

# Content and Construct Validation of a Robotic Surgery Curriculum Using an Electromagnetic Instrument Tracker

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**Purpose:** Rapid adoption of robot-assisted surgery has outpaced our ability to train novice roboticists. Objective metrics are required to adequately assess robotic surgical skills and yet surrogates for proficiency, such as economy of motion and tool path metrics, are not readily accessible directly from the da Vinci® robot system. The trakSTAR™ Tool Tip Tracker is a widely available, cost-effective electromagnetic position sensing mechanism by which objective proficiency metrics can be quantified. We validated a robotic surgery curriculum using the trakSTAR device to objectively capture robotic task proficiency metrics.

**Materials and Methods:** Through an institutional review board approved study 10 subjects were recruited from 2 surgical experience groups (novice and experienced). All subjects completed 3 technical skills modules, including block transfer, intracorporeal suturing/knot tying (fundamentals of laparoscopic surgery) and ring tower transfer, using the da Vinci robot with the trakSTAR device affixed to the robotic instruments. Recorded objective metrics included task time and path length, which were used to calculate economy of motion. Student t test statistics were performed using STATA®.

**Results:** The novice and experienced groups consisted of 5 subjects each. The experienced group outperformed the novice group in all 3 tasks. Experienced surgeons described the simulator platform as useful for training and agreed with incorporating it into a residency curriculum.

**Conclusions:** Robotic surgery curricula can be validated by an off-the-shelf instrument tracking system. This platform allows surgical educators to objectively assess trainees and may provide credentialing offices with a means of objectively assessing any surgical staff member seeking robotic surgery privileges at an institution.

**Key Words:** robotics; surgical procedures, minimally invasive; instrumentation; validation studies; benchmarking

MINIMALLY invasive urological surgery has rapidly evolved in the preceding 2 decades, becoming the standard of care for renal pathology and the driver of innovation for managing other oncological diseases, such as those of the bladder and prostate. The da Vinci surgical robot is used with increasing frequency

for several urological cases, of which the most ubiquitous is robot-assisted radical prostatectomy.

Although the reason for this trend is complex, involving surgeon preference, patient choice and marketing, there remains a fundamental dilemma of training surgeons to proficiency on the ro-

## Abbreviations and Acronyms

FLS = fundamentals of laparoscopic surgery

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botic platform. Inherent in the rapid adoption of new technology is the need to establish training curricula to develop surgeon competency, in addition to instituting standardized credentialing processes. Safe, effective clinical application of new technology must be determined by professionals in the field with adaptation of applicable training platforms and assessment methods. In a recent best practices article Lee et al reported that the American Urological Association Laparoscopy and Robotic Surgery Committee determined that validation and curriculum development must occur together.<sup>1</sup>

Curriculum design consists of validation of training platforms based on benchmarks set by experts, allowing trainees to practice in a safe environment with the objective of achieving a level commensurate with that of experts.<sup>2</sup> To effectively compare novice to experienced robotic surgeons a training platform must incorporate quantitative metrics as measures of surgeon performance. We sought to prove the construct, face and content validity of a robotic surgical skills curriculum using trakSTAR, an off-the-shelf electromagnetic tracking device.

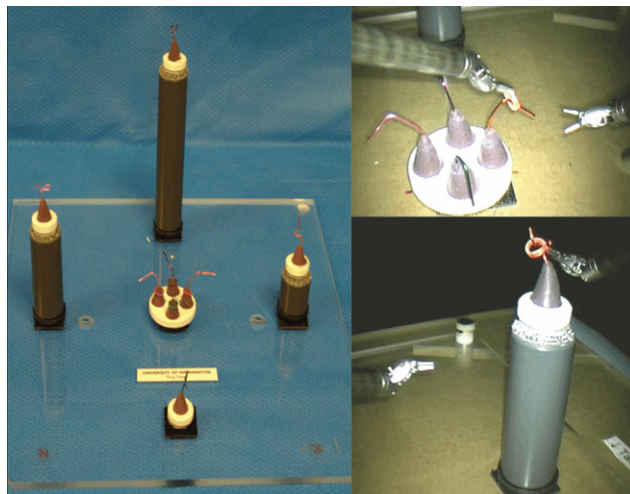
## METHODS

We performed a prospective, institutional review board approved study to evaluate the face, construct and content validity of a robotic surgical skills curriculum. We affixed the trakSTAR electromagnetic tracking device to training daVinci robot instruments, which allowed us to gather time and economy of motion performance metrics. The device is commercially available and more cost-effective than other simulation platforms available to training programs. It can be attached to the da Vinci tools.

We enrolled 10 subjects, including 5 experienced and 5 novice robotic surgeons. The experienced group consisted of urology faculty from multiple institutions with at least 50 robotic cases completed. The novice group consisted of postgraduate years 1 to 4 urology residents from a tertiary military medical facility, of whom none had performed cases as a surgeon at the console.

All subjects used the robot to perform 3 tasks, including 2 from previously validated FLS training curricula and a new, modified task, that is block transfer and intracorporeal knot tying (FLS),<sup>3</sup> and ring tower transfer (fig. 1). Data were gathered by the proprietary software included with the tracking device.

All subjects were given a standardized introduction to the robotic surgery platform and then had 10 minutes to practice before testing to minimize any practice effect. Before the start of each task a standardized set of task instructions was read to the subjects. The first task performed was the block transfer exercise, in which 2 Maryland dissectors were used to transfer 6 objects between 12 pegs on a peg board. The second task was the simple suture and intracorporeal knot exercise. In this exercise 2 da Vinci large needle drivers were used to place a 3-zero polyglactin suture cut to 15 cm long through a longitudinally slit Penrose drain and tie an intracorporeal knot.



**Figure 1.** Ring tower transfer requires significant camera and clutching maneuvers for completion.

These study tasks were performed in accordance with protocols previously established in validation studies of the FLS curriculum.

The final task was the ring tower transfer, in which a series of rings was removed from a central obstacle, placed on peripheral obstacles and replaced in order. This exercise requires significant camera and clutching maneuvers, which we hypothesized would significantly distinguish novice from experienced robotic surgeons.

Exercise performance was scored by the trakSTAR device using the standard metrics of time, path length and economy of motion. Measured time was the duration in seconds required to complete the task. Calculated economy of motion, which is a surrogate for precision, was derived from time divided by path length.<sup>4</sup> An observer assigned penalty was assessed for dropping blocks or rings and for failing to precisely place suture and adequately tie the intracorporeal knot. Mean performance metrics were compared between the 2 groups with the independent t test using STATA®.

After finishing the tasks all subjects completed a non-validated questionnaire to rate parameters of face and content validity. In the questionnaire the training platform was rated on a 5-point Likert scale on parameters such as ease of use, perceived accuracy of proficiency assessment and overall relevance of the platform to robotic surgical education.

## RESULTS

Experienced surgeons significantly outperformed novices on all metrics (table 1). Statistically significant differences were found between the 2 groups in time to task completion as well as economy of motion for all 3 tasks. Mean performance time and economy of motion were most similar between the groups in the peg transfer and intracorporeal suturing exercises with stark differences observed for the ring

**Table 1.** Novice and professional surgeon results of robotic surgical skills curriculum

Task (metric)	Mean Novice (95% CI)	Mean Experienced (95% CI)	p Value
Block transfer:			
Time (secs)	128.6 (94.1–163.1)	84.65 (70.3–98.9)	0.006
Motion economy (cm/sec)	2.168 (1.6–2.7)	2.750 (2.6–2.9)	0.012
Intracorporeal suture:			
Time (secs)	177.6 (112.1–243.1)	90.70 (71.8–109.6)	0.004
Motion economy (cm/sec)	1.306 (1.0–1.6)	1.770 (1.1–2.4)	0.0498
Ring tower transfer:			
Time (secs)	551.6 (137.6–965.6)	162.5 (121.3–203.7)	0.016
Motion economy (cm/sec)	1.276 (1.1–1.4)	1.996 (1.6–2.4)	0.001

tower task (time and economy of motion 551.6 and 1.276 cm per second for novices vs 162.5 and 1.996 cm per second for experienced surgeons,  $p = 0.016$  and  $0.001$ , respectively). There were no observer enforced penalties committed by participants in either group.

Figure 2 shows a representative graphic of a 3-dimensional tool path comparing a novice to an experienced robotic surgeon who each completed the block transfer task. There were immediately apparent differences between them with much more precise tool trajectories achieved by the experienced surgeon.

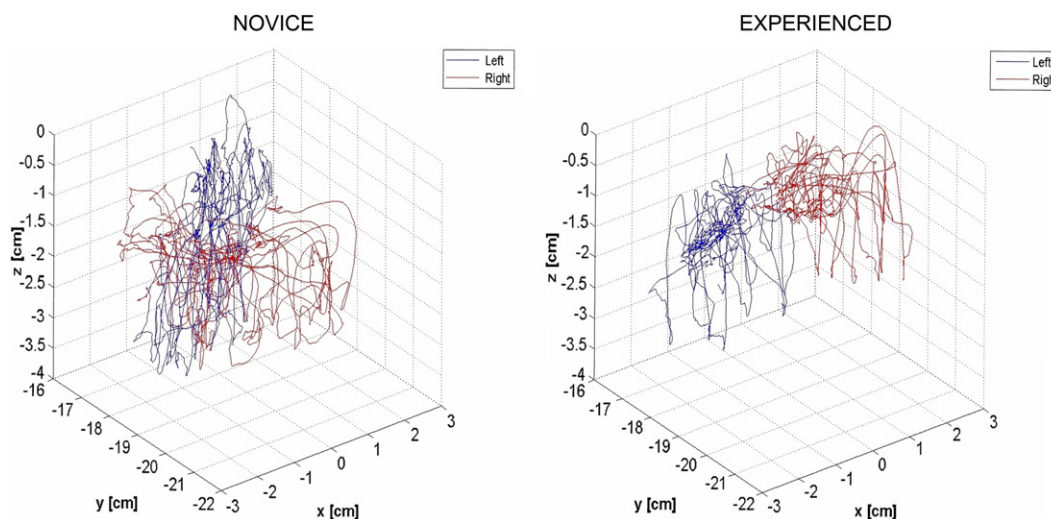
Table 2 lists face and content validity questionnaire results. All participants rated the curriculum as representative of robotic skills and tracking device affixation did not detract from robot function. Experienced surgeon answers on content validity suggested that the curriculum is relevant to robotic training and representative of robotic surgical skills.

**DISCUSSION**

Objective metrics can assess proficiency as novice robotic surgeons train. However, to our knowledge

what is not known at this time is how these objective metrics translate into actual performance on the robot. Current studies of the impact of training on robotic performance rely on comparisons between objective simulator data and subjective robotic performance data. Objective performance assessments are essential to attain data free from the confounding biases inherent to subjective performance evaluation.<sup>5</sup>

To our knowledge we performed the first prospective, institutional review board approved study to establish the face, content and construct validity of a daVinci surgical skills curriculum that provides objective measurement of surgeon performance by gathering data using an electromagnetic tracking device affixed to the instruments. Previous studies correlated performance on laparoscopic simulators with improvement in laparoscopic surgical skills.<sup>6,7</sup> As different robotic simulator platforms are validated and introduced into residency and robotic training programs, the usefulness of these devices as trainers must be determined and weighed against the cost of acquisition and maintenance. A curriculum that provides objective assessment of robotic



**Figure 2.** Tool tip paths for subjects during block transfer task. Note noneconomic motions by novice vs precise task completion by experienced robotic surgeon. Blue curve indicates left tool. Red curve indicates right tool.

**Table 2.** Questionnaire results proving face and content validity

Question	Score	
	Novices	Experts
This simulation platform was easy to use	4.8	5
Optics of this simulation platform were adequate	5	5
Depth perception was not problem	5	5
Instrument movements during task performance were not problem	5	5
Robotic task performance on this simulation platform compared to robotic task performance without simulator	5	5
This simulation platform accurately assessed my proficiency with robotic task performance	—	5
This simulation platform is:		
Relevant to robotic surgery	—	5
Useful as practice format for robotic surgery	—	5
Useful training tool for residents	—	5
Useful instrument for measuring performance assessment in robotic surgical training	—	4.8
There is role for reality based simulation for robotic surgical training	—	5

performance can serve as a reference to evaluate trainee progression. This information would also be useful when establishing proficiency before actual cases.

The metrics that we used to evaluate subjects are similar to those used in previous laparoscopic simulation studies and to those recorded by other robotic simulators.<sup>8,9</sup> Task time is a clear reflection of overall proficiency and the experienced group had faster task times than the novice group for all 3 tasks. Economy of motion, which is a surrogate for precision, improves along with subjective improvement in proficiency.<sup>7,10</sup> In our study experienced surgeons had significantly shorter path length and higher economy of motion scores for all 3 tasks. This finding is in agreement with previous laparoscopic simulation studies in which the experts were more likely than novices to keep the instruments in central view.<sup>9</sup> The dramatic difference in performance between the experienced and novice groups in this study was not unexpected. It is attributable to the superior laparoscopic surgical skills and overall superior proficiency on the da Vinci robotic surgical system of those with experience.

An issue of the implementation of various virtual reality simulation platforms is the monetary cost of the devices. The trakSTAR is significantly less expensive (approximately \$4,000) than any

other commercially available, all inclusive training platform.

Questionnaire results demonstrate that all subjects deemed the training curriculum acceptable for implementation into training programs. There were no significant differences between the 2 groups in the overall assessment of the training platform. All subjects agreed that the curriculum provided a forum in which robotic surgical skills were accurately represented and none reported difficulty with the addition of the tracking device. Questionnaire results provide evidence that this curriculum is a reasonable option for assessing performance on the da Vinci Surgical System.

Study limitations include our small subject size of 5 experienced and 5 novice robotic surgeons. Power analysis based on a previous study by our group<sup>11</sup> suggested that this small of a group could detect a statistically significant difference between the cohorts and this was the case. Also, the training platform requires a robot to perform the tasks, necessitating a dedicated training robot or the removal of one from clinical application. Further studies, and consensus among experts and professionals in our field must be reconciled to validate and establish training curricula and ultimately credentialing processes for urological surgeons to safely and effectively implement the robot in patient care.

## CONCLUSIONS

Robotic surgery applications are penetrating many aspects of urological care and objectively measuring surgical proficiency is required to optimize outcomes. To our knowledge this is the first study to validate a novel robotic surgical skills curriculum that used an electromagnetic tracking device to generate objective performance metrics. Training programs can implement such a curriculum into resident education with the aim of providing novices with a safe learning environment to hone skills and achieve the level of expert benchmarks. Further study must be done to standardize such curricula to establish guidelines for the credentialing of robotic surgeons.

## ACKNOWLEDGMENTS

Figure 1 was adapted from a task by the Chamberlain Group, Great Barrington, Massachusetts.

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