A HEAD-TO-HEAD COMPARISON OF INCREASED DEGREES-OF-FREEDOM (IDOF) LAPAROSCOPIC INSTRUMENTS FOR COMPLEX ANGLE INTRACORPOREAL SUTURING

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Introduction

Robotic surgical platforms have been steadily gaining traction for general surgical procedures. One of the primary values many surgeons see in these devices is the added degrees of freedom their end-effectors provide. Particularly attractive, is leveraging these added capabilities to enable suturing at awkward angles such as in anastomoses or abdominal wall reconstruction where standard laparoscopic instruments founder. A plethora of new instruments and platforms that attempt to mimic the wristed action of the robotic platform have recently emerged. Using a number of objective and subjective metrics, we endeavored to compare the suturing capabilities and learning curve of a number of these novel, increased-degree-of-freedom (IDOF) devices including the Artisential (AL), FlexDex (FD), and HandX (HX) instruments. To provide a baseline for comparison, we collected the same data using "straight stick" standard laparoscopic instruments (SL), and the DaVinci (DV) platform. To our knowledge this is the first head-to-head comparison between these five technologies.

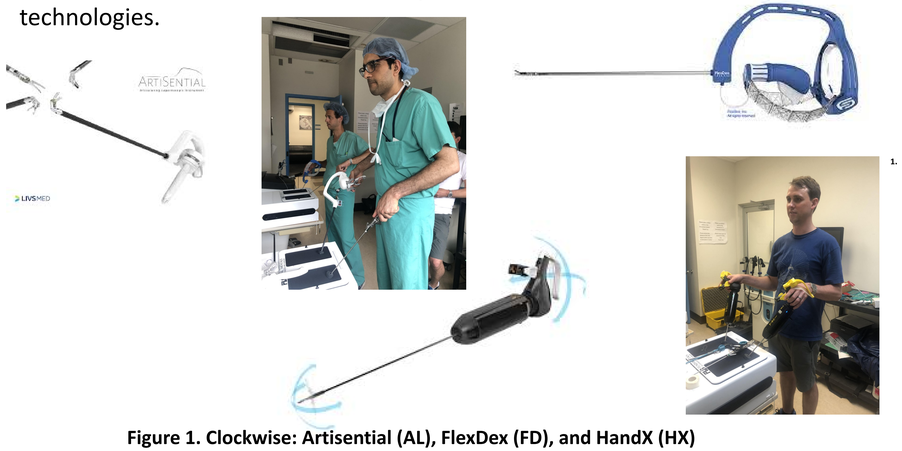


Figure 1. Clockwise: Artisential (AL), FlexDex (FD), and HandX (HX)

Methods

Surgeons from the following expertise levels participated in this evaluation: junior level trainee, senior level trainee, MIS fellow, attending with minimal robotic training and an attending with extensive robotic training. The tasks chosen involved suturing at sites of varying degrees of angulation from 0 – 270°. All participants received training on each instrument as recommended by the manufacturer prior to initiating the task. Data collected, included task accuracy, time to complete each task, completion of a NASA-Task Load Index (NASA-TLX) evaluation and completion of a subjective questionnaire

Results

Time to completion and accuracy, correlated well with the subjective parameters. DV was best overall for all parameters and was significantly better than all of the IDOF instruments and SL. Junior level subjects struggled to complete many of the tasks even with the added capabilities of the IDOF instruments and their scores were not significantly better than that achieved with SL. Amongst the senior level subjects, FD fared consistently better than SL especially for the tasks with the highest level of complexity. The DV was consistently better than all of the IDOF instruments and SL for all parameters and this improvement extended to the junior trainees.

Discussion

We began this exercise in an attempt to identify the best non-DV option for incorporation into our hospital's laparoscopic program. We decided to add objective measures to this evaluation and also look at the impact on junior level trainees and their learning curve.

Work-load demand is becoming more widely recognized as playing a vital role in the performance quality of high demand, high stakes applications. For this purpose we chose the NASA-TLX which is a readily accessible tool available as a smartphone app.

This is the first report to our knowledge that endeavors to compare these 5 different technologies. Although there are fundamental differences between these IDOF technologies, at their core they propose to provide improved suturing at angles inaccessible to SL by adding articulation in either a purely mechanical or electro-mechanical platform. For this reason we chose to use progressively challenging suturing tasks to test the abilities of these instruments. We also performed identical tasks with SL and DV so as to provide a baseline since most surgeons have experience with these modalities.

Our findings indicate that despite adding IDOF, the AL and HX instruments introduce additional learning curve elements not present with SL. These factors negatively impacted all of the parameters evaluated in this study even for the experienced surgeons. FD on the other hand provides IDOF with a resultant statistically significant improvement in both the objective and subjective parameters for the advanced surgeons.

The fundamental differences in design between these instruments do lead to some limitations in the current study. One stark example is that in this study we prioritized "dynamic/natural" motion suturing i.e. the use of an intuitive suturing motion more similar to the DV platform. Although the DF stood out in this respect, this motion may not necessarily be the optimal technique for using the HX which employs a more rigid joystick –like technique.

Conclusion

DV still remains the best overall IDOF system for complex suturing tasks but is also by far the most expensive and has the largest footprint of all of the instruments we evaluated. Of the novel singular IDOF instruments we assessed, FD had the shortest learning curve, added the least overall work-load demand and augmented the capabilities of the experienced surgeons.