Kinematic Analysis of Suturing Tasks Using Senhance® Robotic System through augmentOR™ Portal

Yike Xu, MD[1]; Sara S. Lazzaretti, PhD[2]; Jeffrey P. Spalazzi, PhD[3]; Janette Gil, MSN, RN[3]; Edward Chekan, MD, FACS [3,4]
1 Asensus Surgical Europe S.a.r.l. – Swiss Branch
2 Asensus Surgical Italia S.r.l., Milan, Italy
3 Asensus Surgical Inc., Durham, NC, USA
4 Duke University Health System, Department of Surgery.

Background

Robotic-assisted surgery increasingly incorporates digital solutions that enable objective evaluation of technical skills. The augmentOR™ Portal integrates intraoperative video with system log data to deliver performance analytics without reliance on costly external tools. Suturing represents a technically demanding task and an ideal model for assessing learning curves. This study explored whether force feedback (FFB) accelerates stabilization of motion patterns and efficiency during repeated suturing using the Senhance® Surgical System, while demonstrating the feasibility of augmentOR™ as a training and research platform.

About Senhance

The Senhance Surgical System (Fig.1) initially named Telelap ALF-X, is intended to assist in the accurate control of laparoscopic instruments for visualization and endoscopic manipulation of tissue. It was approved by European regulators for clinical use in gynecology, urology, general, and thoracic surgery in 2014 and clearance by the Food and Drug Administration (FDA) in 2017 through the 510(k) pathway. It received expanded FDA 510(k) clearance for pediatric indication in 2023. Senhance is an open-architecture, multi-arm surgical system that enables the surgeon to control surgical instrumentation from a console remotely during. It is composed of three main parts: Manipulator Arms, Cockpit and Intelligent Surgical Unit (ISU).

Fig.1: Typical Senhance three-arm setup

Methodology

A standardized dry-lab suturing task was performed using the Senhance® Surgical System and a laparoscopic training model (LAPARO, Wroclaw, Poland). One experienced surgeon completed 12 intracorporeal sutures with a crossover design (six with Force Feed Back (FFB)-ON, six with FFB-OFF). Each procedure was video-recorded and system logs captured 36 kinematic parameters per instrument arm. augmentOR™ was employed to integrate video and telemetry for quantitative analysis of suturing time, instrument travel distance, velocity, applied force, and movement counts.

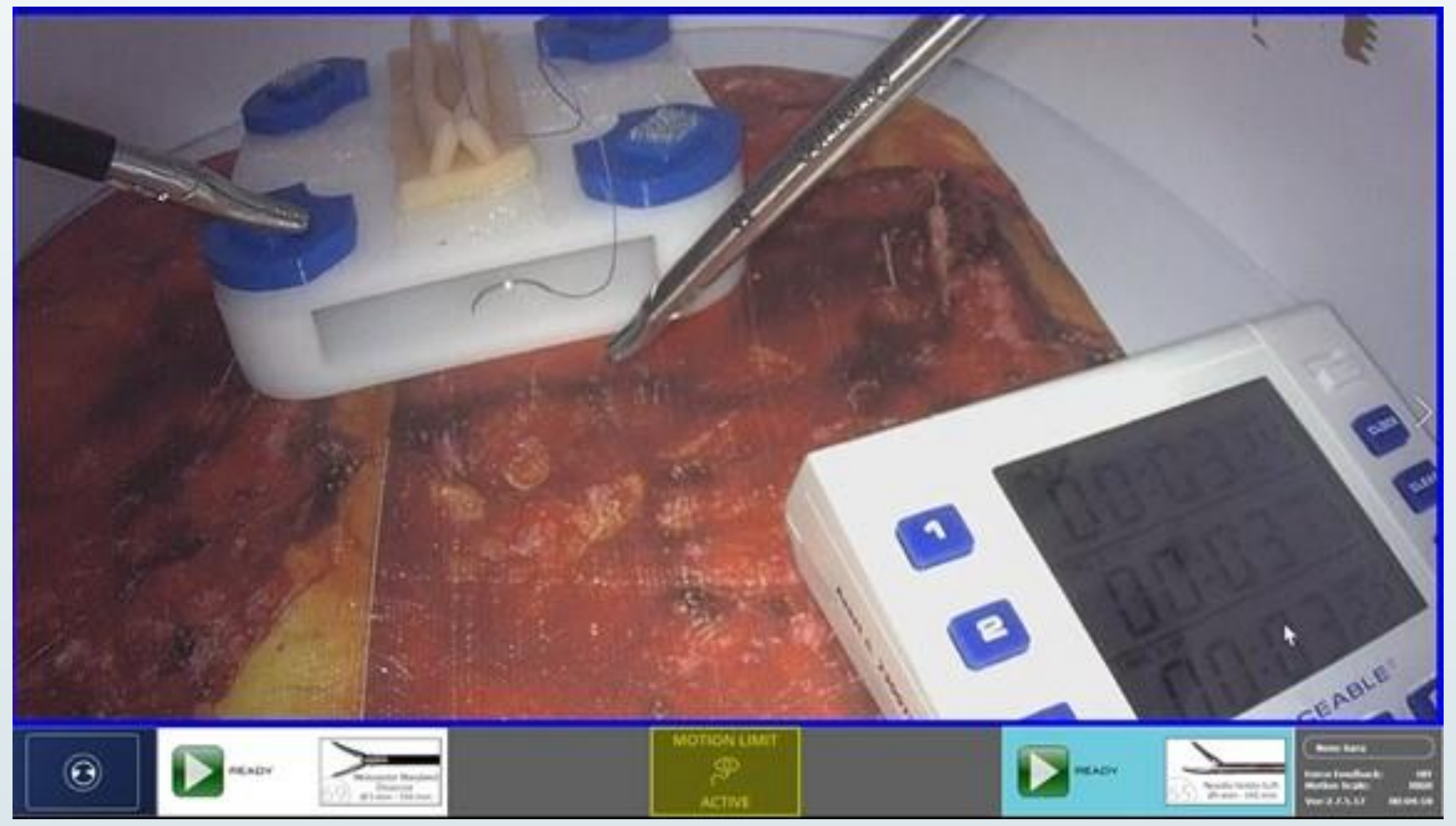

Fig. 2: Standardized suturing bench setup with stopwatch

Force feedback

The distal part of each robotic manipulator arm is equipped with a force torque sensor. The scaled 1:1 force feedback feature of the Senhance System measures the forces experienced by the instruments in the X, Y, and Z Cartesian plane and transfers these forces electronically to the handles at the console. The surgeon perceives tissue presence, contact, and relative stiffness via force feedback information regarding contacted tissues with the instrument tips and/or shaft during surgical maneuvers.

Results

Preliminary analysis of the trial indicated more efficient and consistent performance when FFB was enabled. Median suturing time was shorter with FFB-ON (194.5s) versus FFB-OFF (203.0s), with lower variability (SD 14.9 vs. 22.1). Although differences did not reach statistical significance due to limited sample size (n=6 per group, p=0.259), effect size calculations estimated that 34 trials per group would be needed to confirm differences in task duration. Motion analysis revealed slower but more controlled arm speeds under FFB-ON, while instrument travel distances remained comparable between groups.

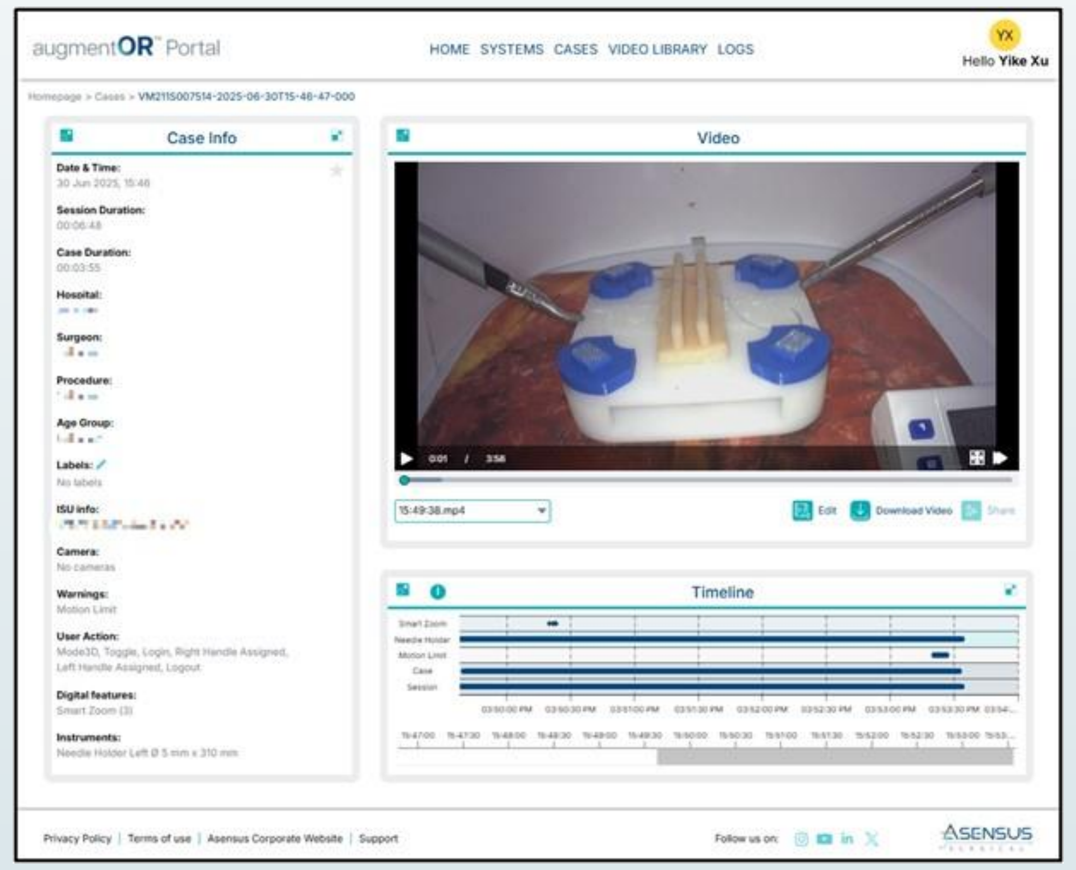

Fig 3: augmentOR™ Portal integrating video and telemetry data

Force Warnings and Exceeding Force Protection

To reduce the risk of injury, the system integrates a force-monitoring safety mechanism based on force sensors. When the applied force approaches a predefined threshold, the system provides a "Force Limit Warning" alert. FORCE LIMIT WARNING

If the applied force continues to increase and exceeds the defined safety limit, the system triggers an "Force Limit Exceeding" alert and automatically halts instrument motion. This automatic stop is designed to prevent excessive tissue loading. FORCE LIMIT EXCEEDED

Conclusion

Kinematic analysis of data recorded through augmentOR™ and analyzed for research purposes demonstrates that multimodal data—including force, speed, distance, and direction—can effectively quantify progression of suturing performance. Early findings suggest that FFB contributes to shorter, more consistent task times and enhanced motion control, potentially accelerating learning curve stabilization. This pilot study highlights the feasibility of leveraging existing system logs and synchronized video data generated during routine system use to conduct high-resolution training research, without additional hardware or expense. While the analytical methods applied in this study are not currently available as user-facing features within the augmentOR™ portal, the results support the value of such data for objective performance assessment in a research setting. Expansion to larger cohorts will provide statistical confirmation and inform evidence-based curricula for Performance-Guided Surgery™.

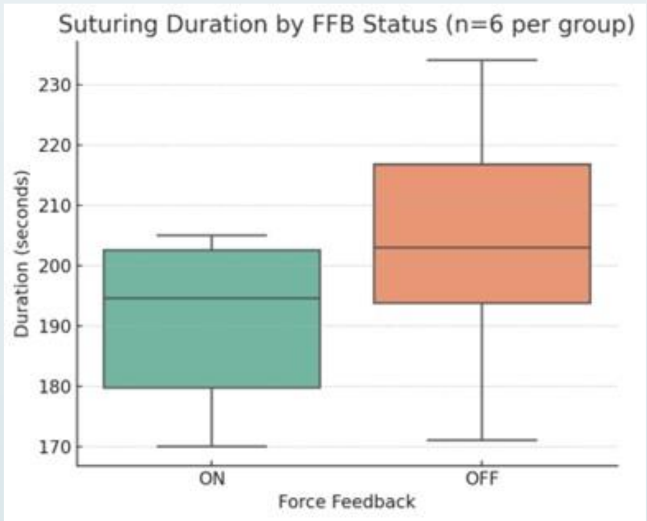

Fig. 4: Boxplot comparing suturing duration between FFB ON and OFF

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