

Visual cues as a surrogate for tactile feedback during robotic-assisted laparoscopic prostatectomy: posterolateral margin rates in 1340 consecutive patients

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OBJECTIVE

To analyse consecutive cases of robotic-assisted laparoscopic prostatectomy (RALP), present the incidence of nerve-sparing-related positive surgical margins (SM+), include visual cues that might assist in smoothly changing to the robotic platform, and discuss the scientific rationale for 'intersensory integration' which might explain the 'reverse Braille' phenomenon, i.e. the ability to feel when vision is greatly enhanced, as the lack of tactile feedback during RALP is often cited as a disadvantage of robotic surgery, interfering with a surgeon's ability to make intraoperative oncological decisions.

PATIENTS AND METHODS

Data from 1340 consecutive patients undergoing RALP from one institution were

analysed and trends for positive posterolateral SM+ (PLSM+) were correlated with oncological variables before and after RALP. A sample of patient slides were reviewed by an extramural pathologist. Multivariate regression modelling was used to compare the projected rates of PLSM+ vs the actual rate, given the effect of a conscious effort to use visual cues. Finally, video recordings of the procedure were systematically reviewed and correlated with anatomical and histopathological images in an integrated session involving the surgeon and the pathology team.

RESULTS

The incidence of PLSM+ was 2.1%, which gradually declined to 1.0% in the last 100 patients. The reduction in PLSM+ occurred despite an increased rate of high-risk tumours operated on during this period. Forecasting analysis showed that the actual PLSM+ rate declined by half in the most recent 1000 patients, due to an

integrated effort involving the use of visual cues during surgery. The following visual cues were considered important; appreciation of periprostatic (lateral prostatic) fascial compartments; colour and texture of the tissue; periprostatic veins as a landmark for athermal dissection; signs of inflammation; and a freely separating bloodless plane showing loose shiny areolar tissue.

CONCLUSION

Adapting to the robotic platform is easy and there is no compromise of the oncological safety of this procedure. Experienced surgeons can use visual cues to assist during nerve-sparing RALP and achieve low PLSM+ rates.

KEYWORDS

prostate cancer, robotic, prostatectomy, surgical margin, haptic feedback

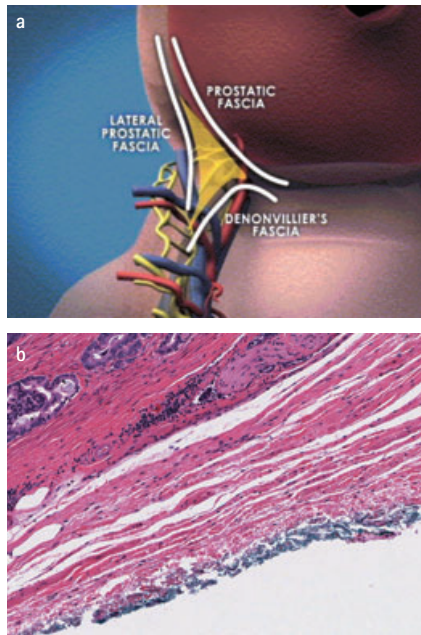
INTRODUCTION

Robotic-assisted laparoscopic radical prostatectomy (RALP) is a popular surgical method for treating prostate cancer [1–3]. The

robotic equipment allows for enhanced vision and precision, while enabling a minimally invasive approach. Theoretical concern exists over the oncological safety involved in using this procedure, forcing surgeons to trade

tactile sensation for visual magnification. The compromise involved can affect intraoperative decision-making. Indeed, open surgeons often use tactile feedback during nerve-sparing at the posterolateral aspect,

FIG. 1. (a) A diagram showing the space where the NVBs travel (yellow) bounded by the lateral prostatic fascia, prostatic fascia, and Denonvilliers' fascia; (b) posterolateral surgical margin.



where the neurovascular bundles (NVBs) adhere to the prostate [4–6]. As a result, evidence suggests a positive posterolateral surgical margin (PLSM+) is associated with a significantly increased risk of recurrence [7–9]. In patients undergoing open radical prostatectomy (RP), SM+ are found in 10–35%, and PLSM+ in 2.8–9% [5,7–11].

The use of tactile evaluation is based on the premise that infiltrating cancer cells and related angiogenesis produce changes in tissue firmness that can be identified via palpation during surgery. The surgeon can then make appropriate adjustments in the need for wider resection to achieve negative margins.

Currently, there are no published data suggesting that a lack of tactile sensation during minimally invasive surgery translates into a higher PLSM+ rate. It is possible that robotic surgeons rely on compensatory visual strategies to overcome this handicap, and SM+ rates are a function of experience and technique rather than robotic surgery alone.

In addition, there is scientific evidence that sensory stimuli interact to the point of

creating aesthetic illusions. These illusions are related to the experience of 'presence'. This connection suggests a relationship between vision and tactile sensation [12]. We propose that there is 'intersensory integration' which can explain the 'reverse Braille phenomenon' during robotic surgery, i.e. the ability to feel when vision is enhanced [13].

We hypothesise that surgical experience [14–16] and enhanced vision in a bloodless field can compensate for the lack of tactile sensation, allowing surgeons to identify visual cues such as a change in colour or texture, bulging and surface irregularities, adhesiveness of planes, and the obvious presence of the mass effect produced by the tumour. Ultimately, if this hypothesis is correct, an experienced robotic prostate cancer surgeon should be able to obtain rates of negative PLSM similar to those published for open RP [5,14,15,17–20].

To test this hypothesis we examined pathology results from 1340 consecutive RALPs from January 2005 to August 2008. We reviewed the incidence of SM+ with a particular focus on the posterolateral region (Fig. 1a). We determined if there was a correlation between technical modifications and the rate of PLSM+ in this cohort. Our data suggested a trend of gradual improvement in surgical results with experience, enabling us to identify several strategies before and during RALP that might help to reduce the occurrence of SM+.

PATIENTS AND METHODS

Data on patients undergoing RALP were prospectively collected through our institutional review board-approved protocol; 1340 RALPs were performed by one surgeon between January 2005 and August 2008. Variables collected included: age, body mass index (BMI), preoperative PSA level, International Index of Erectile Function survey responses, the IPSS survey responses, comorbidities, medication use, clinical staging, preoperative imaging, systematic biopsy data, intraoperative information, prostate volume, and Gleason sum on final histopathology. Final histopathology noted the presence of high-grade prostatic intraepithelial neoplasia, perineural invasion, percentage cancer in the specimen, lymph node positivity, SM status, and extraprostatic extension (EPE) of the tumour.

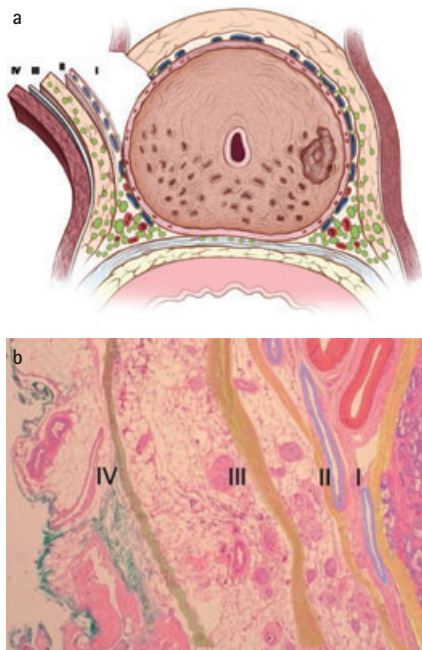
Imaging included CT and nuclear bone scintigraphy in patients who had a biopsy Gleason score of ≥ 7 , a serum PSA level of ≥ 10 ng/mL, and/or patients with clinical T3 disease. Suspicious findings were further evaluated using plain films, focused CT/MRI, and in rare cases, biopsies.

Endorectal MRI (eMRI) was performed 6–8 weeks after the biopsy; the eMRI data included: (a) size, shape and anatomical relationship of the prostate; (b) visibility of tumour, size and location, proximity to the capsule, apical involvement, breach of capsule or capsular invasion, and obvious or microscopic invasion of NVBs; (c) size, shape and location (deep vs superficial) of the seminal vesicles; (d) other findings, e.g. accessory arteries, median lobes, bladder diverticula, pelvic lymph node enlargement, length of membranous urethra [21], shape and contour of the prostatic apex, bony prominence of the pubic arch, thickness and location of the bladder neck, vesicle stones, phlebolith, periprostatic inflammation and prostatic haemorrhage.

All biopsy specimens were reviewed by our institution's Department of Pathology and Laboratory Sciences. Collected systematic biopsy data included number of sampled cores, number of positive cores, percentage of cancer on each biopsy, location of positive biopsy cores, estimated prostate volume, side-specific and site-specific cancer positivity, and Gleason score of each positive core.

Patients were selected for different types of nerve-sparing (NS) procedures (graded, see below) based on preoperative data and intraoperative findings (Figs 2,3). Patients with a PSA level of < 10 ng/mL, clinical stage T1c, Gleason sum ≤ 6 , less than a third of sampled biopsy cores positive, $< 5\%$ prostate cancer, and negative eMRI were directed to Grade I NS. Patients with a PSA level of < 10 ng/mL, T2 clinical stage, Gleason sum ≤ 6 , more than a third of sampled biopsy cores positive, 5–22% prostate cancer, and negative eMRI were directed to for Grade II NS. Patients with more than two risk factors, prostate cancer percentage $> 22\%$, more than two-thirds positive biopsy cores, a PSA level of 10–19 ng/mL, T2 clinical stage at the apex, Gleason sum ≥ 8 , and a suspicious eMRI were directed to Grade III NS. Those patients with a prostate cancer percentage $> 50\%$, clinical stage T3, Gleason sum ≥ 8 and $> 90\%$ cores positive were directed to Grade IV NS [22].

FIG. 2. *a*, Diagrammatic representation of the four regions of NS and *b*, histopathological representation of the four regions of NS.



RALP was performed using the daVinci® Surgical System (Intuitive Surgical, Sunnyvale, CA, USA). All RALPs were performed using a transperitoneal approach; our surgical technique and nerve-sparing procedure were described previously [16,22–31]. Extended pelvic lymph node dissection was carried out based on individual characteristics, such as a PSA level of >10 ng/mL, biopsy Gleason sum ≥ 8 , a palpable nodule on DRE, suspicious lymphadenopathy on radiology, and intraoperative visual feedback. We used athermal (i.e. cautery-free) [22,23,26] and trizonal [22] nerve preservation techniques to match patient risk factors with surgical planes, and made adjustments to intraoperative visual cues.

To develop intraoperative visual cues we video-recorded the RALP and correlated the anatomy and pathology, with the help of our genitourinary pathology staff (J.J.T., M.A., M.A.R. and M.S.). The intraoperative images were matched with the histopathology. Visual cues were later used in successive RALPs and the effect of technical refinements was assessed statistically.

All prostate specimens were examined by a genitourinary pathologist (J.J.T., M.A.R., M.A., M.A.S.). The right side was marked in green ink

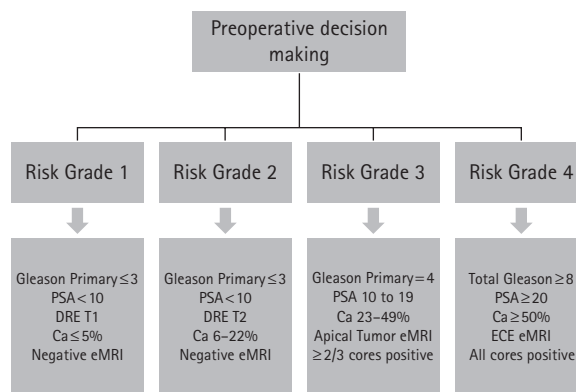


FIG. 3. Cornell algorithm for meeting competing goals.

and the left in black; specimens were serially sectioned from apex to base (Figs 1b and 4a,b). After histological examination the following data were recorded: prostate volume, histological type of cancer, primary, secondary and tertiary (if applicable) Gleason pattern, Gleason sum, pathological stage, lymph node positivity, SM+, presence of EPE, presence of seminal vesicle invasion, and presence of angiolymphatic invasion. A SM+ was noted if cancer was present at the inked margins (Fig. 1b). Its location was classified as apical, posterior, posterolateral, bladder neck, anterior, base, or multifocal; total and PLSMs are reported.

An extramural pathologist examined a random sampling of 100 RALP slides (stained with haematoxylin and eosin); findings between the extramural pathologist and the genitourinary staff were compared.

For the anatomical studies, the non-NS specimens were stained and digital pictures magnified and enhanced using Adobe Photoshop® (Adobe Systems Inc., San Jose, CA).

All data were entered in a custom database; 5% of the data were evaluated for accuracy through random chart review. The mean (SD) was calculated for variables, and were evaluated using Student's *t*-test and the chi-square test where appropriate. Univariate and multivariate regression analyses were used to determine which preoperative patient characteristics predicted PLSM+.

RESULTS

In all, 1340 patients had ≥ 3 months of follow-up and had a central pathology review

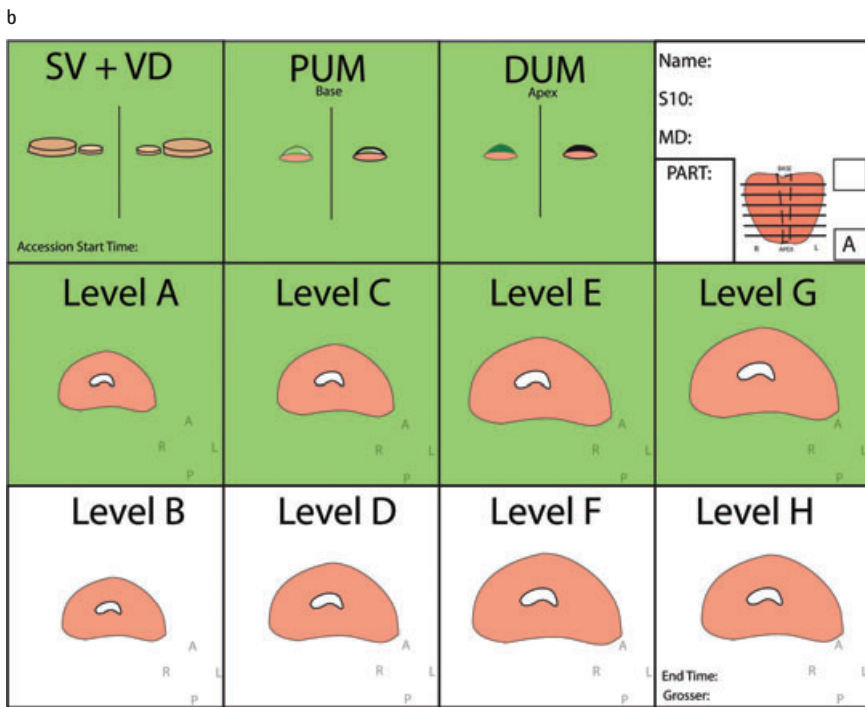
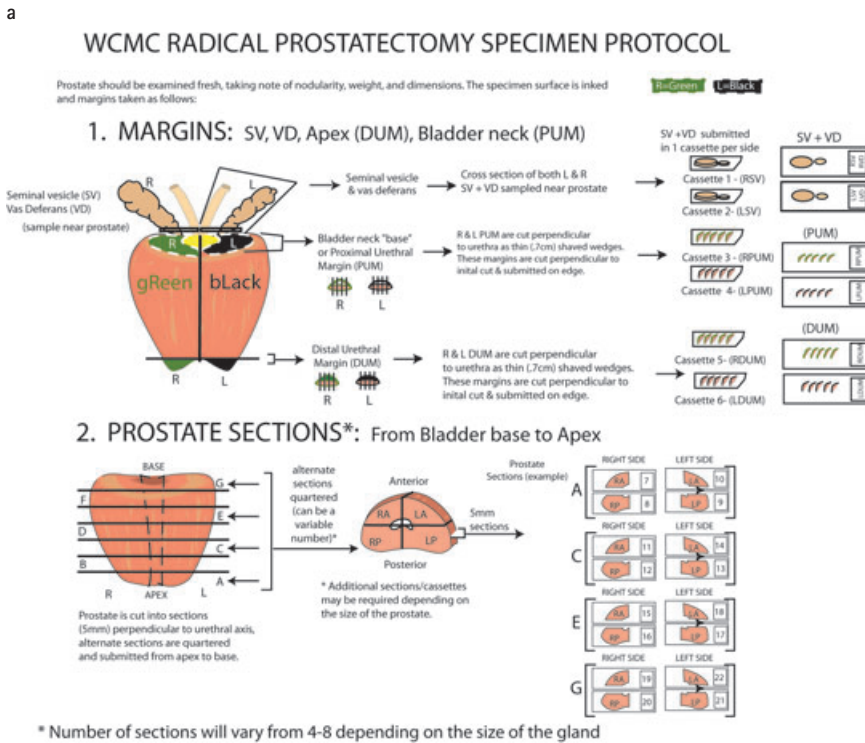
completed Table 1 summarizes the relevant demographic, oncological and histopathological data for these patients. To examine the effect of technical progression the series was stratified into the initial 500, last 500 and last 100 cases. While later cases had a higher Gleason score, a risk factor for more aggressive cancer, the PLSM+ rate in all stages gradually declined (2.6% in the initial 500 patients to 1% in the last 100).

Table 2 shows the correlations between biological factors and surgical outcomes. While the biopsy Gleason score was not significantly different between PLSM+ and PLSM- cases, the pathological Gleason score was significantly higher in patients with PLSM+ ($P < 0.05$). There was Gleason sum upgrading in patients with PLSM+ when the biopsy data were compared with pathology data. Patients with PLSM+ also had smaller prostates (43.3 vs 51.6 g, $P < 0.05$), a greater proportion of biopsy cores showing cancer (37% vs 27%, $P < 0.05$) and positive cores having a greater maximum percentage of cancer (41% vs 27%, $P < 0.05$).

Table 3 shows the results of univariate and multivariate regression analyses using preoperative predictors of PLSM+. Significant predictors of PLSM+ on univariate analysis included Gleason grade, clinical stage pT1, core positivity, maximum percentage of cancer on biopsy, and prostate volume. Multivariate analysis identified no statistically significant predictors of a PLSM+.

Table 4 shows differences in the significant variables described above in PLSM+ early in the series compared with more recent PLSM+ cases. The PLSM+ rate in the first 500 patients was 2.4% and in the last 500 was 1.4% ($P = 0.174$). The incidences of all three important

FIG. 4. (A) The RP protocol; (B) the grossing protocol.

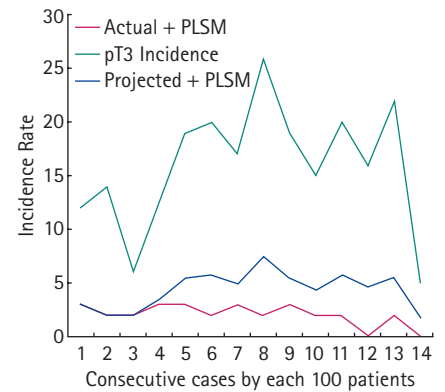


determinants of PLSM+ (i.e. prostate volume, proportion of biopsy cores positive for cancer and smaller prostates) were higher in the recent sample, in which the PLSM+ incidence was halved. This suggests that developing of

surgical learning can overcome biological factors that leave patients prone to PLSM+.

Table 5 shows the SM+ and PLSM+ rate in 100-case increments. To track the change in

FIG. 5. A plot of the incidence of pT3 disease as a function of 100 case increments and the relation to the actual and the projected PLSM+ rates.



surgical skill we assessed the incidence of PLSM+ in intervals of 100 cases and cross-referenced this with the frequency of pT3 disease (Fig. 5). This plot shows the probability of PLSM+ based on the surgeon's initial series (i.e. the first 200 patients in this graph) and adjusts corresponding to the incidence of pathological pT3 disease. The incidence of pT3 disease tended to increase as the series progressed. Assuming that the rate of PLSM+ is constant, the projected PLSM+ rate also increased. On the contrary, the actual PLSM+ rate was about half of the projected value, suggesting that intraoperative decision-making (i.e. the use of visual cues) improved.

The visual cues and surgical manoeuvres used in this series were: (a) anatomical appreciation of periprostatic (lateral prostatic) fascial compartments; (b) avoiding use of electrocautery, thus preserving the original colour and texture of tissue; (c) use of periprostatic veins as an anatomical landmark; (d) developing small pedicles and precise control whilst close to the prostate; (e) appreciating changes in texture, colour, contour and the characteristic signs of inflammation (e.g. redness, adhesions, vascularity); (f) finding the perfect bloodless plane which separates freely, showing a shiny loose areolar tissue; (g) occasionally, under vision, sharply cutting through veins and periprostatic tissue rather than forcing a plane with blunt dissection, which is more likely to produce a capsular flap at the areas of adhesion, EPE or entry of capsular arteries (Fig. 6).

Anatomical studies [29] show a clear magnified view of periprostatic tissue and

TABLE 1 Preoperative variables, baseline demographics, systemic biopsy data, pathological data, and PSA recurrence data for all patients, the first 500, last 500 and last 100 in 1340 patients

Mean (SD) or % variable	All	First 500	Last 500	Last 100	P (1 st 500 vs last 500)
Age, years	60.0 (7.2)	59.7 (6.9)	60.2 (7.4)	59.8 (7.5)	0.309
BMI, kg/m ²	26.99 (4.06)	27.42 (4.68)	27.15 (3.69)	27.32 (3.84)	0.309
PSA level, ng/mL	5.93 (4.96)	6.06 (4.80)	6.12 (6.06)	6.16 (5.6)	0.858
Max % cancer in biopsy core	26.8 (25.3)	26.4 (24.9)	27.0 (25.5)	30.7 (27.0)	0.700
% core positivity	27.4 (21.2)	28.9 (22.7)	26.0 (20.8)	26.2 (19.3)	0.04
Biopsy Gleason sum	6.43 (0.66)	6.38 (0.63)	6.49 (0.67)	6.58 (0.63)	0.01
≤6	64.0	64.4	59.4	50	
7	29.8	25.8	33.9	42	
8–10	6.3	5.8	7.0	8	
Clinical stage					0.11
T1	81.1	86	90.4	87	
T2	18.4	23	9.6	12	
T3	0.5	1.1	0	1	
Prostate volume, mL	51.4 (23.4)	53.0 (27.1)	50.8 (21.0)	51.1 (23.4)	0.17
Pathological Gleason sum	6.68 (0.08)	6.63 (0.86)	6.74 (0.90)	6.69 (1.1)	0.04
≤6	36.9	42.7	31.1	27	
7	57.4	51.3	62.9	68	
8–10	5.9	6.0	6	5	
Pathological stage	2.15 (0.43)	2.12 (0.41)	2.16 (0.43)	2.13 (0.43)	
T1-2	83.6	87.4	82.4	85.0	
PT3,4	16.4	12.6	17.6	15.0	
SM+ % (T2–T4)	9.4	7.4	9.0	7.0	0.362
PLSM+ % (T2–T4)	2.1	2.6	1.4	1.0	0.174
PSA recurrence	4.3	5.4	2.6	1.4	0.046

reveal about three compartments which could be developed by entering appropriate fascial planes during surgery (Fig. 2A,B). The first compartment is medial to the periprostatic venous plexus and lies superficial to the prostatic capsule, invested by a thin flimsy fascia (i.e. prostatic fascia). Veins, small arteries and ≈5% of the nerve fibres are located in this compartment (Fig. 2B). The second compartment lies superficial to the veins and is bounded laterally by another fascial layer (i.e. inner layers of lateral prostatic fascia). Most nerves travel in this compartment. However, the outermost compartment is clearly bound by the levator fascia, which covers the levator ani muscles.

These compartments can be entered and the appropriate planes developed if the surgeon is familiar with certain visual cues and recognises other signs of EPE, e.g. changes in colour, planar adhesion, obvious bulging, white colour of intracapsular planes and yellowing of subcapsular and transcapsular glands.

Our NS procedure was grouped into four grades (Figs 2,3,6 (<http://www.youtube.com/>).

Mean (SD) or % variable	PLSM–	PLSM+	P
No. of patients	1311	29	
Age, years	60.1 (7.16)	58.3 (8.53)	0.267
PSA level, ng/mL	5.90 (4.96)	7.05 (4.83)	0.201
Biopsy Gleason sum	6.43 (0.65)	6.69 (0.89)	0.13
≤6	64.2	51.7	
7	29.7	34.5	
8–10	6.1	13.8	
Clinical stage	1.19 (0.39)	1.50 (0.61)	0.03
1	81.8	55	
2	17.8	40	
3	0.4	5	
Core positivity	27.2 (21.1)	37.2 (23.0)	0.032
Max % in biopsy	26.5 (25.1)	40.7 (29.6)	0.02
Prostate volume, mL	51.6 (23.5)	43.3 (14.4)	0.005
BMI, kg/m ²	27.0 (4.06)	26.9 (4.25)	0.904
NS, %	1.47 (0.94)	1.51 (1.15)	0.829
Yes	85.2	82.8	
No	14.8	17.2	
T stage			
T1–T2	84.4	51.7	
T3–T4	15.6	48.2	
Pathology Gleason sum	6.67 (0.88)	7.03 (0.90)	0.044
≤6	37.1	24.1	
7	57.3	62.1	
8–10	5.7	13.8	
% Cancer	8.7 (9.31)	16.11 (11.4)	0.088
PSA recurrence	4.0	20.8	0.05

TABLE 2

Variables before and after RALP, comparing patients with PLSM– vs PLSM+

Variable	B	P	Exp(B)	95% CI
TABLE 3				
<i>Univariate and multivariate analysis for predicting PLSM+ based on preoperative characteristics</i>				
Univariate				
Age	-0.035	0.182	0.966	0.918–1.016
BMI	-0.006	0.899	0.994	0.907–1.09
Pre-op PSA level (log)	0.468	0.138	1.596	0.861–2959
Core positivity %	0.018	0.017	1.018	1.003–1.033
Max % biopsy	0.018	0.005	1.018	1.005–1.031
Prostate volume (log)	-1.329	0.022	0.265	0.085–0.824
Biopsy Gleason sum				
6	-1.827	0.021	0.161	0.034–0.756
7	-1.464	0.071	0.231	0.047–1.135
8	-1.237	0.232	0.29	0.038–2.208
Clinical stage				
T1	-2.884	0.016	0.056	0.005–0.581
T2	-1.674	0.167	0.188	0.017–2.012
Multivariate				
Age	-0.043	0.254	0.958	0.890–1.031
BMI	0.022	0.653	1.022	0.930–1.124
Pre-op PSA (log)	0.26	0.522	1.297	0.585–2.872
Core positivity %	0.019	0.093	1.019	0.997–1.042
Max % biopsy	0.002	0.873	1.002	0.981–1.023
Prostate volume (log)	-0.564	0.489	0.563	0.115–2.812
Gleason sum total		0.981		
Clinical stage		0.157		

watch?v=DK260H2mdt8)). Grade I NS involves dissection of the plane between the prostatic capsule and periprostatic veins. Grade II NS involves dissection of the plane between the periprostatic veins and the inner layer of the lateral pelvic fascia. Grade III (incremental) NS involves dissection of the plane between layers of the lateral prostatic fascia farther from the venous arcade. Grade IV NS involves excision of a segment or a complete length of neurovascular tissue. In some cases, the resultant gap was bridged by primary anastomosis of the neurovascular tissue [30].

DISCUSSION

We examined how experience in NS RALP influenced the rate of PLSM+ in patients with clinically localized prostate cancer. This study addresses an important concern about the lack of tactile feedback in robotic surgery that could potentially increase SM+ rates. Our data clearly show that this phenomenon does not occur, as patients with pT2 and pT3 cancers had an initial 2% PLSM+ rate, which decreased to 1% with increased surgical experience. We credit this rate to the use of targeted protocols for oncological efficiency, a careful appreciation of anatomical planes, and judicious use of visual cues during robotic surgery. We believe that there is a theoretical basis for this visual compensation, using arguments from research involving sensory integration [13].

The role of planning is especially critical, as the use of NS has several consequences related to the short-term oncological efficiency of the surgery and long-term sexual function outcomes. In addition, various grades of NS are possible [32]. It is possible to either resect a small segment of the neurovascular tissue and repair the gap by primary anastomosis [33], or shave off the medial aspect of neurovascular tissue (i.e. incremental NS) to meet the most important goal of surgery, i.e. the complete excision of the tumour.

We adopted several techniques for presurgical planning during the course of the study that might have influenced these outcomes. Before surgery a detailed oncological map is created for each patient and real-time access to eMR images is provided during surgery. In addition, patients have a thorough DRE while they are anaesthetized, and suspicious zones are highlighted, thereby enabling surgical

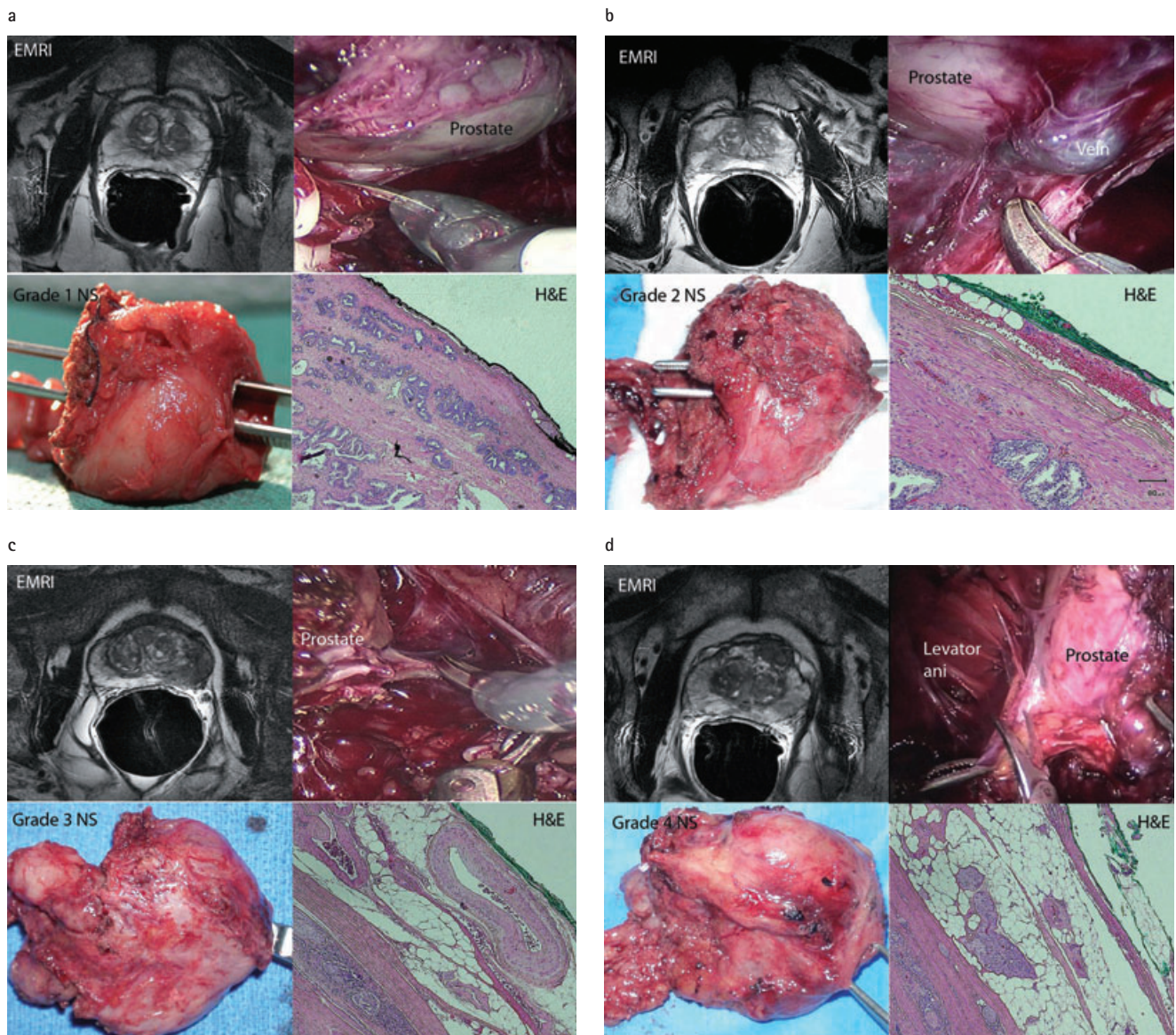
TABLE 4 Changes in PLSM+ rates and the effect of the integrated programme

Mean (SD), % or n/N variable	PLSM+				P (1 st 500 vs last 500)
	All	First 500	Last 500	Last 100	
No. of patients	29	13	7	1	
Age, years	58.3 (8.53)	59.4 (11.57)	58.9 (4.67)	59	0.877
BMI, kg/m ²	-	25.9 (2.75)	29.7 (5.55)	25.8	0.130
PSA level, ng/mL	7.1 (4.83)	6.4 (2.94)	7.9 (7.18)	1.1	0.626
Max % cancer in biopsy core	40.7 (29.6)	32.7 (25.3)	52.1 (33.0)	5	0.213
Core positivity %	37.2 (23.0)	40.3 (29.7)	98.2 (10.9)		0.824
Gleason sum biopsy	6.69 (0.89)	6.46 (0.88)	7.42 (0.97)	6	0.050
≤6	51.7	9/13	1/7	1/1	
7	34.5	3/13	3/7	0	
8–10	13.8	1/13	3/7	0	
Clinical stage	1.50 (0.61)	1.52 (0.66)	1	1	0.012
T1	55	6/13	7/7	1/1	
T2	40	5/13	0	0	
T3	5	1/13	0	0	
Prostate volume, mL	43.3 (14.4)	46.4 (17.4)	42.1 (10.2)	26.4	0.493
Pathology Gleason sum	7.03 (0.90)	6.77 (0.83)	7.75 (1.07)	7	0.04
≤6	24.1	5/13	0	0	
7	62.1	7/13	4/7	1/1	
8–10	13.8	1/13	3/7	0	
Pathological stage	2.51 (0.57)	2.38 (0.65)	2.57 (0.53)	2	0.501
T1-T2	51.7	9/13	3/7	1/1	
T3-T4	48.2	4/13	5/7	0	
PSA recurrence, %	20.8	4/13	1/7	0	0.08

TABLE 5 The change in SM+ and PLSM+ rate as a function of each 100 consecutive patients (values are rounded to the nearest integer)

Variable, %	Groups of 100 cases														All
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	Last 40	
T2 rate	87	85	93	88	80	79	83	73	81	85	80	84	75	95	83
T3 rate	12	14	6	12	19	20	17	26	19	15	20	16	22	5	16
SM+ rate	7	5	7	9	9	11	10	18	13	7	12	7	12	0	10
SM+ in pT2	5	4	6	7	6	4	5	12	10	6	9	6	8	0	6
SM+ in pT3	23	14	17	25	21	40	35	35	28	13	25	13	27	0	25
PLSM+ rate	3	2	2	3	3	2	3	2	3	2	2	0	2	0	2
PLSM+ rate in pT2	2	2	2	3	0	1	0	0	4	0	1	0	1	0	1
PLSM+ rate in pT3	8	0	0	0	18	5	19	8	0	13	5	0	5	0	6

FIG. 6. eMR images, intraoperative view, gross specimen and correlation from haematoxylin and eosin-based anatomy of (a) Grade I NS, (b) Grade II NS, (c) Grade III NS, and (d) Grade IV NS.



planes to be chosen for the right and left side and zones of the prostate. The anterior prostate is inaccessible to DRE, so we rely on eMRI data to recognise these tumours. Finally, patients are divided into four groups based on the risk of EPE (Fig. 3).

Despite of having several clusters of high pT3 cancers, our PLSM+ rate was below the projected rate. We attribute this to modifications of surgical technique in consecutive cases, including adapting to visual cues.

In reports of open RP the effect of individual surgical technique has emerged as one of the most important drivers of oncological outcomes. Studies by Swindle *et al.* showed that positive margin and PSA recurrence rates vary significantly between surgeons and are influenced by the use of specific techniques during retropubic RP. This analysis also showed that a major risk factor for a SM+ included surgical volume. Our study differs in that it involves many consecutive patients under the care of one surgeon to examine the effect of changing surgical experience and technique.

What is the implication of the lack of touch in robotic surgery and can a surgeon compensate for the lack of touch with magnified vision? William Molyneux, the 17th century philosopher, posed a similar question to John Locke, in a letter. He asked, 'Do the senses talk to each other?' Molyneux wondered whether a man born blind was able to touch and differentiate between a cube and a sphere. Louis Braille later answered in the affirmative in 1821, when he invented a written language for the blind [12,13,34].

In an analogous way, we are asking whether stimuli of one sensory channel, i.e. vision, affect stimulation in another sense, e.g. touch. Is the 'reverse Braille phenomenon' possible for robotic surgeons who see the colour of tissue, contours of the surface, separate planes between tissue layers, and grasp (and cut) structures between the jaws of forceps and scissors? We contend that the answer is yes. Having felt tissue during open surgery, the mind remembers the feel, and vision that is greatly enhanced through the robot compensates for the lack of tactile information. The sensory motor system fills in the gaps and gives a complete experience, which enables the performance of various

surgical steps without missing tactile feedback [12,13,34].

There are several limitations to the present study, including its single-centre design, specialized tertiary-care setting, and lack of randomization with other surgical methods. While these shortcomings are significant, they do not undermine the findings that an experienced robotic surgeon can achieve excellent cancer control and compensate for the lack of tactile feedback by relying solely on visual cues. Ideally, a randomized study involving multiple surgeons with varying levels of surgical experience and performing both open and minimally invasive surgery should be conducted. The present study sheds some light on this important medical dilemma. Tactile feedback is not necessary to prevent SM+. Some open surgeons have also suggested that intraoperative tactile feedback is not very accurate in staging [35]. Another shortcoming of this study is the focus on PLSM+. Other SMs, e.g. apical and multifocal margins, might be equally important in promoting oncological safety. Finally, we feel that a discussion of postoperative functional outcomes is beyond the scope of this study.

In conclusion, our study highlights how surgical experience, planned staging and the appreciation of periprostatic anatomy, are all significant in reducing PLSM+ rates. Furthermore, we show that the lack of tactile feedback in RALP does not increase the incidence of PLSM+.

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CONFLICT OF INTEREST

None declared.

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- Abbreviations:** RALP, robotic-assisted laparoscopic radical prostatectomy; RP, open radical prostatectomy; NVB, neurovascular bundle; (PL)SM, (posterolateral) surgical margin; EPE, extraprostatic extension; NS, nerve sparing; BMI, body mass index; eMRI, endorectal MRI.