MOTION ANALYSIS IN ENDOSCOPIC SURGERY: DEVELOPMENT OF AN ENHANCED SIMULATION PLATFORM TO AID IN RESIDENT TRAINING

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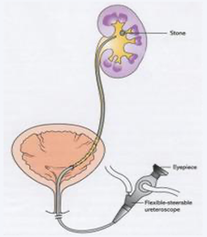
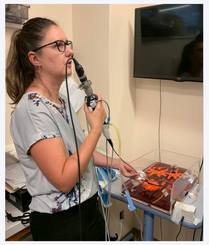
INTRODUCTION

- Hand/instrument motion-tracking in surgical simulation can provide valuable data to improve psychomotor skills, and can also serve as a more formative evaluative tool.
- Although motion analysis has been well studied in laparoscopic surgery, it has been very poorly studied in endoscopic surgery - with essentially no studies done for flexible ureteroscopy (fURS), a surgical procedure that requires a significant amount of hand dexterity.
- In this study we aimed to develop a ureteroscopic surgery simulation platform that incorporates motion tracking capabilities.



METHODS

- Polhemus™ system used to design motion tracking platform for benchtop ureteroscopy simulator.
- Specific instrument motions determined to be important during fURS were captured.
- Motion data was captured for a defined task performed on a simulator.
- Motion analysis metrics for fURS are explored and established.
- 1-way ANOVAs and post-hoc paired *t*-tests were used to evaluate differences between participants of differing expertise levels.



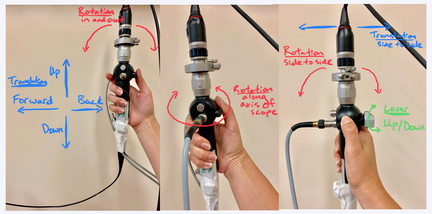
DEFINED ENDOSCOPIC TASK

- Visualization of one upper, one inter-, and one lower pole calyx on commercially available Cook benchtop surgical simulator.
- Participants were asked to pause for 10 seconds when visualizing each papilla to help discriminate the motion data.
- 25 participants recruited (5 novices, 13 residents, 7 urologists).

DEGREES OF FREEDOM

Analyzed key motions during fURS:

- Translational movement
  - Scope forward and back
  - Scope side to side
  - Scope up and down
- Rotational movement
  - Rotation along axis of scope
  - Rotation side to side
  - Rotation in and out
- Lever movement up and down

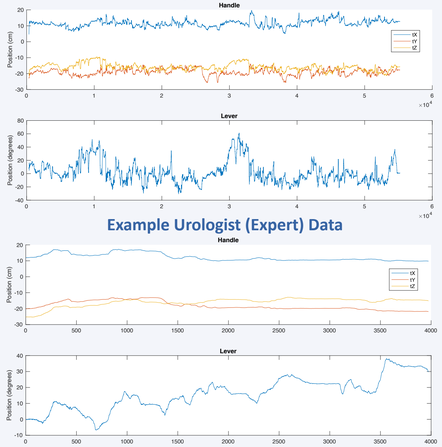


(sensors attached to scope)

MOTION ANALYSIS PARAMETERS

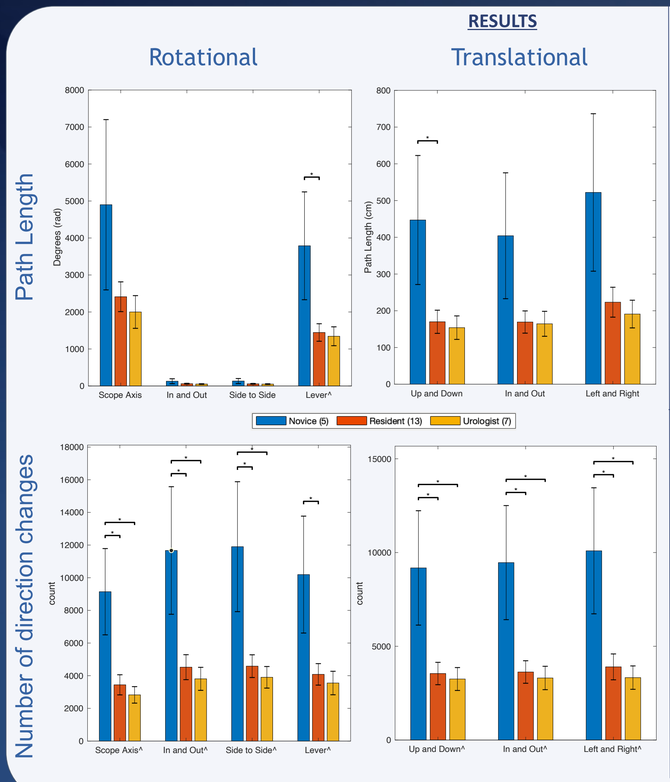
- Output data filtered and cleaned using low pass filter. Physiologically impossible positions and movements removed.
  - Average of 0.804% of data removed per participant.
- **Path Length**: Total distance travelled in each degree of freedom.
- **Number of direction changes**: Number of times each degree of movement changes direction.
- **Volume of movement**: Maximum 3-dimensional space used during the task. (Max – min) in each 3 translational dimension multiplied together.

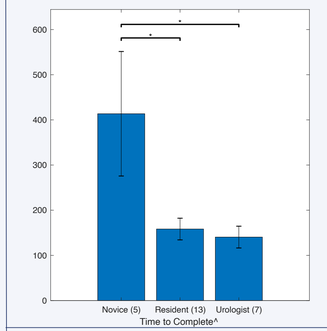
Example Novice Data

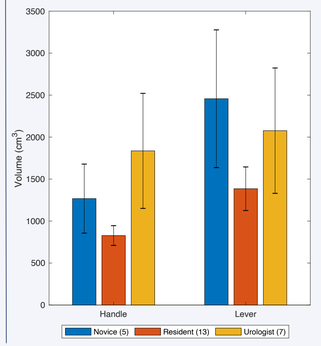


Example Urologist (Expert) Data

RESULTS







^ Denotes significance ($p < 0.05$) in 1-way ANOVA. * Denotes significance ($p < 0.05$) in paired *t*-tests.

CONCLUSIONS

- A spread in time to task completion suggests good construct validity in our task.
- We were able to successfully create a flexible ureteroscopy simulation platform that captures instrument motion. Preliminary data analysis suggests motion analysis parameters can distinguish between levels of expertise. In particular, the number of direction changes significantly discriminates between Novice and Urologist in every degree of freedom captured.
- Further analysis may develop advanced motion metrics in fURS (such as the degree of discordance between surgeon hand motion and ureteroscope tip motion).

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