USE OF FORCE FEEDBACK IS ASSOCIATED WITH DECREASED FORCE DURING ROBOTIC SURGERY

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Introduction

One of the described limitations of robotic surgery is the inability for the surgeon to feel force exerted in the operative field. The da Vinci 5 Surgical System was launched in 2024 with new technology that provides Force Feedback. Force Feedback instruments incorporate sensors that measure push and pull forces at instrument tips and convey these forces to hand controllers on the robotics console (Figure 1).

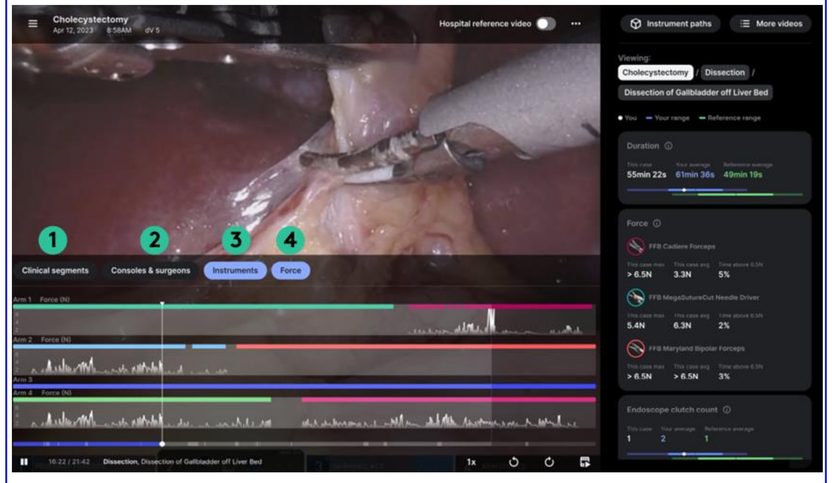


Figure 1. Force timeline display on Intuitive's Case Insights.

Objective

The objective of this study was to determine whether the use of Force Feedback instruments is associated with changes in force applied at the tips of instruments during robotic surgery.

Methods

This study included data from all robotic surgery procedures across surgical specialties performed on the da Vinci 5 surgical system using at least one Force Feedback instrument from system launch on March 29, 2024 to September 15, 2024. One-way analysis of variance (ANOVA) and post-hoc Tukey's HSD tests were performed to compare average forces overall, by instrument type, and by Force Feedback setting (i.e., off, low, medium, and high). This study analyzed de-identified data from the da Vinci surgical system and was determined exempt by the WCG Institutional Review Board.

Results

During the study period**, 1,110 procedures** meeting eligibility criteria were done by 261 unique surgeons. In 791 cases (71.3%), only one Force Feedback instrument was used; two were used in 280 cases (25.2%), three in 35 cases (3.2%), and four in 4 cases (0.4%). The ANOVA test revealed statistically **significant differences in average force across settings** (F-statistic = 66.3, $p < 0.001$). Post-hoc Tukey's HSD tests further identified statistically **significant differences between all pairwise comparisons of force settings** (off vs. low, off vs. medium, off vs. high, low vs. medium, low vs. high, and medium vs. high, all $p < 0.001$). Average force was 2.21 Newtons with Force Feedback set off, 2.02 Newtons on low, 1.83 Newtons on medium, and 1.67 Newtons on high, with higher forces seen for use of Cadiere forceps and fenestrated bipolar forceps versus the large needle driver (Figure 2).

Variable	Count (%)
Total Procedures	1,100
Unique Surgeons	261
1 FFB Instrument	791 (71.3%)
2 FFB Instruments	280 (25.2%)
3+ FFB Instruments	39 (3.6%)

Table 1. Characterization of Procedures & Instrument Usage.

Results

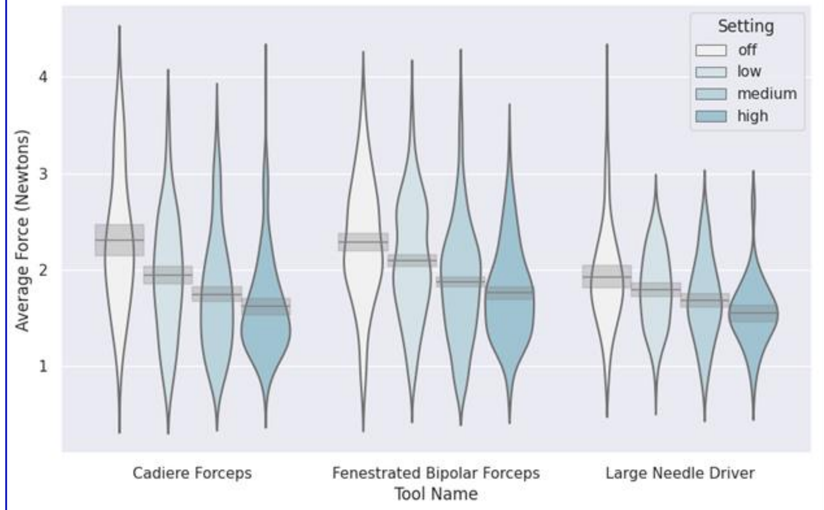


Figure 2. Violin Plot by Setting with Mean and 95% Confidence Interval.

Conclusions

During early experience with Force Feedback instruments, the **average force decreased with increasing force setting**, with the **greatest forces being measured when Force Feedback was off**. Greater differences in force across settings were observed for retraction instruments, which may receive less visual attention from the operating surgeon. **Use of Force Feedback may support gentler surgery.** Future research will examine whether decreased force translates to improved outcomes.