-handed knots

Max Vertical Displacement

- 1-handed knots
- 2-handed knots

p=0.16

p=0.14
Results

Knot Time

- Attendings
- Seniors
- Juniors

1-handed knots
2-handed knots

Max Vertical Displacement

- Attendings
- Seniors
- Juniors

1-handed knots
2-handed knots

\( p < 0.01 \)

\( p = 0.20 \)
Results

**Knot Time**

- **p = 0.01**

**Max Vertical Displacement**

- **p = 0.80**

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Discordance between:

- dominant hand vs. working hand
- preferred knot tying approach vs. knot performed

Did **not** make a significant difference on time or displacement for either 1- or 2-handed knots across all groups of participants.
Knot tying time decreased and vertical displacement increased with increasing level of experience

Able to distinguish among levels of performance based on vertical displacement
Expert Characteristics

Ability to maximally adapt to task constraints:

- Recognized the knot tying board as a robust/sturdy model
- Displacement “appeared less critical” in this context
- Un-blinded author had lowest observed displacement during pilot testing

Limitations and Future Directions

• Sample size
  - Some of the trends started to approach significance

• Knot security
  - Will incorporate this metric into future designs
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  - Some of the trends started to approach significance

• Knot security
  - Will incorporate this metric into future designs

• Future iterations:
  - Appear more delicate
  - Specific tissue instructions
  - Tie-at-depth model
Summary

• Open knot tying and respect for tissue are fundamental surgical skills necessary for the performance of safe surgery.
• The use of displacement as a metric for knot tying performance may serve as proxy for tissue handling.
• May promote the development of knot tying and tissue handling skills by residents.
A novel, low-cost knot tying board was developed to incorporate a new metric of performance, knot displacement, as a proxy for tissue handling.


Questions?
• Speed-accuracy trade-off phenomenon
  - Accuracy decreases as the performance speed of a task increases and vice versa
  - Displacement, which increased as task time decreased, may be a proxy for accuracy

Heitz RP. Front Neurosci. (2014)