

Anatomical retro-apical technique of synchronous (posterior and anterior) urethral transection: a novel approach for ameliorating apical margin positivity during robotic radical prostatectomy

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OBJECTIVE

To describe a novel synchronous approach to apical dissection during robotic-assisted radical prostatectomy (RARP) which augments circumferential visual appreciation of the prostatic apex and membranous urethra anatomy, and assess its effect on apical margin positivity.

PATIENTS AND METHODS

Positive surgical margins (PSM) during RP predispose to earlier biochemical recurrence, and occur most frequently at the prostatic apex. Conventional apical transection after early ligation of the dorsal venous complex (DVC) remains suboptimal, as this approach obscures visualization of the intersection between prostatic apex and membranous urethra, leading to inadvertent apical capsulotomy and eventual margin positivity.

A synchronous urethral transection commenced via a retro-apical approach was adopted in 209 consecutive patients undergoing RARP by one surgeon (A.T.) between April to September 2009. The apical margin rates for this group were compared with those of 1665 previous patients who received conventional urethral transection via an anterior approach after DVC ligation. Outcomes were adjusted for differences in clinicopathological variables. All RP specimens were processed according to institutional protocols, and examined by dedicated genitourinary pathologists. The location of PSMs was identified as apex, posterior, posterolateral, bladder neck, anterior, base, or multifocal.

RESULTS

Patients receiving synchronous urethral transection had significantly lower apical PSM rates than the control group (1.4% vs 4.4%, $P=0.04$). This marked improvement in the retro-apical group occurred despite a significantly higher incidence of aggressive

cancer ($\geq pT3a$) documented on final specimen pathology (16% vs 10%, $P=0.027$). Technical difficulty was encountered in three of 209 study patients, in whom urethral transection had to be completed using the classic anterior approach.

CONCLUSION

Improved circumferential visualization of the prostatic apex, membranous urethra and their anatomical intersection facilitates precise dissection of the apex and its surrounding neural scaffold, and optimizes membranous urethral preservation. This has significantly ameliorated apical PSM rates in patients undergoing RARP, despite having to deal with more aggressive cancer on final specimen pathology.

KEYWORDS

prostate, cancer, margin, apex, robotic, prostatectomy, retro-apical, urethra

INTRODUCTION

Many patients with prostate cancer choose to undergo radical prostatectomy (RP); it is safe

and effective, but in a few cases it is unsuccessful at completely removing the cancer, with patients having positive surgical margins (PSMs) on final specimen pathology.

PSMs double a patient's risk of cancer recurrence [1,2], which requires either radiation treatments or hormones. Apart from being expensive propositions [3], such

treatments are also psychologically distressing for the patient who has already undergone radical surgery.

The probability of PSMs is greatest at the prostatic apex, which remains the 'Achilles heel' of prostate cancer surgery. At this location, the prostate subtly merges with the urethral sphincter complex and the urethra, and it is difficult to distinguish these structures. While several modifications and technical refinements have been made to prostate cancer surgery [4–13], including the use of a robotic platform [14–18], apical PSMs continue to be a recurring adverse outcome. Apical PSMs occur primarily because the surgeon cannot differentiate between prostatic tissue, the dorsal venous complex (DVC), and the urethral sphincter. The imperceptible transition from prostate to urethra makes recognition challenging, as does the lack of a formal prostatic capsule at this location. Also, because extraprostatic extension (EPE) at the apex is usually microscopic, surgeons cannot recognize it by feel or by magnification. To locate the junction amidst the ever-changing configurations of apical shapes and beaks, a surgeon must cut through the DVC (the pearly white layer of veins, fat, ligaments and smooth and skeletal muscle fibres). Because it is difficult to judge the thickness of this tissue, small sections of the prostatic apex can remain after surgery. PSMs at the apex can be a result of this scenario. To compensate for poor visualization of the apical junction, surgeons can deliberately cut far from the prostate into the urethra and sphincter, but this approach often results in intrinsic sphincter deficiency, significantly delaying the return of continence [19].

In our institution, histopathology slides from patients with PSMs are reviewed monthly by a multidisciplinary team comprising the surgical scrub team, and an experienced genitourinary radiologist and pathologist. During these virtual surgical sessions, areas of margin positivity are correlated against preoperative MRI prostate images and relevant intraoperative videotape of the patient's surgery, to identify technical steps that might be improved to ameliorate recurrence in future cases. It became increasingly evident that the posterior prostatic apex is covered only by Denonvilliers' fascia (DF) and the rectourethralis muscle, so this afforded a much clearer path to the apex.

We thus developed a retro-apical approach to the apical junction, using a 30° upward-facing lens for optimally visualizing the transition of the prostatic apex into membranous urethra. We found this novel approach afforded ample space to complete the posterior dissection and nerve-sparing, followed by sharp transection of the membranous urethra. This renders the prostate fully mobile, attached anteriorly by only the DVC, anterior fibromuscular stroma and the puboprostatic ligaments. We then switch to a 0° degree lens and transect the DVC anteriorly. Haemostasis is achieved with caudal traction using an inflated Foley balloon (inflated behind the prostate through the open urethra lumen) whilst the anterior anchoring tissue is cut. This synchronous technique of urethral transection was adopted in 209 consecutive cases. We compared its effect on apical PSMs against those of our previous 1665 consecutive cases (during which our approach to urethral transection was primarily an anterior one).

PATIENTS AND METHODS

We postulated that better visualization of the apical-urethral junction facilitates more accurate urethral transection and results in lower apical PSM rates. In brief, our technique of synchronous (posterior followed by anterior) urethral transection diverges from the conventional anterior approach which involves early suture ligation of the DVC followed by sharp dissection through the bunched tissue to identify an often obscured apical-urethral junction. The postulated benefits of this novel approach include: (i) precise release of the retro-apical nerves during posterior apical dissection; (ii) accurate identification of the membranous urethra and its intersection with the prostatic apex, thereby preserving maximum urethral length and thickness for optimizing early return of continence; (iii) reducing accidental capsulotomy into the prostatic apex; and (iv) obviating the risk of rectal injury from an anterior approach.

Our technique of synchronous urethral transection was adopted in 209 consecutive patients undergoing robotic-assisted (RA) RP (RARP) by one surgeon (A.T.) between April and September 2009. The apical PSM rates for this group were compared to those of 1665 previous patients who received conventional urethral transection via an anterior approach after DVC ligation. Outcomes were adjusted

for differences in clinicopathological variables.

The specific details of our approach to RARP, with emphasis on technical manoeuvres for optimizing early return of continence [20–22], and balancing aggressiveness of nerve-sparing whilst ensuring complete extirpation of cancer, were described previously [23–27]. The technique highlighted in the present study focuses on synchronous retro-apical urethral transection and management of the DVC.

After transecting the bladder neck, we identify the vas deferens and seminal vesicles behind the retrotrigonal layer [28]. The seminal vesicles and vas deferens are enveloped in a fascial compartment (part of DF) made of loose areolar tissue, veins, arteries, lymphatics and some fat. Each seminal vesicle has its own compartment and most of the blood supply enters near the tip and anterolateral aspect. Lateral to this compartment and near the tip lies the proximal neurovascular plate, which is part of the inferior hypogastric plexus [24–26]. This spatial relationship has profound implications for our nerve-sparing technique because the crucial neural tissue can be damaged (or avulsed) by heat, crushing, and the torque of traction during seminal vesicle dissection. However, most of the medial wall of a seminal vesicle [24] lies adjacent to a nearly avascular space. This medial avascular plane serves as a safe starting point for lateral dissection of the seminal vesicles. We then mobilize the vasa deferentia and clip the proximal end behind the trigone. The transected distal ends of the vasa deferentia are grasped by the left-side assistant (the fourth robotic arm) and pulled anteriorly, tenting the DF occupying the retroprostatic space. This fascia is incised in the midline and the opening is enlarged laterally toward the medial edge of the pedicles. The under surface of the prostate is identified and a plane is developed within the layer of DF (Fig. 1). A cave-like space is created behind the prostate and dissection is deliberately extended distally to release the apex and the urethra from deeper tissue.

Next, we release the neurovascular tissue using both our trizonal-neural-hammock-release technique (Fig. 2) and our athermal approach [24,26,27]. We use sharp athermal dissection of the prostatic pedicles, controlling arteries and veins with Hem-O-Lok® clips (Teleflex Medical Inc, Research

FIG. 1. The surgical plane is developed within the layer of DF, creating a cave-like space behind the prostate.

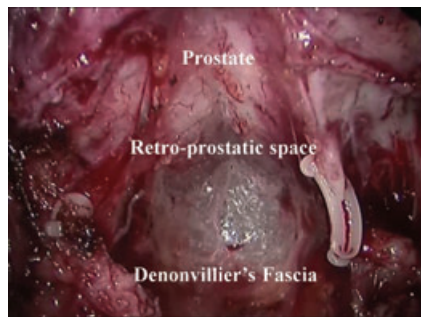
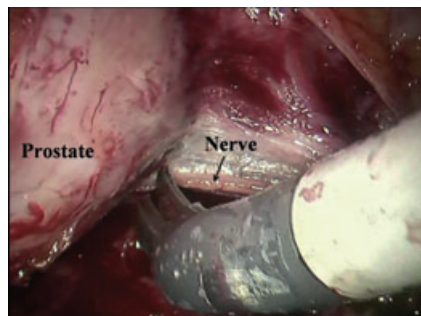


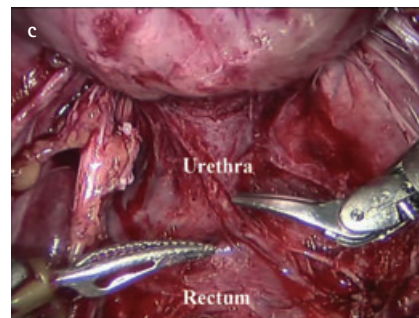
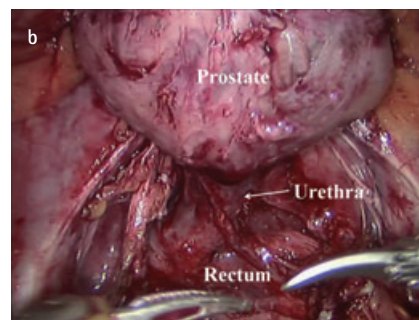
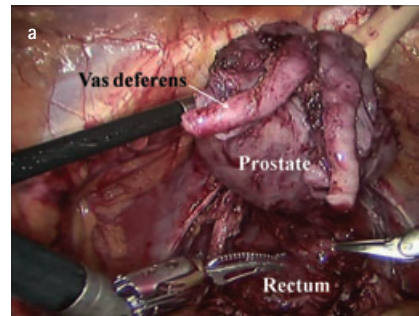
FIG. 2. Nerve-sparing using our trizonal-neural-hammock-release technique.



Triangle Park, NC, USA) as they enter the prostatic base. The prostate is then completely freed posterolaterally on either side. At this point it is quite mobile and is lifted anteriorly towards the anterior abdominal wall and pubic symphysis (Fig. 3a). This action opens the space behind the urethra and apex, and twists and angles the DVC, thus temporarily occluding it.

We now change to a 30° upward-facing lens for the retro-apical approach to the apical-urethral junction. Care is taken in navigating the lens directly behind the prostate without having it smudged by the bladder or the under surface of the prostate (Fig. 3b). Once positioned at the perfect vantage point, there is a surprising level of clarity with which the glistening white surface of apex can be differentiated from the membranous urethra. The transition from prostatic apex into urethra is further appreciated by manipulating the 20 F Foley catheter in and out of the urethra apical junction. Here, the prostate has few layers of DF covering its posterior surface, and the membranous

FIG. 3. (a) Prostate retracted anteriorly by the left assistant. (b) Posterior dissection down to prostatic apex. (c) Close-up view of apical-urethral junction and membranous urethra as seen from retro-apical approach.



urethra is posteriorly supported by the rectourethralis muscle (Fig. 3c).

Using sharp, curved scissors we then dissect the superficial layers of the DF and expose the precise prostate-urethral junction. Next, the posterior hemicircumference of the urethra is sharply incised 1 mm distal to the apex (Fig. 4). The Foley catheter is exposed and positioned with its tip at the distal urethral opening (Fig. 5). This permits appreciation of the anterior urethral hemicircumference, with urethral mucosa and muscular wall being seen clearly (Fig. 6). Using blunt and sharp dissections, the urethra is divided circumferentially (Fig. 7). At this point all the muscle fibres are transected and the DVC is

FIG. 4. The posterior wall of the urethra is sharply incised 1 mm distal to the apex



FIG. 5. Foley catheter is exposed and withdrawn through the posterior urethral opening.

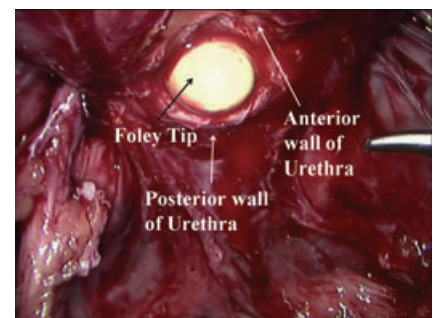
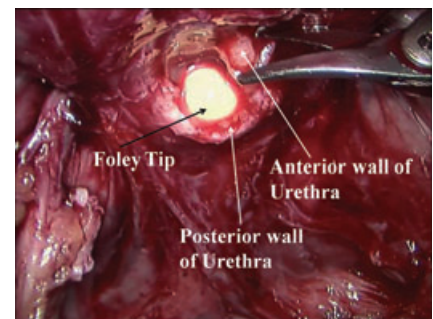


FIG. 6. The anterior wall of the urethral mucosa and the muscular wall exposed.



left attached to the anterior surface of the prostate (Fig. 8).

Management of the DVC now depends on the width and thickness of the anterior tissue. If it is broad and thick, we ligate the DVC using a CT-1 needle and an O-polyglactin suture using a slip knot (Fig. 9). However, if the remaining tissue is thin, we increase the pneumoperitoneum to 20 cmH₂O pressure, and inflate the Foley

FIG. 7. Circumferential transection of the membranous urethra via retro-apical approach.

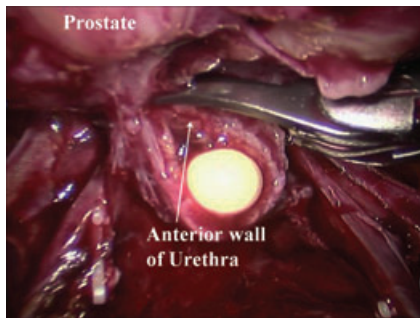


FIG. 8. Urethral stump seen after prostate mobilized.

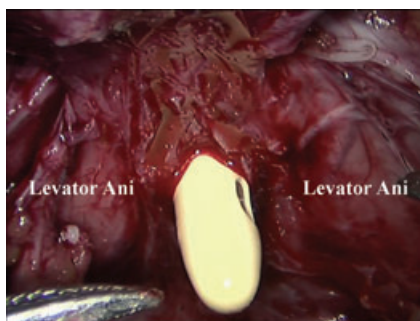


FIG. 9. DVC control using DVC suture ligation.

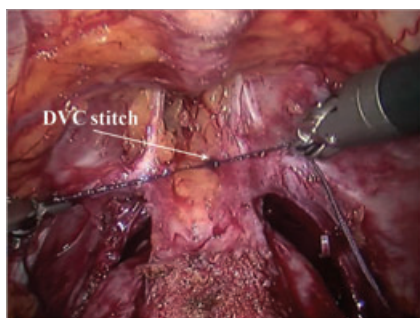


FIG. 10. DVC control using caudal Foley balloon traction.

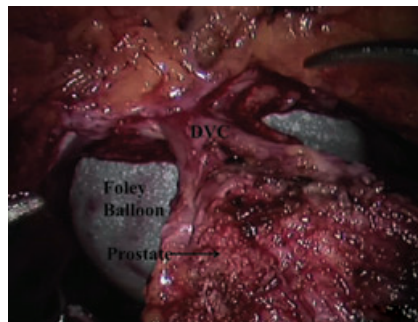


FIG. 11. DVC transection continued anteriorly using sharp scissors.

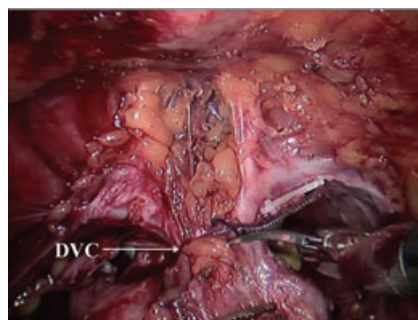


FIG. 12. Sharp athermal transection through the DVC venous sinuses.

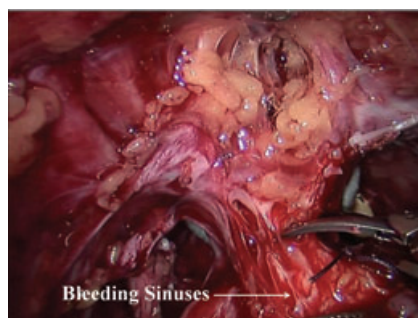


FIG. 13. Hood of ligaments and venous tissue still on the prostatic apex.

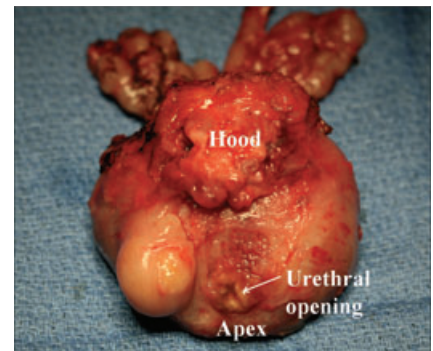


FIG. 14. The pubo-prostatic ligaments and arcus tendineus are preserved for later reconstruction.

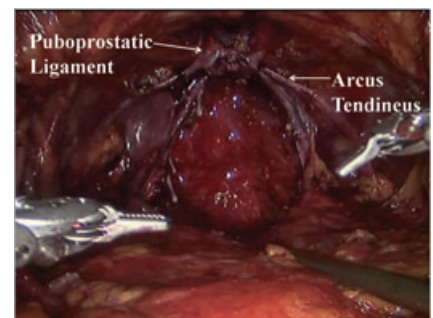
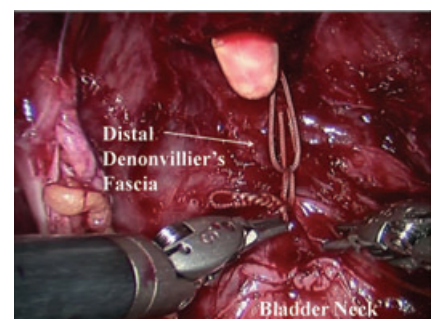


FIG. 15. Posterior reconstruction of Denonvilliers' musculofascial plate.



catheter balloon to 30 mL behind the prostate (Fig. 10). The Foley balloon is placed on caudal traction, resulting in partial occlusion of the DVC and developing the space behind the prostate.

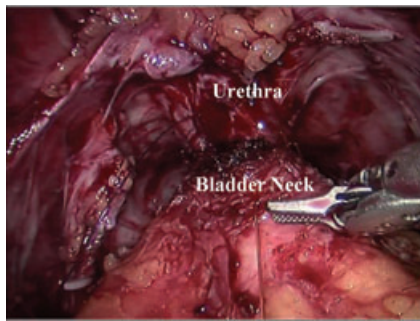
The lens is now changed to 0° and prostatic apical dissection is continued anteriorly. The prostate is retracted cephalad by the left assistant grasping the seminal vesicles and distal ends of the transected vasa deferentia. Using robotic Maryland dissectors on the left

arm, the anterior tissue is grasped between its two jaws to ensure that only venous tissue and some parts of the ligaments are gripped (Fig. 11). We sharply cut distally to the grip, and can see the sharp scissors cutting through the venous sinus (Fig. 12). Bleeding is minimal due to the inflated balloon under traction or suture if the DVC is thick and wide. The prostate is freed with a 1-mm hood of ligaments and venous tissue still on the prostatic apex (Fig. 13). Care is taken in preserving the pubo-prostatic ligaments and

arcus tendineus for later reconstruction (Fig. 14) [29–31].

Once the prostate is freed, we perform a lymph node dissection and place this specimen in a laparoscopic entrapment bag. The DVC is oversewn robotically with a 0-polyglactin suture if this has not already been done. Care is taken to avoid including the sphincter, urethra and deeper nerves. This is followed by posterior reconstruction of Denonvilliers' musculofascial plate (Fig. 15),

FIG. 16. Completed vesico-urethral anastomosis.



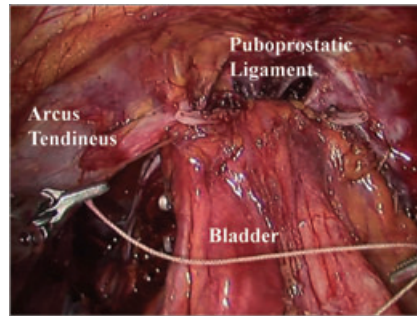
construction of the vesico-urethral anastomosis (Fig. 16), anterior reconstruction of the arcus tendineus and puboprostatic ligaments (Fig. 17), before completing surgery.

All RP specimens were processed according to institutional protocols, and examined by dedicated pathologists with significant experience in genitourinary pathology (J.T., M.S.). Routinely, the right side of the prostate is marked in green ink and the left in black, and specimens serially sectioned from apex to base. After histological examination, the following variables were reported: prostate volume, histological type of cancer, primary Gleason pattern, secondary Gleason pattern, total Gleason score, pathological stage, lymph node positivity, SM positivity, presence of EPE, presence of seminal vesicle invasion, and presence of angiolymphatic invasion. A PSM is reported when cancer is present at the inked margins, and the PSM location identified as apical, posterior, posterolateral, bladder neck, anterior, base, or multifocal. Gross RP specimens were also photographed to improve appreciation of variations in prostate apical anatomy.

To ameliorate interobserver variability in Gleason sum reporting, 182 consecutive RP specimens were previously externally reviewed by an experienced off-site genitourinary pathologist (M.A.). After establishing a concordance rate of 89% between our in-house and off-site pathologists' reports, external validation was discontinued for financial prudence.

The following variables for each patient undergoing RARP in our programme are routinely entered into a Health Insurance Portability and Accountability Act compliant institutional database under an institutional

FIG. 17. Reconstruction of anterior puboperineal collar.



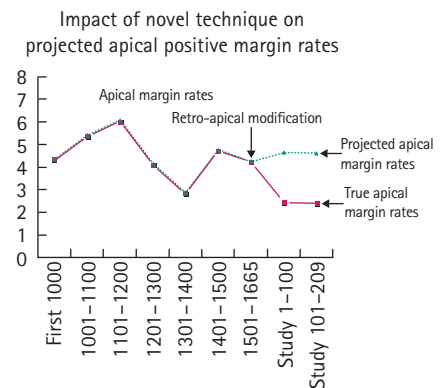
review board-approved protocol: patient age, body mass index, preoperative PSA level, International Index of Erectile Function, IPSS, comorbidities, medication use, clinical staging and preoperative imaging, systematic biopsy data, intraoperative information, prostate volume, Gleason score on the final histopathology, high-grade prostatic intraepithelial neoplasia, perineural invasion, percentage of cancer in specimen, lymph node positivity, SM status, and EPE of tumour. Results were assessed using univariate and multivariate analysis.

RESULTS

Table 1 summarizes the clinicopathological profiles of patients in both the retro-apical (209) and control groups (1665), the latter receiving conventional anterior urethral transection after DVC ligation. Patients receiving anatomical retro-apical urethral transection had significantly lower apical PSM rates than the control group (1.4% vs 4.4%, $P = 0.04$). This marked improvement in the retro-apical groups occurred despite a significantly higher incidence of aggressive cancer ($\geq pT3a$) documented on final specimen pathology (16% vs 10%, $P = 0.027$). In three of the 209 most recent cases in the retro-apical group, retro-apical dissection could not be done safely due to challenging body habitus, local anatomy and a large prostate. In these instances, dissection was completed using the conventional anterior approach. One of these three patients had PSMs. Nonetheless, this patient's data were included in the retro-apical group results, as we used an intent-to-treat analysis for this study.

Table 2 summarizes the data on apical PSMs for the two groups; all clinical and

FIG. 18. Projected (green) and actual (red) apical PSM rates after incorporating the anatomical retro-apical technique for urethral transection.



pathological variables were comparable in both these groups, with no significant differences. Figure 18 illustrates the effect that the development of the surgical technique had on apical PSM rates. An actuarial model was created based on data averages from the initial 1665 patients, using both true and projected apical PSM rates from this initial group. Apical PSM rates were significantly reduced in the retro-apical group after incorporating our anatomical retro-apical technique for urethral transection.

Table 3 summarizes the findings of univariate and multivariate analysis for predictors of apical PSM rates. The preoperative serum PSA level, the percentage of positive cores (positive cores/total sampled cores) and the retro-apical technique were all significant factors in predicting whether or not a patient will have apical PSMs.

DISCUSSION

Complete clearance of cancer at the of the prostatic apex remains technically challenging for several reasons: (i) the apex is the narrowest part of the prostate, and so cancer is never too far from the surface; (ii) there is an imperceptible transition between prostate glandular tissue (often containing cancer) and the sphincteric muscle; (iii) unlike other parts of the prostate gland, the apex lacks a true and well-defined capsule; (iv) the anterior part of the apex is covered with large veins intermingled with fibromuscular stroma, making it difficult to identify the precise junction between the apex and the

TABLE 1 Preoperative variables, baseline demographics, systemic biopsy and pathological data, comparing all patients, control and retro-apical group

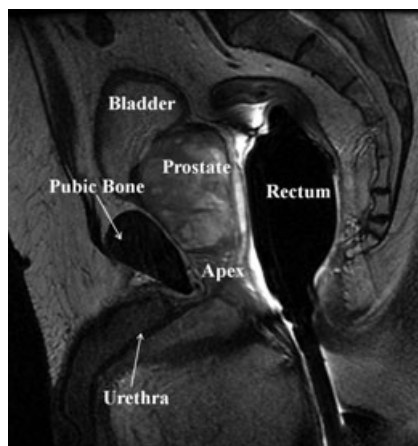
Mean (SD), median (IQR) n/N (%) or % variable	All (1874)	Control (1665)	Retro-apical (209)	P
Age, years	59.87 (7.13)	59.91 (7.16)	59.53 (6.89)	0.460
Body mass index, kg/m ²	27.00 (3.97)	27.00 (3.97)	27.05 (4.03)	0.851
PSA level, ng/mL	5.85 (4.92)	5.90 (5.03)	5.44 (3.99)	0.206
Max percentage cancer in biopsy core	27.59 (25.80)	27.43 (25.68)	28.86 (26.73)	0.453
Core positivity, %	25.74 (29.07)	25.42 (21.56)	28.29 (62.36)	0.511
Biopsy Gleason score				0.065
≤6	61.8	62.6	55.5	
7	31.6	30.7	38.7	
8–10	6.5	6.5	5.7	
Clinical stage				0.777†
T1	87.9	87.9	88.0	
T2	11.9	11.9	12.0	
T3	0.21	0.24	0	
Prostate volume, mL	46.0 (38.0–58.0)	46.0 (38.0–58.0)	46.0 (37.0–56.0)	0.292
Final pathology				0.095
Gleason score				
≤6	33.9	34.8	27.3	
7	60.1	59.3	66.5	
8–10	5.9	5.8	6.2	
Pathology stage				0.027
T2	84.6	83.9	89.8	
T3,T4	15.4	16.1	10.2	
Overall PSM rate, % (pT2–pT4)	9.3	9.8	5.3	0.032
Apical PSM (whole group)	4.1	4.4	1.4	0.040
Apical PSM (pT2)	53/1571 (3.4)	52/1386 (3.8)	1/185 (0.54)	0.016*
Apical PSM (pT3 + pT4)	24/276 (8.7)	22/255 (8.6)	2/21 (9.5)	0.691*

*Fisher's exact test. Two cells had an expected count of <5 (the minimum expected was 45).

urethra; (v) the apex is the one part of the prostate where a cancer-prone peripheral zone wraps around anteriorly, thus bringing cancer close to the surface [32–34]; (vi) the apex is the most inaccessible part of the prostate, wedged deep in the human bony pelvis beneath the pubic arch (Fig. 19) and DVC, packed tightly between the rectum, nerves, blood vessels and sphincter; (vii) the apex is surrounded by a cavernous mesh-work of veins which is very prone to bleeding (torrential bleeding from poor vascular control can quickly obscure vision of the operative field and impairs precise apical dissection); and (viii) considerable surgeon experience in appreciating the myriad configuration of the prostatic apex (beaks and protrusions) is required to identify the correct plane of dissection.

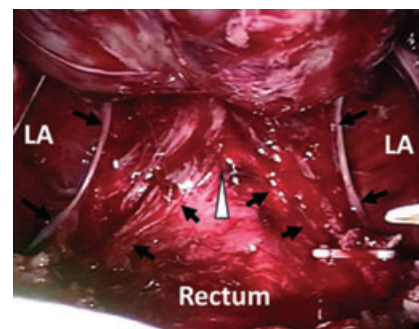
In addition, balancing cancer clearance with good functional outcomes is very difficult during apical dissection with little latitude either way. The prostatic apex comprises the

FIG. 19. Sagittal view of preoperative MRI showing relationship of prostate apex and urethra.



final common pathway for exit of the erectogenic nerves to the penile tissue (and is where these nerves come closest to the prostate) (Fig. 20). Optimizing membranous

FIG. 20. Sexual nerves are at risk as they converge close to the urethra at this location.



urethral length has been shown to correlate with the early return of continence [35]. As such, there is little room for wide excision at the apical urethral junction without ultimate compromising sexual and urinary function. Finally, obesity and large prostates also present technical challenges for surgeons in finding an optimal plane of dissection.

TABLE 2 The clinicopathological profile of all patients with PSMs

Mean (SD), median (IQR) or % variable	Control	Retro-apical	P
Age, years	60.65 (8.11)	54.00 (12.49)	0.454
PSA level, ng/mL	8.69 (11.09)	6.70 (5.60)	0.612
Biopsy Gleason score			0.424*
≤6	62.2	33.3	
7	29.7	66.7	
8–10	8.1	0	
Clinical stage			1.000*
1	89.2	100	
2	10.8	0	
3	0	0	
Core positivity, %	34.42 (22.11)	46.02 (26.48)	0.302
Maximum % cancer in biopsy core	32.45 (26.50)	51.00 (37.59)	0.484
Prostate volume, mL	48.36 (18.61)	42.00 (10.54)	0.409
Body mass index, kg/m ²	26.54 (3.69)	28.30 (3.46)	0.418
T stage, % in group			0.228*
T1–T2	70.3	33.3	
T3–T4	29.7	66.7	
Pathological Gleason score, % in group			1.000*
≤ (6, 7 (3 + 4))	75.7	33.3	
7 (4 + 3)	14.9	66.7	
8–10	9.6	0	
% cancer	11.69 (11.50)	17.33 (9.29)	0.407
Node positive	2.70	0	1.000*

*Fisher's exact test.

TABLE 3 Univariate and multivariate analysis for predicting apical PSMs based on preoperative, operative and pathological characteristics

Variable	B	P	Exp(B)	95% CI
Univariate analysis				
Age	0.013	0.440	1.013	0.980–1.048
Body mass index	−0.037	0.247	0.964	0.906–1.026
Pre-op PSA level (log)	1.866	<0.001	6.461	2.669–15.64
Core positivity %	0.384	0.076	1.468	0.960–2.243
Maximum % biopsy	0.007	0.145	1.007	0.998–1.015
Prostate volume (log)	−0.783	0.337	0.457	0.092–2.259
Gleason score, biopsy	0.019	0.925	1.019	0.689–1.505
Clinical stage	−0.193	0.628	0.824	0.378–1.800
Surgical technique	−1.166	0.050	0.311	0.097–0.999
Multivariate analysis*				
Age	NA	NS	NA	NA
Body mass index	NA	NS	NA	NA
Pre-op PSA level (log)	1.752	0	5.766	2.364–14.07
Core positivity %	0.461	0.043	1.586	1.015–2.478
Maximum % biopsy	NA	NS	NA	NA
Prostate volume (log)	NA	NS	NA	NA
Gleason score biopsy Total	NA	NS	NA	NA
Clinical stage	NA	NS	NA	NA
Surgical technique	−1.242	0.049	0.289	0.084–0.993

*Multivariate model obtained using Backward Wald elimination model.

Most surgeons approach apical dissection by securing the DVC and cutting through the bunched veins, fatty tissue, puboprostatic ligaments, anterior fibromuscular stroma and occasional arterial bleeders (Fig. 21). This surgical approach remains suboptimal given the paucity of anatomical (visual or tactile) landmarks. With poor appreciation of the apical urethral junction from the distorted anatomy, often compounded by ongoing trickling of venous bleeding from incomplete DVC ligation, accurate transection of the membranous urethra is often a 'hit and miss' experience with the risk of cutting a divot into the apical tissue. For these reasons, apical dissection remains the 'Achilles heel' of prostate cancer surgery.

To reduce the PSM rate at the apex, several surgeons have described innovative techniques for apical handling. The classical descriptions by Walsh [36] and Chuang *et al.* [37] remain the reference standard for safe and successful management of the apex. These elegant reports not only clarified the anatomy of the apex and DVC, but also highlight technical refinements to help achieve continence and negative SMs. Myers *et al.* [38] also described the anatomy of this area in great detail and highlighted the benefits of magnification of the apex during surgery, and they addressed the importance of carefully handling the variations in the shape of the apex. Also, Menon *et al.* [7] and Laven *et al.* [8] discussed the importance of apical dissection in several landmark articles. Joseph Smith, who has made the transition from the open RP to the robotic procedure, also studied apical PSMs and mentioned the important technical refinements to reduce PSM rates [39]. Other innovative approaches towards this goal include blunt dissection, by Namiki *et al.* [11], transecting the DVC with no suture, by Guru *et al.* [5], and the use of a lateral viewing camera through an assistant's port, by Sasaki *et al.* [40]. All of these techniques have their merits and limitations.

We chose to approach this stage of the operation differently in search of better results, and modelled our technique on perineal RP, where a surgeon views the urethra circumferentially, from behind and with no DVC or puboprostatic ligaments obstructing the view (Fig. 22). The potential challenge to this technique was posed by very obese patients with large prostates, who have little space in the pelvis to allow for adequate mobilization (retraction) of prostate. A

FIG. 21. Pictorial illustration of conventional approach to urethral transection.

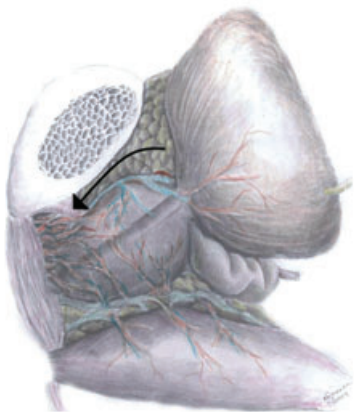


FIG. 22. Pictorial illustration of the anatomical synchronous retro-apical technique.

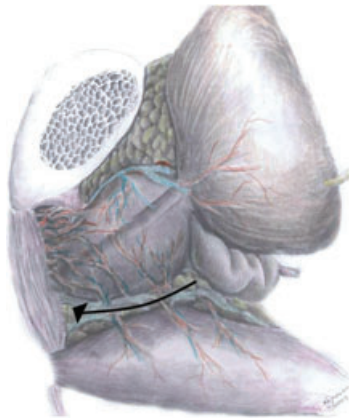
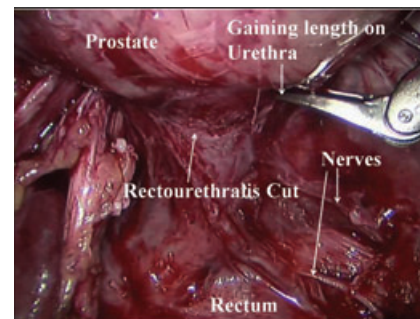


FIG. 23. Optimizing membranous urethral length.



surgeon must also be willing to approach their dissection from an unfamiliar vantage point when using this technique. However, our team quickly (within 5–10 cases) became so familiar with this new viewpoint that it was difficult for us to go back to the classic anterior approach. (Importantly, our new surgical technique is not solely posterior but is synchronous, involving a combination of posterior and anterior dissections). As previously stated, with very obese patients we might not be able to use the retro-apical approach.

Our approach has the following perceived benefits: (i) neurovascular bundles are released out of harm's way before we embark on apical dissection; (ii) identification of the prostatic-urethral junction is very easy and precise; (iii) it allows us to gently push the posterior apical beak away from the sphincter, thus gaining a few extra millimetres of length (Fig. 23); (iv) it does not require early suturing of the DVC when the prostate is not yet free (and so avoids unnecessary inclusion of the sphincter or nerves while attempting suture placement with limited mobility and vision); (v) it sometimes allows for balloon tamponade of the DVC, obviating the need for suturing before transection; (vi) it still allows us to preserve maximum urethral length, pubo-prostatic ligaments and arcus tendineus, all of which are critical in preserving continence [31]; and (vii) there is a greater safety margin with the synchronous approach than with the conventional approach (Fig. 24).

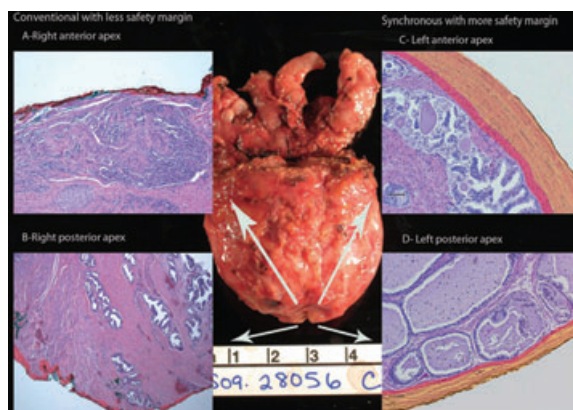


FIG. 24. Safety margin with anatomical retro-apical technique compared with the conventional approach.

Nonetheless, our approach of synchronous urethral transection has been difficult to execute in obese patients or in those with large prostates. In addition, skilful assistants are needed who retract the prostate just enough to open the retroprostatic fossa and who are able to change the camera to a 30° upward-facing lens without smudging the lens on the bladder or prostate. Also, this approach has only been attempted by one surgeon in 209 patients. These data need further validation by other surgeons and should be analysed from a larger patient pool. However, we think that our transition to this approach accounts for close to a four-fold reduction in the apical PSMs as the factors such as development of technique, focus on apical dissection and attention to detail all contribute to surgical outcomes in

both approaches. We are excited by the merits and promising early results of this technique, and recommend it to other surgeons seeking to reduce their apical PSM rates.

In conclusion, we developed a novel approach toward apical dissection during RARP which provides the surgeon with a circumferential view of the prostatic apex, membranous urethra and their anatomical intersection. Improved visualization and transection of the apical urethral junction, with precise dissection of the apical neural scaffold and optimal control of the DVC, has significantly ameliorated apical PSM rates in our patients undergoing RARP, despite having to deal with more aggressive cancer on final specimen pathology.

CONFLICT OF INTEREST

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REFERENCES

- Eastham JA, Kuroiwa K, Ohori M *et al.* Prognostic significance of location of positive margins in radical prostatectomy specimens. *Urology* 2007; **70**: 965–9
- van den Ouden D, Bentvelsen FM, Boeve ER *et al.* Positive margins after radical prostatectomy: correlation with local recurrence and distant progression. *Br J Urol* 1993; **72**: 489–94
- Yossepowitch O, Bjartell A, Eastham JA *et al.* Positive surgical margins in radical prostatectomy: outlining the problem and its long-term consequences. *Eur Urol* 2009; **55**: 87–99
- Ahlering TE, Eichel L, Edwards RA *et al.* Robotic radical prostatectomy: a technique to reduce pT2 positive margins. *Urology* 2004; **64**: 1224–8
- Guru KA, Perlmutter AE, Sheldon MJ *et al.* Apical margins after robot-assisted radical prostatectomy: does technique matter? *J Endourol* 2009; **23**: 123–7
- Klein EA. Modified apical dissection for early continence after radical prostatectomy. *Prostate* 1993; **22**: 217–23
- Menon M, Hemal AK, Tewari A *et al.* The technique of apical dissection of the prostate and urethrovesical anastomosis in robotic radical prostatectomy. *BJU Int* 2004; **93**: 715–9
- Laven BA, Alsikafi NF, Yang XJ *et al.* Minor modifications in apical dissection of radical retropubic prostatectomy in patients with clinical stage T2 prostate cancer reduce positive surgical margin incidence. *Urology* 2004; **63**: 95–8
- Myers RP. Re: Antegrade approach to radical retropubic prostatectomy in patients with difficult apical dissection. *J Urol* 1992; **148**: 1267–8
- Soulie M, Seguin P, Benoit J *et al.* Impact of a modified apical dissection during radical retropubic prostatectomy on the occurrence of positive surgical margins: a comparative study in 212 patients. *Urology* 2001; **58**: 217–21
- Namiki K, Kasraeian A, Yacoub S *et al.* Blunt apical dissection during anatomic radical retropubic prostatectomy. *BMC Res Notes* 2009; **2**
- Stamey TA, Villers AA, McNeal JE *et al.* Positive surgical margins at radical prostatectomy. importance of the apical dissection. *J Urol* 1990; **143**: 1166–72
- Terakawa T, Takenaka A, Tunemori H *et al.* [Modifications in the technique for apical dissection of radical retropubic prostatectomy to improve urinary incontinence]. *Nippon Hinyokika Gakkai Zasshi* 2006; **97**: 1–9
- Berryhill R Jr, Jhaveri J, Yadav R *et al.* Robotic prostatectomy. a review of outcomes compared with laparoscopic and open approaches. *Urology* 2008; **72**: 15–23
- Laurila TA, Huang W, Jarrard DF. Robotic-assisted laparoscopic and radical retropubic prostatectomy generate similar positive margin rates in low and intermediate risk patients. *Urol Oncol* 2009; **27**: 529–33
- Tewari AK, Jhaveri JK, Surasi K *et al.* Benefit of robotic assistance in comparing outcomes of minimally invasive versus open radical prostatectomy. *J Clin Oncol* 2008; **26**: 4999–5000
- El-Hakim A, Leung RA, Tewari A. Robotic prostatectomy. a pooled analysis of published literature. *Expert Rev Anticancer Ther* 2006; **6**: 11–20
- Tewari A, Peabody J, Sarle R *et al.* Technique of da Vinci robot-assisted anatomic radical prostatectomy. *Urology* 2002; **60**: 569–72
- Nguyen L, Jhaveri J, Tewari A. Surgical technique to overcome anatomical shortcoming. Balancing post-prostatectomy continence outcomes of urethral sphincter lengths on preoperative magnetic resonance imaging. *J Urol* 2008; **179**: 1907–11
- Tan GY, Jhaveri JK, Tewari AK. Anatomic restoration technique: a biomechanics-based approach for early continence recovery after minimally invasive radical prostatectomy. *Urology* 2009; **74**: 492–6
- Tewari A, Jhaveri J, Rao S *et al.* Total reconstruction of the vesico-urethral junction. *BJU Int* 2008; **101**: 871–7
- Tewari AK, Rao SR. Anatomical foundations and surgical manoeuvres for precise identification of the prostatovesical junction during robotic radical prostatectomy. *BJU Int* 2006; **98**: 833–7
- Tewari A, Peabody JO, Fischer M *et al.* An operative and anatomic study to help in nerve sparing during laparoscopic and robotic radical prostatectomy. *Eur Urol* 2003; **43**: 444–54
- Tewari A, Takenaka A, Mtui E *et al.* The proximal neurovascular plate and the tri-zonal neural architecture around the prostate gland: importance in the athermal robotic technique of nerve-sparing prostatectomy. *BJU Int* 2006; **98**: 314–23
- Takenaka A, Leung RA, Fujisawa M *et al.* Anatomy of autonomic nerve component in the male pelvis: the new concept from a perspective for robotic nerve sparing radical prostatectomy. *World J Urol* 2006; **24**: 136–43
- Tewari A, Rao S, Martinez-Salamanca JI *et al.* Cancer control and the preservation of neurovascular tissue: how to meet competing goals during robotic radical prostatectomy. *BJU Int* 2008; **101**: 1013–8
- Tewari AT, Dorsey PJ, Yadav R, Ramanathan R, Patel N, Takenaka A. Optimizing erectogenic outcomes during athermal robotic prostatectomy: a risk-stratified tri-zonal approach. *Urol Times Clin Edition* 2008; **3**: s4–12
- Tewari A, El-Hakim A, Rao S *et al.* Identification of the retrotrigonal layer as a key anatomical landmark during robotically assisted radical prostatectomy. *BJU Int* 2006; **98**: 829–32
- Poore RE, McCullough DL, Jarow JP. Puboprostic ligament sparing improves urinary continence after radical retropubic prostatectomy. *Urology* 1998; **51**: 67–72
- Tan GY, El Douaihy Y, Te AE *et al.* Scientific and technical advances in continence recovery following radical prostatectomy. *Expert Rev Med Devices* 2009; **6**: 431–53
- Tewari AK, Bigelow K, Rao S *et al.* Anatomic restoration technique of

- continence mechanism and preservation of puboprostatic collar: a novel modification to achieve early urinary continence in men undergoing robotic prostatectomy. *Urology* 2007; **69**: 726–31
- 32 **Al-Ahmadie HA, Tickoo SK, Olgac S et al.** Anterior-predominant prostatic tumors. zone of origin and pathologic outcomes at radical prostatectomy. *Am J Surg Pathol* 2008; **32**: 229–35
- 33 **Fine SW, Al-Ahmadie HA, Gopalan A et al.** Anatomy of the anterior prostate and extraprostatic space: a contemporary surgical pathology analysis. *Adv Anat Pathol* 2007; **14**: 401–7
- 34 **Koppie TM, Bianco FJ Jr, Kuroiwa K et al.** The clinical features of anterior prostate cancers. *BJU Int* 2006; **98**: 1167–71
- 35 **Borin JF, Skarecky DW, Narula N et al.** Impact of urethral stump length on continence and positive surgical margins in robot-assisted laparoscopic prostatectomy. *Urology* 2007; **70**: 173–7
- 36 **Walsh PC.** Re: Radical prostatectomy. The value of preoperative, individually labeled apical biopsies. *J Urol* 2001; **165**
- 37 **Chuang AY, Nielsen ME, Hernandez DJ et al.** The significance of positive surgical margin in areas of capsular incision in otherwise organ confined disease at radical prostatectomy. *J Urol* 2007; **178**: 1306–10
- 38 **Myers RP, Goellner JR, Cahill DR.** Prostate shape, external striated urethral sphincter and radical prostatectomy: the apical dissection. *J Urol* 1987; **138**: 543–50
- 39 **Kordan Y, Salem S, Chang SS et al.** Impact of positive apical surgical margins on likelihood of biochemical recurrence after radical prostatectomy. *J Urol* 2009; **182**: 2695–701
- 40 **Sasaki H, Miki J, Kimura T et al.** Lateral view dissection of the prostatourethral junction to reduce positive apical margin in laparoscopic radical prostatectomy. *Int J Urol* 2009; **16**: 664–9

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Abbreviations: (RA)RP, (robot-assisted) radical prostatectomy; DF, Denonvilliers' fascia; (P)SM, (positive) surgical margin; DVC, dorsal venous complex; EPE, extraprostatic extension.