Objective Methodology to Quantify Motor Skills in Basic Orthopaedic and Gynecologic Surgical Tasks

THE UNIVERSITY OF ARIZONA COLLEGE OF MEDICINE PHOENIX

Sarah Kennedy Sharer; Kanav Kahol Ph.D, Arizona State University;
Matthew Nugent M.D., Alex McLaren M.D., Melissa Gioia M.D. Banner Good Samaritan Medical Center

Introduction

- Skill level of surgeons is an important metric to capture in a training environment.
  - To date, teaching of skills has been subjective.
- Objective outcome measures in surgery are identified in the literature, and are effective in differentiating levels of expertise in surgical tasks.
  - An experienced surgeon demonstrates expertise through sophisticated motor skills, which are refined, smooth, and very efficient.
  - Comparatively, a novice's performance appears awkward and highly inefficient.
- Fine level detailed analysis in surgical procedures reveals important mechanisms involved in surgical learning.
- There is a need to develop a cross-compatible evaluation system that can be employed with many simulators, skills, and even in the OR.

Hypothesis

Surgical skill levels of individuals with various years of training can be differentiated using data gloves (Immersion CyberGloves ®).

Materials & Methods

Study 1 – Orthopaedic Drilling

IRB approval through Banner Health and informed consent from all participants. 16 Participants were recruited based on experience:

- No Skills - 6 medical students that had never used a drill
- Limited Skills – 4 junior orthopaedic residents with 6 months – 1 year of exposure
- Expert Skills – 6 practicing orthopaedic surgeons with extensive use of these skills

Figure 1: Setup orthopaedic drilling

Task:
Drill a 3.2 mm hole in cadaveric femur, tap threads into the hole using a tap on a T-handle, and insert a 4.5 mm cortical screw into the hole until the head was tight against the near cortex. Repeat 10 times. Real time wrist, hand and finger position was recorded using Immersion CyberGloves® and the Ascension Liberty Tracker®.

Study 2 – Gynecologic Suturing

IRB approval through Banner Health and informed consent from all participants. 20 participants enrolled:

- No Skills – 5 First year residents with minimal to no practice of their suturing skills
- Limited Skills – 5 Second year residents with limited practice of their suturing skills
- Advanced Skills – 5 Upper level residents with ample suturing practice
- Expert Skills – 5 Practicing obstetrician gynecologists with extensive use of suturing as a routine part of their practice

Figure 2: Layout Study 2 suturing.

Task:
Place five continuous running sutures across each of the five 10 cm incisions in an artificial silicone skin. Repeat five times. Real time wrist, hand and finger position was recorded bilaterally using Immersion CyberGloves® and the Ascension Liberty Tracker®.

Discussion

Published studies discuss the use of tool movements and force profiles as the means of assessing competency of the performer in simulation environments. None of the studies measured hand movement and posture during the task, important components of basic motor skills. Measuring hand movements allows detailed analysis and feedback. Our system is capable of quantifying hand movement and posture in addition to the parameters associated with tool movements.

Immersion CyberGloves® can capture objective, quantitative, continuous, performance data from participants performing fundamental orthopaedic tasks such as drilling a hole, tapping threads in a hole, and inserting a screw into the tapped hole; as well as gynecologic tasks like placing the needle in the needle driver, driving the needle into the appropriate layer of tissue repeatedly to bring the edges of the wound together. The data acquired in these studies was able to objectively distinguish between the skill levels of the participant groups.

Results – Study 1

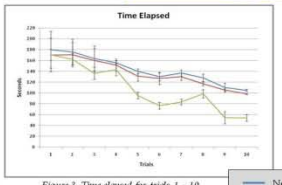

Figure 3. Time elapsed for trials 1 – 10 for each skills group.

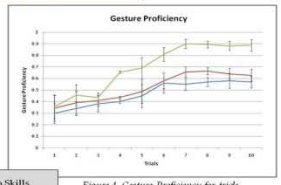

Figure 4. Gesture Proficiency for trials 1 – 10 for each skills group.

No Skills
Limited Skills
Expert Skills

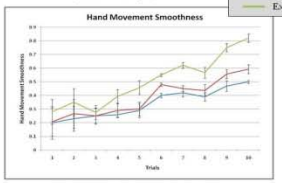

Figure 5. Hand Movement Smoothness for trials 1 – 10 for each skills group.

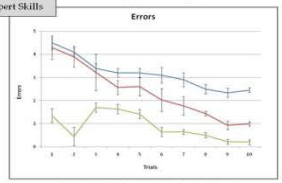

Figure 6. Number of Errors for trials 1 – 10 for each skills group.

Results – Study 2

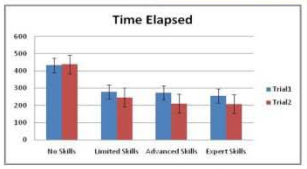

Figure 7. Time elapsed to complete the tasks in each trail for the four skills groups.

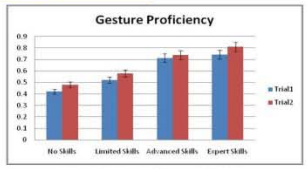

Figure 8. Gesture Proficiency achieved by the four skills groups in two trials.

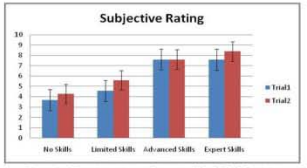

Figure 9. Subjective rating, as determined by skilled physicians based on video footage, of participants' performance in all four skills groups in two trials.

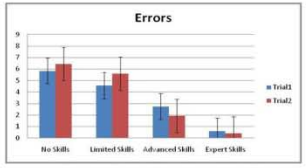

Figure 10. Number of Errors in completion of the tasks two trails for all four skills groups.

Conclusion

In conclusion, hand movement data can be acquired for basic surgical skills required to perform tasks such as suturing, drilling a hole, taping threads in a hole and insertion of a screw. That data can be used to identify motor skills levels and learning across skill levels.

Acknowledgements

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