Development and Validation of a Virtual Teaching Method for Minimally Invasive Surgery Skills: A Prospective Cohort Study

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Introduction

This study aimed to evaluate whether minimally invasive surgery (MIS) skills could be effectively taught remotely using widely available technology with objective assessments of proficiency.

Teaching MIS skills remotely presents challenges such as reduced depth perception, limited range of motion, and fulcrum effect. This objective of this study was to validate a pragmatic, scalable virtual MIS course and compare it to face-to-face (F2F) teaching, using both performance and cognitive workload metrics.

Methods

Design: Prospective cohort study conducted at the training centre of the London Postgraduate School of Surgery (March–April 2022). Study ran over two days: Day 1 served as a pilot virtual course to identify and resolve technical and logistical issues; Day 2 comprised the main study comparing virtual and face-to-face (F2F) sessions.

Participants: Twenty novice trainees with minimal prior experience in minimally invasive surgery.

Group allocation: F2F group (n = 8) and Virtual group (n = 12).

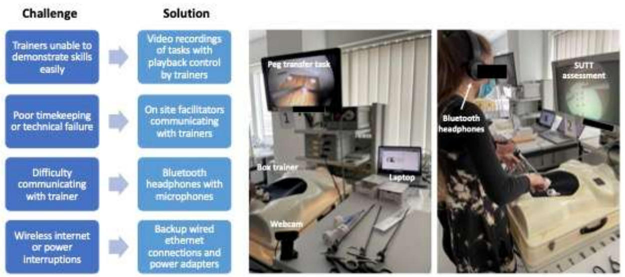
Tasks: Standardised laparoscopic simulation tasks – MISTELS peg transfer and SUTT intracorporeal suturing.

Virtual platform: MedAll platform used for live teaching with main-stage demonstrations and breakout rooms for individualised feedback.

Outcome measures: Task completion time, number of errors, knot quality, and tissue trauma.

Cognitive workload assessment: SURG-TLX questionnaire, heart rate monitoring, and eye-tracking metrics including pupil size, fixation frequency, and blink rate.

Statistical analysis: Continuous variables analysed using t-tests or Mann–Whitney U tests depending on distribution; categorical variables compared with Fisher's exact test. Statistical significance set at $p < 0.05$.



[Figure 1: Pilot Challenges and Solutions]

Results

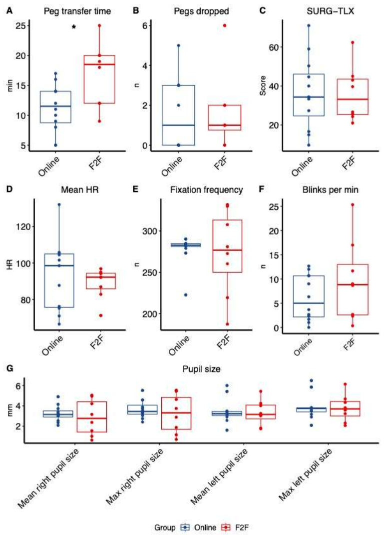
Peg transfer performance: The virtual group completed the task significantly faster than the face-to-face group (11.25 vs 16.88 minutes; p = 0.015).

Errors and suturing outcomes: No significant differences were found in the number of dropped pegs (p = 0.961) or in SUTT performance measures, including completion time, errors, knot quality, and tissue approximation.

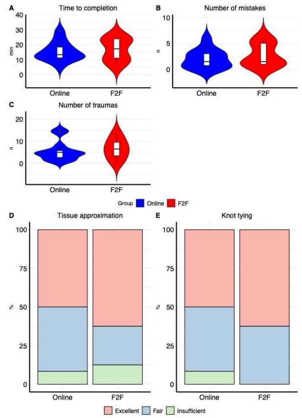
Cognitive workload: SURG-TLX scores, heart rate, and eye-tracking parameters (pupil size, fixation rate, blink rate) showed no significant differences between groups.

Pilot phase insights: The initial pilot identified key technical issues such as communication delays and connection stability. Improvements included clearer communication tools, dedicated facilitators, and wired internet connections for the main study.

Overall findings: Virtual minimally invasive skills training was feasible and produced performance outcomes equivalent to face-to-face instruction.



[Figure 2: Peg Transfer Results and Cognitive Metrics]



[Figure 3: SUTT Assessment Outcomes]

Discussion

Virtual MIS teaching achieved performance outcomes comparable to traditional face-to-face training, with no significant difference in cognitive workload metrics. This equivalence supports the notion that **real-time virtual instruction** using standard simulation equipment can effectively facilitate technical skills acquisition in novices.

Key advantages of virtual delivery include scalability, reduced costs, and improved accessibility—especially for learners in remote or resource-limited settings. These benefits suggest strong potential for expanding training reach beyond conventional constraints.

There ere are, however, important limitations: the small sample size limits generalisability, the study lacked long-term follow-up of skill retention, and outcomes depend heavily on stable, high-quality internet connectivity and adequate infrastructure. The pilot's requirement for troubleshooting underscores this dependency.

Future research should include larger, multi-centre trials to validate these findings across diverse settings; studies with extended follow-up to assess skill retention over time; and subgroup analyses (e.g. by baseline ability, learning styles, or geographic setting) to identify which learners benefit most from virtual approaches.

Conclusion

Virtual teaching of minimally invasive surgical skills using a web-based streaming platform is both feasible and effective.

Performance outcomes and cognitive workload were equivalent to traditional face-to-face instruction, demonstrating that virtual delivery can provide high-quality technical training.

These findings support virtual instruction as a **scalable, cost-effective, and sustainable model** for global surgical education and capacity building.

MTW
Exceptional people, outstanding care

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