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Two-dimensional vs. three-dimensional vision during the laparoscopic radical prostatectomy: A matched comparison of operative and long-term functional outcomes

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Ethics Committee Approval
The study was approved by the institutional review board of Bagcilar Training and Research Hospital (Approval date and ID: May 6, 2010 and 2010-23).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: The three-dimensional (3D) display system can solve essential problems in conventional laparoscopic radical prostatectomy (LRP), like depth perception and spatial orientation. Several studies reported initial comparisons of LRP with 2D and 3D vision systems in terms of operative outcomes, with 3D systems coming out on top. However, there are few published comparison studies on the long-term outcomes of LRP with 2D and 3D vision systems. In this regard, we aimed to compare operative and long-term functional results of 3D-High definition (HD) LRP with conventional two-dimensional (2D)-HD display systems.

Methods: A total of 115 cases that underwent LRP between October 2010 and December 2016 were prospectively evaluated, and a prospective cohort study was conducted. Inclusion criteria at baseline were as follows: age at surgery <75 yr, prostate-specific antigen (PSA) concentration <20 ng/ml, clinical tumor stage <T4, no diagnosis of metastatic disease, and informed consent to participate in the study. Patients who underwent salvage treatments after LRP and patients with incomplete follow-up were excluded. The patients were divided into groups, Group 1 (n=72) and Group 2 (n=43), according to the display systems used, 2D-HD vs. 3D-HD during LRP. Demographic data, operative and postoperative, and long-term follow-up outcomes were recorded. Additionally, urinary continence rate determined with a patient questionnaire and erectile functions determined with the International Index of Erectile Function (IIEF) questionnaire were recorded. All obtained parameters were compared between the groups using the independent t-test and the chi-square test. Differences were considered significant at two-sided $P<0.05$ and 95% confidence interval.

Results: All patients completed a 24-month follow-up procedure. The groups were similar in age, serum PSA level, prostate volume, preoperative Gleason score, and cancer-positive core number. There were significantly better results in group 2 than in group 1 for operative parameters, catheterization time, and hospital stay ($P<0.001$, for all parameters). At long-term follow-up, the urinary continence rate was significantly higher in group 2 than in group 1 ($P=0.023$). Similarly, significantly higher IIEF scores were determined in the group 2 ($P<0.001$).

Conclusion: Our results suggest that using a 3D-HD display system during LRP provides much better long-term functional and operative outcomes and may provide a cheap and equal alternative to the RARP procedure.

Keywords: outcome assessment, prostatectomy, laparoscopy, three-dimensional image

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Introduction

Prostate cancer (PCa) is the most common malignancy and the fifth leading cause of cancer-related death in men worldwide [1]. The surgical treatment of choice for patients with early-stage PCa is radical prostatectomy (RP), which has been shown to reduce mortality [2]. Throughout the modern history of RP, three significant techniques—open retropubic RP (RRP), laparoscopic RP (LRP), and robot-assisted RP (RARP)—have been used as standard operative approaches [3]. Today, laparoscopic and robotic approaches have primarily taken over open radical prostatectomy. However, laparoscopy has many limitations, and a steep learning curve is required for the surgeon. These shortcomings have led to the concept that robots may improve the precision and accuracy of anatomical dissection by offering enhanced freedom and easy maneuverability, thereby improving overall outcomes [4]. However, the high cost of RARP is a severe barrier. As a result, RARP was not extensively adopted right away, and a less expensive version is still needed [5]. Specific enhancements to conventional LRP were made to provide high-definition (HD) vision in order to acquire a less expensive alternative to RARP, such as three-dimensional (3D) vision systems with articulating laparoscopic hand devices [6]. The 3D display system can solve essential problems in conventional LRP, like depth perception and spatial orientation [7]. Several authors and we previously published initial comparisons of LRP with 2D and 3D vision systems regarding operative outcomes, with 3D systems coming out on top [8,9]. However, to our knowledge, there are few published comparison studies on the long-term and long-term functional outcomes of LRP with 2D and 3D vision systems. In the present study, we aimed to investigate the long-term functional outcomes of LRP with a 3D vision system (HD Viking Systems, La Jolla, CA) by comparing it with a conventional 2D-HD (Karl Storz, Tuttlingen, Germany) display system.

Materials and methods

Patient selection and data collection

A prospective cohort study was performed to investigate the outcomes of patients who underwent LRP between October 2010 and December 2016. The study was conducted according to STROBE guidelines following the Helsinki Declaration principles, Ethical committee approval, and informed consent by those participating.

Inclusion criteria at baseline were as follows: age at surgery <75 yr, prostate-specific antigen (PSA) concentration <20 ng/ml, clinical tumor stage <T4, no diagnosis of metastatic disease, and informed consent to participate in the study. Patients who underwent salvage treatments after LRP and patients with incomplete follow-up were excluded. All LRP procedures were performed by a single experienced surgeon (S.A.). The patients were divided into groups, Group 1 (n=72) and Group 2 (n=43), according to the LRP procedure using 2D-HD and 3D-HD vision systems, respectively. The study groups were created by a non-random method. However, they matched the comparison method where participants in each group are assigned so that they are similar in patient demographics and characteristics such as age, body mass index (BMI), serum PSA level, prostate volume, pathological Gleason score on biopsy, and cancer positive biopsy core numbers. Clinical data were collected preoperatively and at regular follow-up visits postoperatively. Patient-reported outcomes, including functional outcomes, were collected using validated questionnaires. Operative and postoperative parameters, including operative time, vesicourethral anastomosis time, estimated blood loss, length of hospital stay, and urethral catheterization, were noted. Pathological data included prostate specimen weight, tumor stage according to the 2002 tumor-node-metastasis classifications, pathologic Gleason score, and presence of positive surgical margins were also determined and noted.

Functional outcome and follow-up

After LRP, patients were followed up at 1-month intervals for the first three months following surgery, then at 3-month intervals for five years. Follow-up examinations included measurement of PSA levels and a DRE, computed tomography scan, magnetic resonance imaging, or bone scintigraphy in the event of suspected disease recurrence. The continence and erectile functions were the essential parts of functional outcomes. Incontinence was measured using the question, “How often do you change a pad, diaper, or sanitary aid during a typical day (24 h)?” Continence was defined as "completely dry" or using only one safety pad in a day, and using more than one protective pad was classified as incontinence. Erectile functions were determined using International Index of Erectile Function (IIEF) questionnaires before and after the surgery. If the score was lower than 11, the patient was defined as having erectile dysfunction.

Statistical analysis

We determined the minimum number of participants required using G*power version 3.1.9.2 data analysis software (Department of Cognitive and Industrial Psychology, Heinrich Heine Universität, Düsseldorf, Germany). The alpha level (the probability of detecting a significant difference) and power were considered 0.05 and 0.75, respectively, in determining the sample size. According to the initial power analysis, we determined the minimum sample size in each group as 40. The IBM Statistical Package for the Social Sciences (SPSS) for MAC 21.0 (IBM, Armonk, New York, NY) was used for statistical analysis. Data distributions and normality tests were evaluated with the Shapiro–Wilk test. Descriptive statistic methods were used to evaluate data, including mean (SD) and median (interquartile range). We compared the normally distributed data between the groups using the independent t-test. The chi-square test was also used to compare the nonparametric categorical variables. Differences were considered significant at two-sided P <0.05 and 95% confidence interval.

Results

Patients, follow-up and preoperative and operative data

A total of 115 patients were included in the study. The mean age, BMI, serum PSA level, prostate volume, preoperative Gleason score, and cancer-positive core number at biopsy results were 63.65 (8.41) years, 30.33 (5.32) kg/m^2, 8.76 (6.15) ng/mL, 55.34 (23.30) mL, 6.13 (1.0) and 3.83 (2.10), respectively. All patients completed a 24-month follow-up procedure, finally.

Patient demographics and clinical data between the groups are provided in Table 1. The groups were similar in age, serum PSA level, prostate volume, preoperative Gleason score, and cancer-positive core number.

Table 1: Preoperative data of the groups.

Parameters	Group 1 (n=72) Mean (SD)	Group 2 (n=43) Mean (SD)	*P*-value
Age, year	64.4 (5.59	62.4 (5.6)	0.07*
BMI, kg/m^2	30.3 (3.2)	30.4 (2.3)	0.09*
PSA, ng/Ml	9.1 (5.9)	8.2 (5.8)	0.28*
Biopsy Gleason Score	6.1 (0.6)	6.2 (0.5)	0.27*
Positive biopsy specimen, n,	3.8 (2.6)	3.9 (2.0)	0.75*
Prostate volume, mL	55.2 (24.7)	55.6 (17.6)	0.93*

BMI: Body mass index, PSA: Prostate specific antigen, SD: Standard deviation, *: Independent t test.

The mean operative time, vesicourethral anastomosis procedure time, estimated blood loss, hospital stay, and duration of urethral catheter time were 166.46 (28.15) min., 65.07 (14.12) min., 117.26 (31.56) mL, 5.43 (0.92) days and 17.70 (1.90) days. Statistically significant better results were noted for Group 2 than Group 1 in terms of operative time, estimated blood loss, catheterization time, hospital stay, and vesicourethral anastomosis procedure time (P<0.001 for all) (Table 2).

Table 2: Comparison of operative data of groups.

Parameters	Group 1 (n=72) Mean (SD)	Group 2 (n=43) Mean (SD)	*P*-value
Operative time, min	189 (29.81)	128.72 (15.7)	<0.001*
Vesicourethral anastomosis time, min	87.43 (16.8)	27.65 (6.68)	<0.001*
Estimated blood loss, mL	138.54 (31.88)	81.63 (33.47)	<0.001*
Hospital stay, day	6 (1)	4.49 (0.869)	<0.001*
Duration of catheter, day	20.53 (1.97)	12.98 (2.43)	<0.001*

SD: Standard deviation, *: Independent t test.

Most patients had pathological T2 and T3 disease (87 and 24 patients, respectively). Pathologically, T1 and T4 diseases were reported only for three patients and one patient, respectively. Positive surgical margin was reported in 15 patients (13.04%) after LRP. The distribution of pathological tumor stage, pathological Gleason score, and positive surgical margin status rate were comparable in both groups (Table 3).

Table 3: Pathological data of the groups.

Parameters		Group 1 (n=72) Mean (SD)	Group 2 (n=43) Mean (SD)	*P*-value
Pathological prostatic tissue volume, mL		59.62 (26.16)	53.83 (19.36)	0.13*
Pathological carcinomatous tissue volume, mL		16.64 (12.11)	13 (9.21)	0.09*
Pathological Gleason score		6.81 (0.69)	6.81 (0.85)	0.95*
Pathological stage		**n (%)**	**n (%)**	***P*-value**
	T1c	-	3 (6.9%)	0.06#
	T2a	2 (2.7%)	6 (13.9%)	
	T2b	9 (12.5%)	4 (9.3%)	
	T2c	43 (59.7%)	23 (53.4%)	
	T3a	11 (15.2%)	6 (13.9%)	
	T3b	5 (6.9%)	1 (2.3%)	
	T3c	1 (1.3%)	-	
	T4	1 (1.3%)	-	
Positive surgical margin		11 (15.2%)	4 (9.3%)	0.35#

SD: Standard deviation, *: Independent t test, #: Chi-square test.

Functional outcomes

Postoperative urinary continence status and erectile function parameters of the patients are provided in Tables 4 and 5 for each follow-up visit. The numbers of patients who reported early continence was higher in Group 2 (53.5%) than in Group 1 (26.4%) at postoperative three months (P=0.003). At the final follow-up on postoperative 24th months, the rate of the continent patients was significantly higher in Group 1 (93.1%) compared to Group 2 (76.4%) (P=0.02). There were comparable IIEF scores for both groups in the preoperative period. Patients in Group 2 had significantly higher IIEF scores than those in Group 1 during the entire follow-up period after LRP (P<0.001, for all). Among the 43 patients, 20 (46.5%) had successful sexual intercourse at the end of 1st year after LRP in group 1. On the other hand, the successful sexual intercourse rate was only 7 (9.7%) patients in group 2 (P<0.001). The complication rates were comparable for groups.

Table 4: Urinary continence status of the patients between the groups during the follow up.

Follow up periods	Group 1 (n=72)	Group 2 (n=43)	*P*-value
3 month			
Continent patients, n (%)	19 (26.4%)	23 (53.5%)	0.003*
Incontinent patients, n (%)	53 (73.6%)	20 (46.5%)	
6 month			
Continent patients, n (%)	40 (55.6%)	34 (79.1%)	0.01*
Incontinent patients, n (%)	32 (44.4%)	9 (20.9%)	
9 month			
Continent patients, n (%)	45 (62.5%)	37 (86.1%)	0.007*
Incontinent patients, n (%)	27 (37.5%)	6 (13.9%)	
12 month			
Continent patients, n (%)	53 (73.7%)	39 (90.7%)	0.02*
Incontinent patients, n (%)	19 (26.3%)	4 (9.3%)	
24 month			
Continent patients, n (%)	55 (76.4%)	40 (93.1%)	0.02*
Incontinent patients, n (%)	17 (23.6%)	3 (6.9%)	

*Chi-square test.

Table 5: IIEF scores of the patients between the groups during the follow-up.

Parameters	Group 1 (n=72)	Group 2 (n=43)	*P*-value
Preoperative IIEF score, Mean (SD)	13.4 (5.8)	15.14 (6.9)	0.15
IIEF score at 3th month, Mean (SD)	5.68 (1.9)	8.07 (4.1)	<0.001*
IIEF score at 6th month, Mean (SD)	6.22 (2.7)	9.86 (5.5)	<0.001*
IIEF score at 12th month, Mean (SD)	6.22 (2.99	10.7 (6.5)	<0.001*
IIEF score at 24th month, Mean (SD)	6 (2.8)	8.94 (6)	<0.001*

IIEF: International Index of Erectile Function, SD: Standard deviation, *: Independent t test.

Discussion

It is essential to achieve cancer control with minimal complications and a short convalescence period with preservation of continence and potency after RP [10]. This way, minimally invasive surgical procedures such as RARP and LRP could successfully provide these [11]. However, while LRP has the benefits of minimally invasive surgery, the loss of depth awareness caused by 2D vision systems is a drawback in traditional laparoscopic surgery [12]. The next-generation 3D display systems bridged the gap between traditional 2D and robotic technologies. Several publications revealed the extraordinary progress made in using 3D vision systems during LRP in recent years [13-16]. However, most of them described their short-term findings and outcomes [8]. The present study is the first to provide long-term outcomes of a 3D display LRP procedure with more than a year of follow-up. Our results showed that long-term functional outcomes were much better for LRP with 3D display systems than for LRP with 2D display systems. In addition, LRP, with a 3D display system, improved operative data. However, oncologic outcomes were similar in both groups.

On the other hand, better oncologic outcomes may be provided with a 3D visualization system in LRP in the future with longer-term follow-up. These superior functional data may be related to the unsurpassed display characteristics of 3D vision. Previously, Becker et al. [17] reported the favorable effects of 3D display systems on depth perception and spatial orientation. Enhanced spherical optics can improve the surgeon's spatial perception and hand-eye coordination during surgery [18]. Thus, better dissection, grasping skills, and suturing can enhance optimal surgical performance. In our view, improved operative and perioperative circumstances influence the functional outcomes of LRP, and improved functional outcomes directly influence early recovery after the operation [19]. Further studies

on this issue are needed to present the superior effects of 3D-HD display systems on LRP.

Several previous series showed better early results with 3D LRP than 2D LRP [6]. To compare long-term outcomes, Bove et al. [20] investigated their cases' 3D LRP and 2D LRP results. They published superior overall pentafecta rates of 62.7% and 67% in 2D and 3D LRP at 12 months after surgery. Our recent findings were similar to those of previous reports. However, in the present study, we showed the beneficial effects of LRP with 3D display at 24 months follow-up. We showed that in addition to better surgical outcomes, 3D vision positively affects functional outcomes that build up over time.

Limitations and/or strengths

The study has some limitations. First, the number of patients in the groups is small and unequal. This was due to uncompleted follow-up visits for some patients. The second limitation is that the results include 24-month follow-up data. More extended follow-up data with high numbers of patients might have provided more accurate results of LRP with a 3D display system. However, this is the first study prospectively conducted and introduced long-term better functional results of LRP with 3D system in selected patients. The critical strength of the present study was the matched comparison method, where participants in each group are assigned as similar in patient demographics and characteristics to reduce potential sources of bias.

Conclusions

The present study demonstrated the positive effects of a 3D vision system on long-term functional outcomes of LRP, besides better surgical outcomes. Our results suggest that using more advanced technology on vision systems could provide much better outcomes after LRP in the future, and it may provide a cheap and equal alternative to the RARP procedure. In the future, using more advanced technology on vision systems could provide much better results for the LRP procedure. LRP with a 3D display system and advanced instruments may also be a less expensive alternative to RARP in selected patients.

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