Could trainees' finger placement at the surgeon's console have any effect on the overall outcomes of robotic surgery specifically in radical prostatectomy? A prospective, blinded robotic simulation education pilot study

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ABSTRACT

Introduction: Robotic surgery for localized prostate cancer offers a greater range of motion attributed to the EndoWrist instruments. Postoperative outcomes are linked to the quality of vesico-urethral anastomosis. Trainees frequently complain of suturing difficulty in a back-handed fashion. We aimed to analyze wrist motion using the DaVinci simulator. We hypothesized that using the thumb and index finger would allow superior surgical proficiency when compared to the middle finger.
Methods: After institutional review board approval, we recruited 42 medical students in one academic medical center. Students were randomly assigned to start with their thumb and index finger (1&2) or thumb and middle finger (1&3). Three standardized modules were used with nine metrics calculated, including: score, total time, economy of motion, efficiency score, collisions, inaccurate puncture, wound approximation, out of view, and penalty subtotal. Statistical analysis of the metrics was calculated using SPSS.
Results: Three metrics were found to have differences between the finger placement of 1&3compared to 1&2. The number of collisions, wound approximation, and penalty score where 1&3 were used had a lower score in each. The number of collisions was 5.7 less in the 1&3

finger placement (p=0.046). This metric was found to have statistically significant differences between finger placement where 1&3 had a lower score compared to 1&2. The wound approximation score was 0.2 points lower when using the 1&3 placement (p=0.075). Lastly, the penalty assigned was 6.5 points lower when using 1&3 (p=0.069).
Conclusions: Although finger placement did not affect the overall score of the completed simulation, instrument collisions and unnecessary wound complications may lead to adverse outcomes when using 1&2 despite offering a wider range of motion. This may be due to decreased comfort in hand position. Trainees may be able to improve the effectiveness of their vesico-urethral anastomosis during robotic-assisted radical prostatectomy.

INTRODUCTION

Minimally invasive surgery using the Da Vinci® surgical system (Intuitive Surgical, Sunnyvale, CA) has become the most adopted robotic platform nowadays. Robotic-assisted laparoscopic procedures usually have less blood loss, transfusions rates, less postoperative complications and faster recovery times when compared to open procedures (1). Robotic technology allows for exceptional magnification, resolution, three- dimensional vision, and greater range of motion of surgical instruments. Subsequently, this allows surgeons to become more precise while having fewer surgical complications (2). Furthermore, standard laparoscopic procedures have their own obstacles such as heavy reliance on a surgical assistant to manipulate the camera and retract tissue. Additionally, standard regular laparoscopic surgery offers less range of motion with non-articulating instruments in comparison to robotic surgery (2). Greater range of motion and efficiency in robotic surgery can be attributed to the EndoWrist® instruments and technology which provides 7 degrees of freedom and an angle up to 90 degrees (3). Those unique properties have helped in increasing the popularity of robotic surgery over other approaches.

As a result, surgical residents, fellows, and attending physicians are learning then incorporating robotic surgery into their practice. This applies to multiple surgical subspecialties, including urology, gynecology, pediatric surgery, thoracic surgery, general surgery, neurosurgery, and otolaryngology (4). Over the years, several training methods have been developed to help overcome the difficult learning curve seen in robotic surgery (4). Having a dual console in the operating theatre has certainly facilitated the teaching of novice surgeons. However, this approach remains an appropriate teaching method when robotic simulation training has been previously incorporated into the curriculum (5). Several simulation platforms are available nowadays. Many training programs use the *Da Vinci® Skills Simulator*- a virtual reality simulator that allows users to practice basic tasks such as knot tying, needle driving, and actual simulated procedures. The shape and size of the da Vinci® skills simulator console is identical to those of the da Vinci® console used in the operating room. While the console in operating rooms allows the control of robotic arms, the simulator console makes use of virtual robotic instruments (6).

Several studies have assessed and demonstrated the validity of the da Vinci® Skills platform (6-10). After each exercise, the program objectively evaluates the trainee and provides a maximum score of 100%. Parameters evaluated include the following: total time, economy of motion, suture break count, instrument collisions, inaccurate punctures, bad wound approximation, and instruments out of view.

To our knowledge, no prior studies support one way to hold the controls of the da Vinci robot. It is unclear if urologists prefer to use their index or middle finger in addition to their thumb. Furthermore, there is no standardized way to teach residents to hold the instruments; personal preference dictates finger position. In our experience, we have noted trainees' discomfort during wrist manipulation while using the thumb and middle finger at the console. This was particularly noticed during robotic assisted laparoscopic radical prostatectomy procedures, when urology residents were found to have some degree of difficulty while suturing the vesico-urethral anastomosis while using their middle finger and thumb. They have described a certain "wrist limitation" specially while holding the needle in a back-handed fashion during the anterior portion of the anastomosis (second half). We therefore hypothesize that using the thumb and index finger might provide greater comfort and higher surgical proficiency and the goal of this prospective blinded robotic simulation pilot study is to validate which finger placement would be the most optimal one. This may help clarify in the future what may be the most ergonomic and efficient way to insert fingers at the console to maybe avoid any adverse surgical outcomes during a robotic assisted laparoscopic radical prostatectomy.

METHODS

After IRB approval (IRB ID# STUDY00001162), we recruited 42 medical students across all 4 years in one academic medical center (Medical Students Year 1, 2, 3 and 4). This was achieved during a 2-week period and facilitated with the distribution of a printed flyer within the School of Medicine. An electronic version was also sent out via email. An informed consent was obtained from all 42 participants, and the students were all provided with a standardized "pre-robotic simulation survey". Students who had any prior exposure or experience with robotic surgery were excluded. Students who consumed caffeinated beverages the day of their participation were also excluded. All 42 medical students were included in this study. None of them had any prior wrist trauma or upper arm surgery. A Judgment statement was provided to the IRB, indicating that this study will have a single fellowship trained endourologist and robotic urologic surgeon (Principal Investigator) who will be blinded and will not have direct access to an individual's performance. Performance will be recorded by the Sub-PIs (one senior urology resident and one medical student rotating in urology) and participant's data and overall results will only be accessed by the two Sub-PIs. Data output will be transferred on a flash drive where each volunteer will be on a number basis at this point. Any participation in the study will not reflect in any manner the medical students' professional outlook.

Each volunteer was given a standardized orientation. This orientation included teaching the basic principles of hands & pedals controls at the robotic console over a 15-minute period,

done by of the Sub-PI's. There was one student at a time present in the robotic simulation room, to avoid any interaction with any other student. All distractors were eliminated (no background noise and no music played), and the room was kept at the same temperature for all students. All students preferred to take their shoes off while using the robotic pedals (Table 1).
Students were then randomly assigned to start with their thumb and index finger (1&2) or thumb and middle finger (1&3). Three standardized modules were used with nine metrics calculated (suturing skills, rings and spheres). These included: score, total time, economy of motion, efficiency score, collisions, inaccurate puncture, wound approximation, out of view, and penalty subtotal. Statistical analysis of the metrics was calculated using SPSS.

RESULTS

Three metrics were found to have differences between the finger placement of 1&3compared to 1&2 (Table 2). The number of collisions ("intracorporeal" collision between instruments inside the surgical field, or between instrument and any adjacent structure), wound approximation, and penalty score where 1&3 were used had a lower score in each. The number of collisions was 5.7 less in the group using the 1&3 finger placement when compared to the group using the 1&2 finger placement (14.7 vs 20.4) (p=0.046). This metric was found to have statistically significant differences between the finger placement of 1&3 compared to 1&2. The number of collisions was significant in the group that used the 1&3 finger placement by having a lower score.

The wound approximation score was 0.2 points smaller when using the 1&3 finger placement when compared to the 1&2 finger placement (0.1 vs 0.3) (p=0.075). The penalty assigned was 6.5 points lower when using the 1&3 finger placement when compared to the 1&2 finger placement (21.2 vs 27.7) (p=0.069). The wound approximation and out of view scores were not statistically significant, however our small sample size and novice participants may influence if there is a real difference. The overall score (p= 0.916), total time (p= 0.945), out of view (p=0.63), and economy of motion (p= 0.809) were not significant from one another.

All participants subjectively felt that they had a limited wrist range of motion while using 1&3 in a back-handed fashion when compared to 1&2, while having the finger hand controls opened. Similarly, all participants described some amount of wrist discomfort when using 1&3 in a back-handed fashion when compared to 1&2 when the hands controls were closed (Figure 1**)**. Using 1&2 allowed the participants to have a wider range of motion, with an angle that is >180 degrees when compared to 1&3 (flat line). As a matter of fact, while using 1&2, participants noted that they were able to turn the needle more allowing it to travel more in the simulated tissue. While using 1&3, they felt that they had a less optimal control of the needle and were unable to have its distal tip exiting the tissue while turning their wrists (Figure 2).

DISCUSSION

Robotic surgery using the Da Vinci® surgical system has been present over more than 2 decades. It is the most commonly adopted minimally invasive surgical platform in urology, gynecology, pediatric surgery, thoracic surgery, general surgery, neurosurgery, and otolaryngology (4).

Robotic surgery offers less blood loss, faster recovery, greater magnification and better postoperative outcomes (2). Most academic centers around the world are nowadays equipped with robotic capabilities, allowing trainees to incorporate that into their surgical curriculum. In urology, robotic assisted radical prostatectomy is the most common robotic assisted procedure. Outcomes depend on the quality of the vesico-urethral anastomosis in addition to other factors. It has been noted that young residents and novice surgeons might struggle during that phase, especially during the second half of the anastomosis. Typically done while holding the needle robotically in a back-handed fashion, the anterior portion of the anastomosis between the 9 o'clock an the 3 o'clock position can be challenging with inappropriate wrist range of motion.

Urology residents have particularly complained during that step, describing that they are unable to identify the needle tip reappearing from the urethral stump tissues. They also frequently mention that the needle would skive requiring multiple attempts (in and out) to have the tip exiting at the desired location. If not done properly, and with the presence of unwanted gaps, a sub-optimal vesico-urethral anastomosis could lead to anastomotic failure, urinary leak, infections and postoperative incontinence.

We therefore aimed to analyze the reason why trainees describe that step as being "delicate", and we hypothesize that they may frequently encounter a certain degree of wrist stiffness or limitations in the range of motion. We tried to elucidate if finger selection at the hand's controls could have adverse effects while performing the anastomosis and aimed to validate that on a simulated model using 3 robotic modules.

To our knowledge, no prior studies support one way to hold the controls of the da Vinci robot. It is unclear if surgeons prefer to use their index or middle finger in addition to their thumb. Furthermore, there is no standardized way to teach residents to hold the instruments; personal preference dictates finger position. In our experience, we have noted trainees' discomfort while using the thumb and middle finger at the console. We therefore hypothesize that using the thumb and index finger might provide greater comfort and higher surgical accuracy during a robotic anastomosis, and the goal of this prospective blinded robotic simulation pilot study was to validate which finger placement would be the most optimal one.

In our study, three metrics were found to have differences between the finger placement of 1&3compared to 1&2. The number of collisions, wound approximation, and penalty score where 1&3 were used had a lower score in each. The number of collisions was less in the 1&3 finger placement when compared to the 1&2 finger placement and this metric was found to have statistically significant differences between the finger placement of 1&3 compared to 1&2. This can be explained by the fact that the index finger can rotate back and get behind the thumb as depicted in Figure 1 and Figure 2.

When performing a back handed anastomosis, using the index finger in conjunction with a maximized wrist extension (up to 60 degrees in a normal person) can help with an ampler range of motion and a more complete needle maneuvering. Brinkman et al (6) discuss the utility of instrument collision as a parameter. It appears that instrument collision showed a steady improvement from 1 to 10 repetitions. Most novices reached expert performance within 10 repetitions. This seems an appropriate parameter, because instrument collision seems to measure the ability to control the instruments well as per the authors.

The initial learning of robotic skills was analyzed by Kung et al. (11) but in their study, they did not study the effect of finger placement. Authors recruited 20 medical students who had no previous robotic experience, assigned them to 1 single module (Tube 2) that imitates a vesico-urethral anastomosis, and their purpose was to have this exercise repeated more than 80 times in order to obtain the plateau of learning curve. In regard to having instruments out of view, students can not be penalized since they have never been trained before, so this should be taken into account in our present study. As a matter of fact, Perrenot et al. (12) clarified that having instruments out of view is common in expert hands only, because these experts have been working with a third robotic arm or may be acclimated to having them out of view. Therefore, our students should not be perhaps scored on that criteria if looking at the overall performance, but they were evaluated based on wrist manipulation.

Bullock et al. (13) published an article in conjunction with the biomedical engineering team at Yale University studied the precision and manipulation of objects using thumb, index and middle fingers. In Their study, they placed sensors and evaluated the range of positions over which 19 participants manipulated a moderately sized (around 3-4cm) object using either the thumb and index finger or the thumb, index and middle fingers. They demonstrated that the 2-fingered workspace is on average 40 % larger than the 3-fingered workspace due to added “kinematic constraints” originating from the middle finger (13). Their results were also similar to other studies including the ones by Feix et al. (14) and Zheng et al. (15) where biomedical engineering was involved measuring the kinetics of wrist movements (14-20). Those results are in concordance with our findings supporting our hypothesis.

There has been several other studies that showed some degree of improvement upon repeating the same task. Lerner et al. (21) reported that, after four training sessions with the simulator, statistically significant performance improvement is reached. Balasundaram et al. (22) demonstrated that when ten novices performed a series of five tasks ten times, it resulted also in a statistically significant improvement for each of the five tasks. However, in our study, we did notice any improvement with our students when they repeated the task, consisting with a possible limitation originating from finger placement at the console while holding the needle in a back-handed fashion.

Our study is not without limitations. First our assessment of wrist motion upon changing finger assignment was evaluated based on metrics issued by the robotic simulator. We did not have continuous 3D cameras recording of wrist motion to measure kinetics differences when participants elected to use their index fingers or their middle fingers. We have approached the biomedical department and we will aim to consider this technology in upcoming studies. Another limitation is the fact that this is a pilot study in our sample size may be relatively on the lower side, however we had statistically significant results. Our study is novel and has never been described before. Future studies and directions will be to evaluate urology residents, and also to evaluate those results on real patients in the operating room while performing a vesico-urethral anastomosis to validate the accuracy of suturing while using the thumb and index finger.

CONCLUSIONS

Robotic surgery is nowadays the most common minimally invasive approach in most surgical sub-specialties. In Urology, robotic assisted radical prostatectomy is one of the most performed procedures. In our novel prospective blinded robotic simulation pilot study, although finger placement did not affect the overall score of the completed simulation, instrument collisions and unnecessary wound complications may lead to adverse outcomes when using 1&2 despite offering a wider range of motion. This may be due to decreased comfort in hand position resulting in a more cautious surgical approach. Trainees may be able to improve the effectiveness of their vesico-urethral anastomosis leading to better surgical outcomes following robotic assisted radical prostatectomy.

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FIGURES AND TABLES

Figure 1.

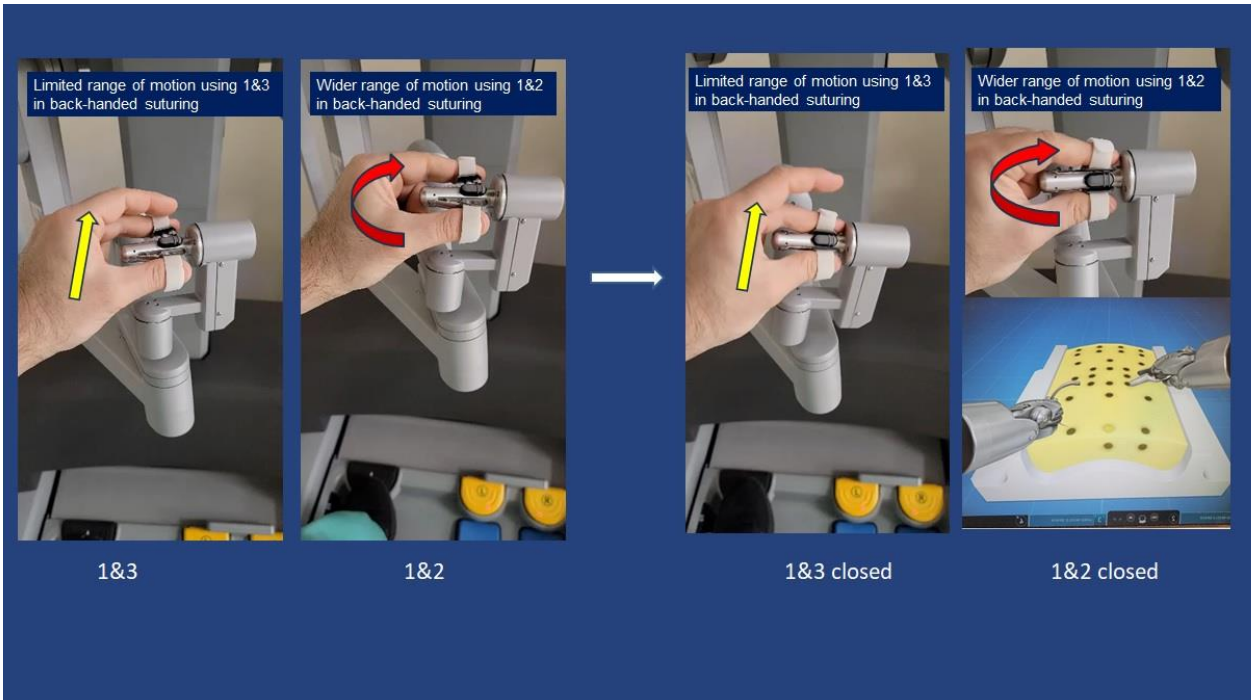

Figure 2.

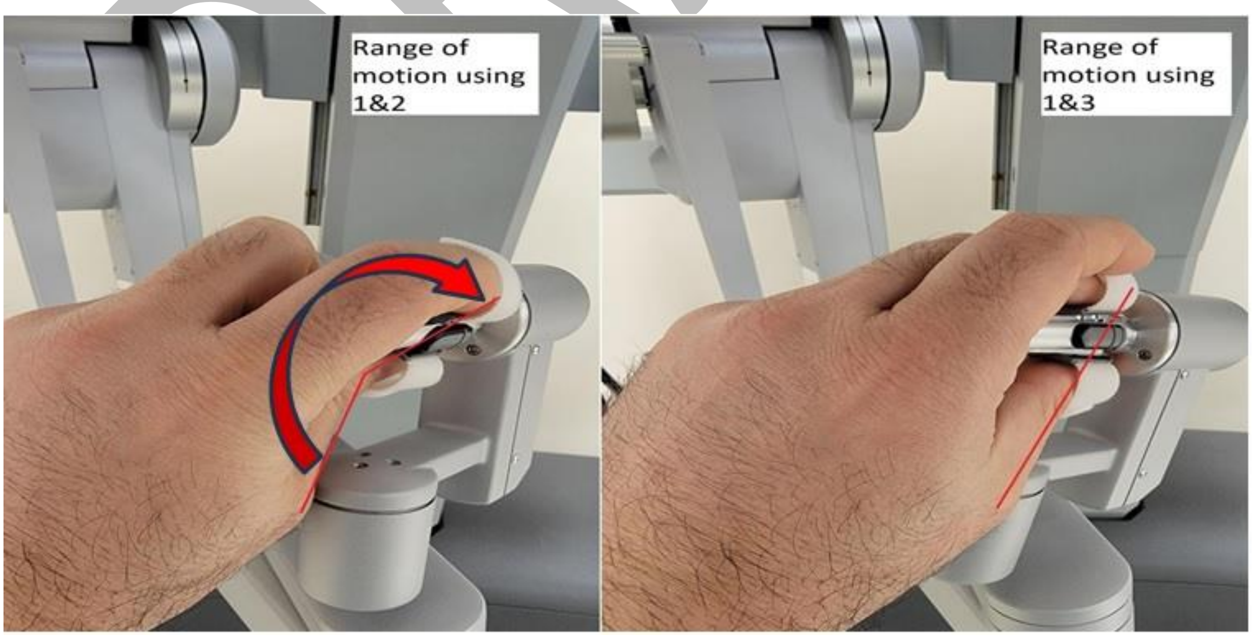

Table 1. Medical students' inclusion criteria and preparation to the simulated robotic tasks
Medical year 1–4
Sandardized "pre-robotic simulation survey"
Consent obtained
No caffeinated beverages
No prior robotic exposure
All blinded to the PI
15-minute standardized orientation
No background noise/music
Shoes off

Table 2. Metrics calculated				
Score	1 & 2	37.2	4.9	0.916
	1 & 3	37.9	5.2	
Total time (seconds)	1 & 2	517	29.7	0.945
	1 & 3	515	28.5	
Economy of motion (cm)	1 & 2	449	31.8	0.809
	1 & 3	440	21.6	
Efficiency Score	1 & 2	50.3	5.6	0.744
	1 & 3	50.3	5.7	
Collisions	1 & 2	-20.4	2.3	0.046
	1 & 3	-14.7	1.6	
Inaccurate puncture	1 & 2	-7.7	0.9	0.206
	1 & 3	-6.2	0.7	
Wound approximation	1 & 2	-0.3	0.1	0.075
	1 & 3	-0.1	0.05	
Out of View	1 & 2	-0.2	0.07	0.63
	1 & 3	-0.2	0.05	

One metric was found to have statistically significant differences between the finger placement of 1&3 compared to 1&2. The number of collisions was significant where 1&3 had a lower score. The wound approximation and out of view scores were not statistically significant, however our small sample size and novice participants may influence if there is a real difference.