Original Article

Evaluation of a 3D system based on a high-quality flat screen and polarized glasses for use by surgical assistants during robotic surgery

Kazushi Tanaka, Katsumi Shigemura, Takeshi Ishimura, Mototsugu Muramaki, Hideaki Miyake, Masato Fujisawa

Division of Urology, Department of Surgery Related, Faculty of Medicine, Kobe University Graduate School of Medicine, Kobe, Japan

ABSTRACT

Introduction: One of the main benefits of robotic surgery is the surgeon's three-dimensional (3D) vision system. The purpose of this study is to evaluate the efficacy of 3D vision using a flat screen and polarized glasses for surgical skills during robotic surgeries. **Materials and Methods:** In an experimental model, six surgeons performed three surgical tasks with laparoscopic devices using a standard 2D and a flat-screen 3D model with polarized glasses. Performance times were compared between two-dimensional (2D) and 3D vision for each task. The surgeons also graded the efficiency of the 3D system, on a subjective scale of 0-100. **Results:** Performance times for task 1 (seven holes) and 2 (elastic bands) were significantly reduced by 84% and 56% using 3D compared with a 2D system and experienced surgeons performed all three tasks faster in 3D than 2D. The surgeons reported the polarized glasses were comfortable to wear and direct vision was seldom affected. **Conclusions:** The use of 3D visualization seems to improve the efficiency of surgical skills during robotic surgery and reduce performance time for characteristic surgical procedure tasks.

Key words: Experimental model, surgical skill, three-dimensional vision

INTRODUCTION

Three-dimensional (3D) vision offers the advantage of improved depth perception and accuracy in the performance of robotic or laparoscopic surgery, particularly for complex surgical tasks such as suturing.[1] These are critical procedures; for instance, in urological surgery, partial nephrectomy requires efficient suturing to control blood loss and minimize renal artery clamping time [2,3] while prostatectomy requires delicate anastomoses between the bladder and urethra to prevent injury to the urethral sphincter muscle and decrease the risk of urinary incontinence post-operatively.[4]

To accomplish these essential surgical tasks, good vision and motor skills are important, and depth perception is particularly necessary for accurate discrimination and recognition.[5] The da Vinci Robot System's true 3D imaging system is considered to be one of the major advantages of robotic surgery.[6] However, unlike the surgeon who uses the da Vinci's 3D visual console, the surgical assistants working at the patient's side in most cases have to depend on two-dimensional (2D) images projected onto a flat screen monitor and have to rely on indirect cues for depth perception.

We have recently adopted a new 3D system using a flat high-quality screen and polarized glasses for the da Vinci system. In this study, we evaluated the impact of 3D vision on surgical performance using this 3D system with experimental tasks and subjective questionnaires.

MATERIALS AND METHODS

To evaluate the efficacy of a 3D system using polarized glasses for robotic or laparoscopic surgery, two experiments were performed: (1) Three surgical procedure-related tasks

For correspondence: Dr. Katsumi Shigemura, Department of Organ Therapeutics, Division of Urology, Faculty of Medicine, Kobe University Graduate School of Medicine, Kobe 650-0017, Japan. E-mail: yutoshunta@hotmail.co.jp

Access this article online	
Quick Response Code:	Website: www.indianjurol.com
	DOI: 10.4103/0970-1591.124199

were evaluated and (2) a subjective questionnaire was administered for evaluation of the 3D system using polarized glasses during robotic prostatectomy. A 3D control unit (Skyjet, Kobe, Japan) was used to display images on a 3D monitor with the da Vinci S surgical system (Intuitive Surgical Inc., Sunnyvale, CA). The standard 2D monitor with the da Vinci S system was used for the 2D system. Six surgeons participated in the study, three experienced and three novice surgeons. The experienced surgeons had performed 52 cases, 70 cases and 63 cases of laparoscopic surgeries, respectively (mean cases: 61.7) as chief surgeon. Novice surgeons were residents and had no experience of laparoscopic surgery as a chief surgeon and had no experience of robotic surgery. They had only dry box training.

Experiment 1

The six surgeons performed three different laparoscopic tasks. Each surgeon performed each task with both the polarized glasses for 3D system and without polarized glasses for the standard 2D system (figure 1). In task 1, 3-0 Monocryl suture was passed through seven holes (upper-right side numbered holes). In task 2, nine small elastic bands were transferred from one cylinder to others. In task 3, suturing was performed using 3-0 Vicryl passed through nine dots. Performance times of these three tasks were recorded and compared statistically. In addition, performance time was compared between the experienced surgeons and novice surgeons.

Experiment 2

The da Vinci 3D signals were projected onto the flat screen through polarizing filters during robotic prostatectomy. The assistants wore polarized glasses for the flat screen 3D monitor throughout the robotic prostatectomy. Six assistants were enrolled and questioned using a subjective scale of 0-100 about the 3D system for surgery. The original questionnaires were as follows:

1. Advantages
   a. How would you rate the vision?
   b. Was 3D visualization helpful in improving your efficiency?
2. What problems did you face?
   a. Weight of the device.
   b. Disturbing your sight.
   c. Eyestrain.
3. Overall satisfaction

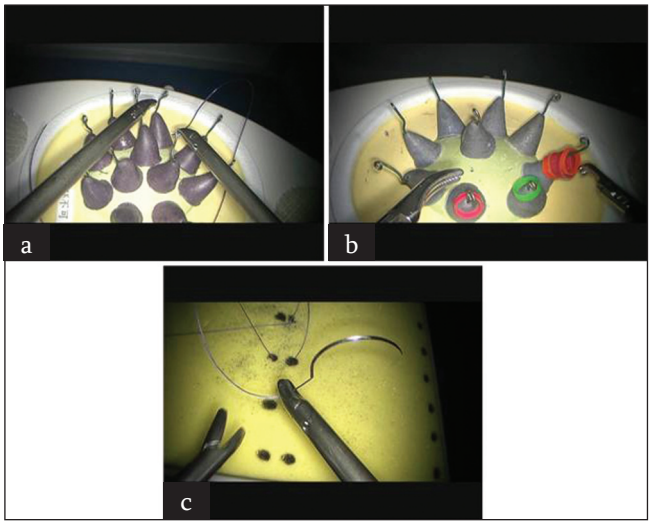

Figure 1: Experimental surgical procedure-related tasks. Panel a: 3-0 Monocryl was passed through seven holes (task 1). Panel b: Nine small elastic bands were transferred from one cylinder to others. Panel c: Continuous suture using 3-0 Vicryl through eight holes

Statistical analyses

Statistical analysis was conducted with the XLSTAT (Addinsoft, New York, USA) using the Student's *t*-test. Statistical significance was established at $P < 0.05$.

RESULTS

Experiment 1

All surgeons had significantly less performance time for tasks 1 (holes) and 2 (elastic bands) using 3D imaging with polarized glasses compared with the 2D system; however, the experienced surgeons also showed significantly less performance time for task 3 (suturing) in 3D compared to 2D [Table 1]. Novice surgeons showed significantly less performance time compared with 2D only for task 1 and task 2 [Table 1]. In comparison between experienced and novice surgeons, experienced surgeons showed significantly less performance time in all three tasks than novice surgeons using the 3D system even though only suturing was significantly better for experienced surgeons than novice surgeons using the 2D system [Figure 2].

Table 1: Mean performance time in three tasks (seven holes elastic bands suturing)

Experiment	2D	3D	% change	*P* value
Task 1: Seven holes				
All	537.2±98.8*	88.0±9.5	83.6	<0.001
Experienced surgeons	520.1±119.0	82.5±6.2	84.3	<0.001
Novice surgeons	554.2±73.8	93.4±9.2	83.1	<0.001
Task 2: Elastic bands				
All	182.8±26.2	80.9±13.0	55.7	<0.001
Experienced surgeons	188.4±18.4	72.1±8.2	61.7	<0.001
Novice surgeons	177.2±31.9	89.7±10.8	49.4	<0.001
Task 3: Suturing				
All	161.5±61.4	145.5±69.5	9.9	0.348
Experienced surgeons	104.6±17.6	81.5±24.4	22.1	0.006
Novice surgeons	218.5±23.1	209.6±24.8	4.1	0.316

2D = Two-dimensional, 3D = Three-dimensional, *All times in second

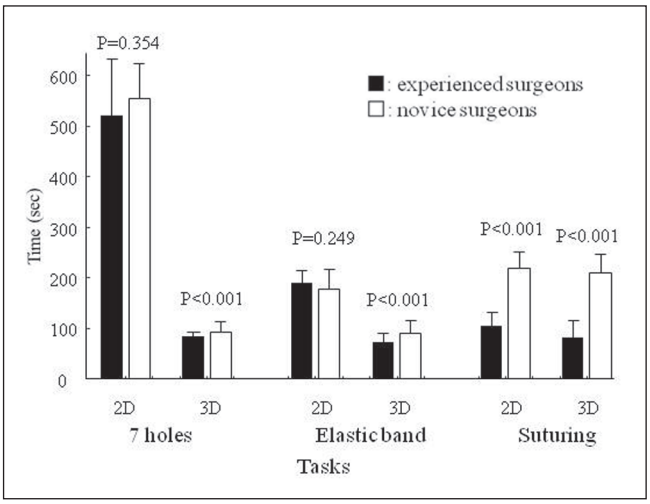

Figure 2: Comparison between experienced surgeons and novice surgeons for task 1 (hole), task 2 (elastic band) and task 3 (suturing). Experienced surgeons (black bars) showed significantly faster performance times in all three tasks compared to novice surgeons (white bars) using the three-dimensional system ($P < 0.001$) even though only suturing ($P < 0.001$) was significantly better with experienced compared to novice surgeons using the two-dimensional system

Experiment 2

All surgeons reported subjective advantages of using the 3D system. The 3D system received a score of 87.7 and visual improvement using the glasses was rated 88.0 on a 0-100 scale. The scores for disadvantages of wearing the glasses during surgery such as weight of the device, disturbing your sight and eyestrain were not high suggesting that the surgeons found the polarized glasses comfortable to wear and direct vision was seldom influenced. The final question about overall satisfaction was given a score of 89.5 [Table 2].

Table 2: Subjective evaluation for 3D system by assistants using the questionnaire of 0-100 score

Questions	Scores
Advantages	
How would you rate the vision?	87.7±7.1
Was 3D visualization helpful in improving your efficiency?	88.0±10.1
What problems did you face	
Weight of the device	−19.2±7.9
Disturbing your sight	−7.5±6.1
Eyestrain	−24.2±7.9
Overall satisfaction	89.5±5.4

DISCUSSION

The lack of depth perception and spatial orientation when using 2D imaging is a recognized limitation of laparoscopic surgery in comparison with open surgery.[7] This directly affects surgical performance, operative time, morbidity and patients' post-operative quality-of-life.[8] 2D vision uses monocular cues to compensate for the lack of depth perception. They include motion parallax through movement of the laparoscope, relative position and size of instruments and anatomic structures, shading of light and dark and texture grading.[9,10]

Conversely, 3D vision offers the advantage of improved depth perception and accuracy comparable to open surgeries.[11] Visual performance and motor skills are a function of depth perception allowing improved discrimination and recognition of targeted organs and their parts.[5] The separate input from two viewpoints allows for summation on a cortical level and perceived improvements in resolution with 3D imaging.[12] Acuity has been improved by 10% using binocular vision.[13]

The benefits of using 3D have translated to the field of robotic surgery as well. A significant improvement in performance parameters for tasks and lower error rates were found when operators used the stereoscopic mode of the da Vinci robotic system.[14] Anatomic drills were completed 65% faster[15] and the time to perform the task was significantly shorter in the group that used a 3D view.[16] Independent of the biomechanical advantages of the da Vinci robot system, 3D vision was found to improve performance times by 34-46% and reduce error rates by 44-66% for both inexperienced residents and experienced laparoscopic surgeons.[6]

The data presented here showed that surgical-related task performance with 3D visualization using the da Vinci camera and 3D control unit is superior to 2D visualization. Experienced surgeons' performances were improved in all three tasks even though novice surgeons' performances were improved in only task 1 and 2, suggesting that task 3 (suturing) as a more delicate technique could be accomplished better using 3D vision by experienced surgeons. This fact may be informative since suturing time during surgery affects operation outcome.[17] Our data showed that experienced surgeons had better outcomes in all three tasks only with 3D vision, not 2D, suggesting that teaching in the 3D system may have learning curve benefits for surgical education. We interpreted this result as follows: Experienced surgeons were familiar with suturing but not with the other tasks (seven holes and elastic bands) because the latter two tasks were not actually necessarily done in real laparoscopic surgery. However experienced surgeons are considered to have better laparoscopic techniques than novices; therefore, our results with the 3D system reflected this difference of experience and laparoscopic technique between the two groups more than 2D system especially in the tasks of seven holes and elastic bands which experienced surgeons never do in real surgery. Taken together, our interpretation regarding benefit of 3D is that it helps both experienced and novice surgeons and experienced surgeons may have more merit even if they had no direct experience of those techniques.

Ramanathan *et al.* reported that the use of 3D visualization improved the assistants' efficiency during robotic surgery.[18]

They used a head mounted device which may potentially cause discomfort owing to the weight of the device. We used polarized glasses and a 3D flat screen without any head tracking device. This had the additional benefit of allowing several surgical assistants and visitors to view the stereoscopic images at the same time. According to the subjective questionnaire evaluation, this system seems to work well for surgeons. Its utility as a teaching aid for prospective robotic surgeons and medical students should also be explored.

We would like to emphasize the study limitations. First, number of subjects may be too small for definitive conclusions. Next, relating to the first limitation, the number of surgeons who were questioned about using polarized glasses during robotic surgery may also not be enough for definitive conclusions. These problems will be overcome in our future work. Third, no evaluation and comparison between 2D and 3D surgical assistants' vision during real surgeries was performed in this study. However, our data show the efficacy of using a 3D vision system for surgeons during surgery *in vitro* and *in vivo* and provide a basis for recommending the 3D system for use in clinics.

CONCLUSIONS

3D vision using a new 3D flat screen system with polarized glasses for the da Vinci system showed improved performance times for surgery-related tasks and was not associated with significant disadvantages for the users. Because this system provides high quality 3D vision simultaneously for surgeons, it has the potential to be used as a teaching aid for robotic surgery.

ACKNOWLEDGMENTS

We thank Dr. Fukashi Yamamichi for drafting manuscripts.

REFERENCES

1. Wagner OJ, Hagen M, Kurmann A, Horgan S, Candinas D, Vorburger SA. Three-dimensional vision enhances task performance independently of the surgical method. Surg Endosc 2012;26:2961-8.
2. Kural AR, Atug F, Tufek I, Akpinar H. Robot-assisted partial nephrectomy versus laparoscopic partial nephrectomy: Comparison of outcomes. J Endourol 2009;23:1491-7.
3. Karim O, Mayer E, Kucheria R, Hrouda D, Vale J. Technique for urethral eversion and vesico-urethral anastomosis: Application to robot-assisted laparoscopic prostatectomy. BJU Int 2010;105:284-7.
4. Tan GY, El Douaihy Y, Te AE, Tewari AK. Scientific and technical advances in continence recovery following radical prostatectomy. Expert Rev Med Devices 2009;6:431-53.
5. Blake R, Levinson E. Spatial properties of binocular neurones in the human visual system. Exp Brain Res 1977;27:221-32.
6. Byrn JC, Schluender S, Divino CM, Conrad J, Gurland B, Shlasko E, *et al*. Three-dimensional imaging improves surgical performance for both novice and experienced operators using the da Vinci robot system. Am J Surg 2007;193:519-22.
7. Honeck P, Wendt-Nordahl G, Rassweiler J, Knoll T. Three-dimensional laparoscopic imaging improves surgical performance on standardized *ex-vivo* laparoscopic tasks. J Endourol 2012;26:1085-8.
8. Kiran RP, Kirat HT, Ozturk E, Geisler DP, Remzi FH. Does the learning curve during laparoscopic colectomy adversely affect costs? Surg Endosc 2010;24:2718-22.
9. Hanna GB, Shimi SM, Cuschieri A. Task performance in endoscopic surgery is influenced by location of the image display. Ann Surg 1998;227:481-4.
10. Falk V, Mintz D, Grünenfelder J, Fann JI, Burdon TA. Influence of three-dimensional vision on surgical telemanipulator performance. Surg Endosc 2001;15:1282-8.
11. Yamauchi Y, Shinohara K. Effect of binocular stereopsis on surgical manipulation performance and fatigue when using a stereoscopic endoscope. Stud Health Technol Inform 2005;111:611-4.
12. Wenzl R, Lehner R, Vry U, Pateisky N, Sevelda P, Husslein P. Three-dimensional video-endoscopy: Clinical use in gynaecological laparoscopy. Lancet 1994;344:1621-2.
13. Rabin J. Two eyes are better than one: Binocular enhancement in the contrast domain. Ophthalmic Physiol Opt 1995;15:45-8.
14. Munz Y, Moorthy K, Dosis A, Hernandez JD, Bann S, Bello F, *et al*. The benefits of stereoscopic vision in robotic-assisted performance on bench models. Surg Endosc 2004;18:611-6.
15. Badani KK, Bhandari A, Tewari A, Menon M. Comparison of two-dimensional and three-dimensional suturing: Is there a difference in a robotic surgery setting? J Endourol 2005;19:1212-5.
16. Blavier A, Gaudissart Q, Cadière GB, Nyssen AS. Impact of 2D and 3D vision on performance of novice subjects using da Vinci robotic system. Acta Chir Belg 2006;106:662-4.
17. Kenngott HG, Muller-Stich BP, Reiter MA, Rassweiler J, Gutt CN. Robotic suturing: Technique and benefit in advanced laparoscopic surgery. Minim Invasive Ther Allied Technol 2008;17:160-7.
18. Ramanathan R, Salamanca JI, Mandhani A, Leung RA, Rao SR, Berryhill R, *et al*. Does 3-Dimensional (3-D) visualization improve the quality of assistance during robotic radical prostatectomy? World J Urol 2009;27:95-9.

How to cite this article: Tanaka K, Shigemura K, Ishimura T, Muramaki M, Miyake H, Fujisawa M. Evaluation of a 3D system based on a high-quality flat screen and polarized glasses for use by surgical assistants during robotic surgery. Indian J Urol 2014;30:13-6.

Source of Support: Nil, **Conflict of Interest:** None declared.