

A Comparison of Pinch Force between Finger and Palm Grasp techniques in Laparoscopic Grasping

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ABSTRACT

Laparoscopic surgery is a new abdominal surgical procedure which helps the patients in many ways like less hospital stay, faster recovery and reduced pain. The main disadvantage in this surgical procedure is the reduced haptic perception by the surgeons due to the usage of laparoscopic instrument to handle tissues which in turn cause damage of it as compared to an open surgery. The primary aim of this investigation was to compare the pinch force applied during two different methods of laparoscopic grasping: Finger and Palm grasp. A low cost force sensing resistor tailor made for the grasper tip was designed and fabricated for quantifying the grasper tip force in the study. The results indicate more pinch force was applied during palm grasp as compared to finger grasp so as to prevent the slippage of the tissues from the jaws of the laparoscopic graspers.

Keywords: Pinch Force; Grasping; Laparoscopic Surgery; Force Sensing Resistor; Laparoscopic Grasper

1. Introduction

Minimally Invasive Surgery (MIS) is a modern surgical procedure, which has made its presence felt since three decades and is slowly replacing the conventional open surgery. Laparoscopic surgery (LS) is one of the MIS techniques done in the abdomen with 3-4 small incisions through which surgeons insert long handled laparoscopic instruments and laparoscope so as to manipulate the target organ in the abdominal cavity [1,2]. The use of long handled instruments leads to reduced haptic perception which in turn may result in excess force being delivered at the target tissue causing unwanted tissue damage. Laparoscopic graspers are one of the most indispensable instruments used for grasping the target tissue in any laparoscopic procedure. The force involved while grasping an object is the pinch force and it's defined as the force with which an individual holds/ grasps an object without letting it slip off the grasper jaws. There are two methods of grasping: Palm and Finger grasp [3]. In palm grasp (**Figure 1(a)**), the palm of the operating hand rest on the ring of the movable handle with the fingers 2-5 on the fixed hand while in the finger grasp (**Figure 1(b)**), the thumb will be inside the ring of the movable handle with other fingers on the fixed hand opposing the thumb.

Sensorized laparoscopic tool with/without modification of a commercial tool were used in various studies related to force measurements [4-11]. Different types of force sensors used in the MIS techniques with respect to their size, sterilizability etc were explained in [12]. The objective of our study was to find whether there is any significant difference in pinch force during finger and palm grasping techniques in the laparoscopic surgical setup. In this study an efficient force measurement arrangement was setup using a cost effective custom made force sensing resistor for tip pinch force sensing and strain gauges for

handle pinch force measurements.

2. Materials and Methods

An atraumatic fenestrated laparoscopic grasper was used for the finger and palm grasp pinch force experiment. The grasper was sensorized (**Figure 2**) and it consists of two force sensors. One sensor was on the handle and another on the tip of the grasper. Custom made force sensing resistor (FSR) was used as tip pinch force sensor. FSR was developed with conductive foam sandwiched between the copper sheets and wires soldered on to these sheets were connected to the preamplifier circuit. The sensor was designed in such a way that it fits to the grasper tip and dimension was 2.2x0.4x0.1cm. The custom made FSR exhibits decrease in the resistance as the applied force increases. The sensor was calibrated by placing known weights on it and has a sensitivity of 0.224V/N. Silicone gel and plastic sheet were used to insulate the sensor from the conductive grasper tip. In addition to the above sensor arrangement on the grasper, strain gauge sensors were attached to the handle of it to get the handle pinch force. The handle of the grasper was assumed as a

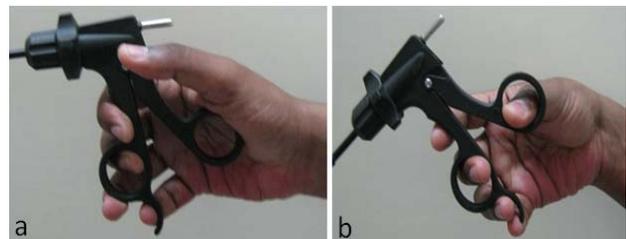


Figure 1. Picture showing (a) Palm grasping technique (b) Finger grasping technique using laparoscopic grasper.



Figure 2. Picture showing (a) Grasper handle attached with strain gauges (b) Grasper tip attached with custom made FSR (c) Sensorized atraumatic fenestrated laparoscopic grasper.

cantilever and was filed and smoothed to ensure proper placement of the strain gauge and for better sensitivity of the sensor towards the applied force. The pair of foil type strain gauges (EC-AL-3FG1-120) from IPA Private Limited, Bangalore; were pasted one on each sides of the movable handle. The strain gauge based cantilever arrangement was then calibrated with known weights and has a sensitivity of 0.021V/N. The connection from the sensors were taken to their respective preamplifier circuit which was in turn connected to the USB port of the computer, (where the signals were acquired for further analysis) through the CMC DAQ (four channel data acquisition system).

The experiment setup (**Figure 3**) for measuring the pinch force while using the sensorized atraumatic fenestrated grasper consists of an abdomen model (Turtle) from Ethicon Endo Surgery, camera, TV monitor, four channels CMC DAQ and a computer. Four different objects [PVC (O_1), Foam (O_2), Ethaflex (O_3) and Plexiglass (O_4)] of same dimensions (2x1x0.5cm), shown in **Figure 4**, were placed inside the turtle. The subjects were asked to grasp the objects for 20 seconds ensuring that the grasped object did not slip off from the grasper jaws, the above procedure was repeated for all the four objects using both finger and palm grasping techniques. Also the subject was instructed to operate the grasper using his/her right hand throughout the experiment. Total of 10 subjects (3 females and 7 males) all above 25 years of age volunteered for the experiment. The inclusion criteria for the subjects was that they have normal functional hand and should be able to use a handle operated instrument like a laparoscopic grasper without much physical discomfort. The group excluded from volunteering in this study were people with loss of sensory feedback in the arm, people with tremors while holding objects and people lacking proper visual feedback. Before acquiring the pinch force data, subjects were asked to operate the laparoscopic grasper in finger and palm grasping techniques to get comfortable using it so as to avoid discrepancies in data due to subject's anxiety. Statistical

analysis of the acquired data was carried out using SPSS 16.0 software. Data of two trials were acquired for each subject and the mean value of handle and tip pinch forces were found out for all objects over the range of subjects, this was done for both the grasping methods. The paired sample t- test were carried out between the finger and palm grasp methods for both handle and tip pinch forces.

3. Results and Discussions

Force profile for a subject grasping an object (O_3) using palm grasping technique is shown in **Figure 5**. The graph on the upper half depicts handle pinch force and that on the lower half depicts tip pinch force.



Figure 3. Step up for Pinch Force Measurement.



Figure 4. A picture of objects used for grasping: (from left to right) PVC (O_1), Foam (O_2), Ethaflex (O_3) and Plexiglass (O_4)

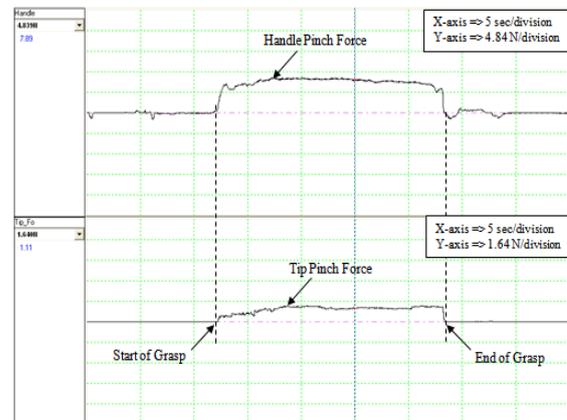


Figure 5. Handle and Tip Pinch Force profile for an object (O_3) grasped by a subject using palm grasping technique.

The handle and tip pinch force was found to be consistently higher during palm grasp for all the grasped objects as compared to finger grasp (Figures 6 & Figure 7). The Figures 6 & Figure 7, represents the mean value of handle and tip pinch forces in Newton with respect to the various grasped objects for finger and palm grasping methods, respectively. The study shows statistically a significant difference in tip pinch force between the two grasping methods ($p = 0.005$) and also in the case of handle pinch force ($p = 0.001$) a greater significant difference was obtained. The handle and tip pinch forces measured while grasping; PVC (O_1) and Plexiglass (O_4) without slipping were relatively higher than the other two objects. This observation was as expected as the first and fourth samples were relatively hard materials as compared to Foam (O_2) and Ethaflex (O_3) which are compressive. As is evident from the graph, it was observed that the handle pinch force is much higher than the tip pinch force this is in line with the findings reported by researchers earlier [4]. A justification for the above observed force pattern is the fact that the finger tips are innervated by

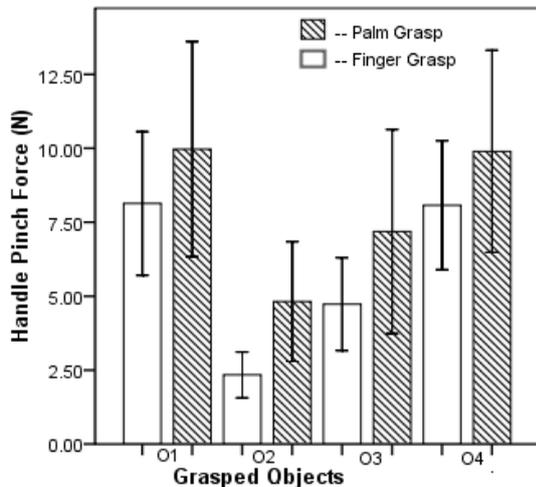


Figure 6. Mean handle pinch force for different objects grasped using Finger and Palm grasping techniques.

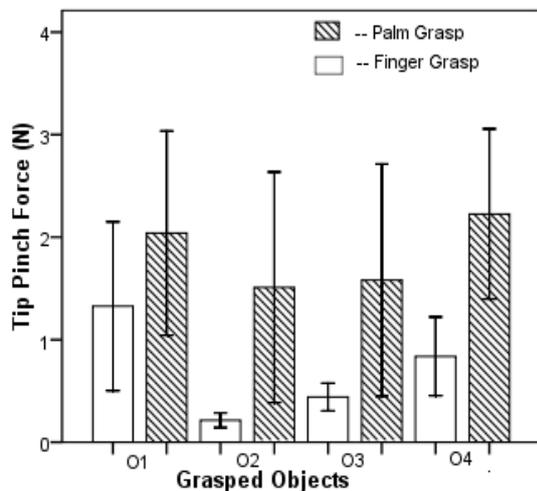


Figure 7. Mean tip pinch force for different objects grasped using Finger and Palm grasping techniques.

more number of mechanoreceptors as compared to the palm [13]. And hence have a better natural/ neural feedback mechanism that perceive the force felt on the handle which in turn is the force actually delivered to the tissue at the tip. Palm grasp is preferred to finger grasp due to its postural advantage as reported by surgeons but it has the adverse effect of delivering more force which may in turn cause tissue damage.

4. Conclusion

This study compared the pinch force for two laparoscopic grasping techniques- Finger Grasp and Palm Grasp; it was observed that the latter technique requires more force as compared to the former. From the observed results it can be concluded that even though palm grasp is preferable owing to its anatomical advantage to the surgeon, it may cause unwanted damage to the target tissue and hence finger grasp is preferable over palm grasp from a patient safety point of view. The number of subjects was limited to ten and the grasping technique was not compared between experienced surgeons and novice. The objects grasped in this study are rigid and elastic which is not the case in a normal laparoscopic procedure. Using viscoelastic objects which closely depict animal tissue properties would be necessary to get a better understanding of the procedure in real surgical situations. An extended study on similar lines with more number of participants, classified into surgeons and novice with tissue mimicking objects for grasping would pave the way for evolving safer laparoscopic procedures.

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