

# Evaluation of a surgeon-centered laparoscopic surgical tool design

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## Abstract

**Surgeon-centered design principles were employed to design an articulating laparoscopic tool. Evaluation of this tool by 38 expert laparoscopic surgeons demonstrated that they believed the new tool could significantly reduce back, shoulder, arm, wrist and hand pain and stiffness. They preferred the new design to conventional designs for comfort and general impression. The added articulation at the grasper tip was deemed a useful addition by 92% and 89% of the surgeons would purchase the tool once it was on the market.**

**This study demonstrates that good surgeon-centered design can improve a standard laparoscopic tool. It further demonstrates that given a choice between current tools and ergonomically designed tools, laparoscopic surgeons will select the more comfortable, useful tool.**

## Introduction

Laparoscopic or minimally invasive surgery employs small incisions for ports into the body. These ports allow for inflation of the area and a camera and tools to enter the body to perform the surgery. This allows faster healing (1 night in hospital and 1-3 weeks before back to work) and lower rates of infection compared to conventional procedures (5-7 nights in hospital, 6-7 weeks before back to work). There are approximately 500,000 laparoscopic procedures performed in the US, with that number rising each year.

Laparoscopic surgery is rising in popularity since the minimally invasive procedures allow for reduced hospitalization (1 day vs 5-7 depending on the operation), time away from work (1 week vs 3-7 weeks), reduced post-operative pain and lower infection rates that conventional "open" surgery. While the benefits to the patients are considerable, they come with a cost to the surgeon. The time to perform the operation can double with laparoscopic surgery as compared to "open" surgery, in awkward postures with poorly designed tools. Although the advantages of minimally invasive surgery have been clearly established for the patient, studies have shown that the surgeon is faced with numerous disadvantages caused by

poorly designed instrument handles, including the potential of harm to the surgeon due to awkward postures, high repetition and high force exertions, and that there is the likelihood of harm to the patient due to poorly designed tools. Thus, the design of these instruments is critical to the result of the surgery.

Current laparoscopic instruments have been found to be very poorly designed ergonomically and it is likely that ergonomics were not considered at all. Berguer et al. (1998) found 8-12% of practicing laparoscopic surgeons frequently experience post operation pain or numbness. This is generally attributable to pressure points on the laparoscopic tool handle. Matern et al. (1999) studied four different handle designs used on laparoscopic tools (shank, pistol, axial, and ring handle) and found that all resulted in either painful pressure spots or caused extreme ulnar deviation.

To gather surgeon feedback on laparoscopic tools currently being used during laparoscopic surgeries, a questionnaire was administered to 18 expert surgeons at the University Medical Center after a session learning a new advanced laparoscopic technique was to examine the limitations and problems associated with conventional tools. The percentage of respondents who indicated experiencing either slight or substantial problems in the indicated areas during or after use of the conventional grasper tools are over 50% for shoulder arm, hand and wrist pain and stiffness, 60% for instruments awkward to manipulate and 47% for not able to perform fine or precise motions (Doné, et al 2004).

Another question asked surgeons to identify, on a picture of a hand, where they felt pain during or after laparoscopic surgery and how painful the area was. Painful areas of the hand were identified by 61% of the respondents with an astounding 22% reporting numbness in the thumb or fingers after surgery. Based upon these data, ergonomic evaluation of current tools and surgeon-centered design principles of ease and efficiency of use for error minimization, accommodation of users to lead to subjective satisfaction, an ergonomic articulating laparoscopic grasping tool was designed. The resulting tool contains several important features including an ergonomic handle with

an articulating end effector which is controlled intuitively. This study is the evaluation of the prototype developed using surgeon-centered tool design.

## Methods

**Subjects:** Thirty-eight laparoscopic surgeons from across the U.S. attending advanced laparoscopic surgical training at the University of Nebraska Medical Center volunteered to evaluate the tool. They were asked to compare a conventional ring-type tool with a surgeon-centered tool design prototype using a questionnaire.

**Apparatus:** The Intuitool, an ergonomic articulating laparoscopic grasping tool was compared to a conventional tool using a questionnaire that had questions from the first questionnaire (summarized above) and some additional questions that directly compare the prototype to a conventional tool.

**Procedure:** Each surgeon was asked to report the pain they felt using the conventional tool during the surgery session they had just completed. These questions were identical to the questions in the pre-design survey asking about the pain. They were then asked to use the prototype tool and the standard ring-type tool in a clear plastic torso to practice some laparoscopic skills. After the practice with both tools, the questionnaire was presented to the surgeon and s/he was asked to complete the survey. They were then asked if prototype tool would relieve any of the problems they experienced with conventional grasping tools (the same list that was initially presented).

**Experimental Design:** Ordinal data were collected throughout this questionnaire; therefore, a Wilcoxon Signed Rank test was used to analyze each hypothesis test. The level of significance for all statistical tests was 0.05. All of the statistical tests were performed using Minitab 14 (Minitab, Inc.).

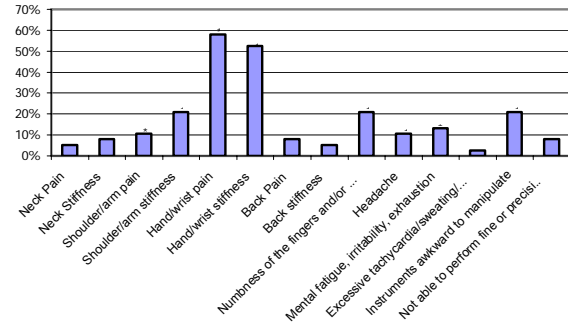
## Results

Surgeons were then asked to indicate which, if any, of the problems they believed would be relieved with use of the prototype tool after using it in the clear plastic torso. The results are shown in Figure 1 with stars to indicate those percentages statistically different from zero ( $\alpha=0.05$ ).

There was statistical preference towards the comfort of the prototype handle ( $p<0.001$ ) against the conventional handles with 84% respondents responding that the prototype was either comfortable or extremely comfortable; however, the median response for the conventional tool (37%) did not differ from zero (indifferent) ( $p=0.151$ ). Thirty-five

(92%) of the 38 respondents indicated that the added articulation of the prototype tool would be either somewhat or very useful, three respondents were indifferent to the addition of the articulation. Thirty-four (89%) of the 38 surgeons said they would be interested in trying the prototype tool once commercially available.

**Figure 1. Percent of surgeons responding that Intuitool would relieve indicated problems**



## Discussion

Based on the questionnaire results, the surgeon-centered design of the prototype tool was successful.

The results of the evaluation questionnaire agreed with those of previous studies that laparoscopic surgeons are subjected to pain and discomfort caused by the tools they use during surgery. Fifty-eight percent of the respondents believe the prototype tool will relieve hand/wrist pain and 53% hand/wrist stiffness. Successful addition of an articulating tip is believed to be useful by 92% of the surgeons. Thirty-four (89%) said they would be interested in trying the prototype tool once commercially available.

This study demonstrates that good ergonomic analysis and design can improve a standard laparoscopic tool. It further demonstrates that given a choice between current tools and ergonomically designed tools, laparoscopic surgeons will select the more comfortable, more useful tool.

## References

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