SURGERY TUTOR FOR COMPUTATIONAL ASSESSMENT OF TECHNICAL PROFICIENCY IN SIMULATED SOFT-TISSUE TUMOR RESECTION

JUSTINE RING¹, CAITLIN T. YEO¹, MATTHEW HOLDEN², AYCA TOPRAK¹, TAMAS UNGI², GABOR FICHTINGER², BORIS ZEVIN¹

¹ School of Medicine, Queen’s University
² School of Computing, Queen’s University
INTRODUCTION

- Competency Based Medical Education (CBME)
  - Need for objective, reliable means of evaluating technical skills
  - Decrease need for faculty presence for low-stakes evaluations
- Lack of data on learning curves for soft-tissue tumour excision
  - Measure the rate of skill acquisition in novice trainees
  - Assess readiness for performing procedures in the clinical environment
OBJECTIVES

- Provide evidence of reliability and construct validity for Surgery Tutor
- Hypothesis:
  - Surgery Tutor can discriminate between novice, intermediate, and experienced surgeons performing soft-tissue tumour excisions
METHODS

- Power calculations determined sample size of 30
- Grouped by number of soft-tissue tumour excisions performed in last 5 years
  - Novice (0-10)
  - Intermediate (11-40)
  - Experienced (>40)
METHODS

Phase 1: Planning
Phase 2: Excision
Phase 3: Closure
METHODS

- **Metrics recorded**
  - Time for each planning, excision and skin closure phases
  - Mass of tissue removed
  - Specimen margin status
  - Motion tracking

- **Each participant excised 4 tumours**
  - 2 palpable and 2 non-palpable
METHODS

- Electromagnetic (EM) motion tracking
  - Surgeon’s hand motions
  - Scalpel
  - Ultrasound probe
  - Tumor location
ANALYSIS

- **Reliability**
  - Interclass correlation coefficient (ICC) – motion tracking metrics for two consecutive excisions

- **Construct validity**
  - ANOVA/Kruskal-Wallis – performance between groups

- **Relating metrics to other variables**
  - Spearman/Pearson correlation coefficient for parametric data against OSATS scores

- **Statistical significance P<0.05**
  - Bonferroni correction for multiple comparisons: P<0.017
### DEMOGRAPHICS; MEDIAN (RANGE)

<table>
<thead>
<tr>
<th>Level of training</th>
<th>Novice (n=10)</th>
<th>Intermediate (n=10)</th>
<th>Experienced (n=10)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior medical student</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Junior resident (PGY 1-2)</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Senior resident (PGY 3-5)</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>General surgeon</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**Number of soft tissue resections**

<table>
<thead>
<tr>
<th></th>
<th>Novice (0-6)</th>
<th>Intermediate (11-40)</th>
<th>Experienced (43-1000)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>21</td>
<td>88.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>ICC</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>-------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novice</td>
<td>0.60 (0.01-0.86)</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>0.57 (0.08-0.86)</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced</td>
<td>0.74 (0.40-0.90)</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HAND AND INSTRUMENT MOTIONS

![Box plot showing the comparison of hand and instrument motions among novices, intermediates, and experienced participants. The plot indicates significant differences (P<0.01) with outliers present.]
TIME TO COMPLETE RESECTION

- Novice: Total Time 191s, Planning 135s, Excision 375s, Closure 154s
- Intermediate: Total Time 254s, Planning 91s, Excision 308s, Closure 125s
- Experienced: Total Time 254s, Planning 71s, Excision 254s, Closure 125s

P<0.01
POSITIVE MARGIN RATES (%)
NUMBER OF TUMOUR BREACHES

The graph shows the number of tumor breaches for different levels of experience: Novice, Intermediate, and Experienced. The data indicates a statistically significant difference between the groups, with a p-value of less than 0.01 (P<0.01).
MASS OF COMPLETELY EXCISED SPECIMENS

P=0.04

Novice  Intermediate  Experienced
OSATS SCORES BY LEVEL OF EXPERIENCE
OSATS CORRELATION COEFFICIENTS

A. Motion vs. OSATS
(r=-0.60, p<0.01)

B. Time vs. OSATS
(r=-0.54, p<0.01)

C. Tumor Breaches vs. OSATS
(r=-0.33, p=0.09)
SUMMARY OF RESULTS

- Surgery Tutor demonstrated moderate to good test-retest reliability, and moderate to strong relation to other variables
- The following metrics from the Surgery Tutor demonstrated construct validity:
  - Number of hand motions
  - Time to perform the procedure
  - Number of times tumor was breached by scalpel
  - Positive margin rate
CONCLUSIONS

- Surgery Tutor is a reliable and construct valid platform for assessment of technical proficiency during open soft-tissue tumor excision in a simulation laboratory.
- Can be used for proficiency-based training in open surgical procedures in the simulation setting.
FUTURE WORK

- Use Surgery Tutor proctorless training
  - Metrics provide formative feedback
- Assess predictive validity
  - Correlate to proficiency in the operating room