

# Three-dimensional Camera Systems Assistant the Sheath of Prostate Preservation Laparoscopic Radical Prostatectomy: Technique and Initial Experience

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## Technical advance

**Keywords:** prostate cancer, radical prostatectomy, the sheath of prostate, incontinence, erectile function

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# Abstract

**Background:** To report our refinement of laparoscopic radical prostatectomy by preservation of the sheath of prostate (SPP-LRP) and 1-year follow-up results.

**Methods:** SPP-LRP was performed in 39 consecutive patients diagnosed as clinically localized prostate cancer from January 2016 to December 2018. The inclusion criteria consisted of Gleason score  $\leq 7$ , tPSA  $\leq 10$  ng/ml, positive in no more than 3 in 12 needles by systematical puncture biopsy, less than 50% tumor core involvement, clinical stage T1-2, good potency. The oncological results were identified by postoperative pathology test. Functional outcomes, including continence and potency, were followed postoperatively.

**Results:** The mean operation time was  $108.3 \pm 35.2$  min and the mean estimated blood loss was  $129.3 \pm 46.4$  ml with no transfusion. The catheter was removed 7 days after the surgery. There were no relevant postoperative complications requiring intervention. The histopathological results showed 2 cases (6.1%) in pT2 and 1 case (16.7%) in pT3 presented positive resection margins for tumor (R1). Only 1 case (pT3a, Gleason score 8) suffered pelvic lymph node metastasis. No biochemical relapse was observed after 1-year follow-up. The continence rates were 71.8% and 87.2% after 1 and 3 months, and no patients suffered G2 incontinence after 6 months, and 97.4% recovered continence after 12 months. The potency rates were 61.5% and 82.1% after 1 and 3 months, and that was 92.3% after 12 months.

**Conclusion:** SPP-LRP is a practical and worth-promoting technique for RP. The initial results are preferable and promising in technical, oncological and functional aspects.

## Background

Radical prostatectomy (RP) is considered to be a standard and curative surgical treatment for clinically localized prostate cancer in men with a life expectancy of  $\geq 10$  years[1-2]. Post-operative incontinence and erectile dysfunction (ED) are the most common complications of RP no matter by open, laparoscopic or robotic-assisted surgery, which reduce the quality of life conspicuously. A recent prospective and controlled research reported the morbidity of incontinence at 12 month after RP was about 20% and that of ED was about 70%[3]. In order to promote the recovery of continence and potency, some modifications and refinements on the technique of RP were developed and applied by numerous teams mainly based on the maximal preservation of periprostatic structures with the advancing understanding of the surrounding anatomy of prostate such as the neurovascular bundles (NVB), pelvic floor, urethral sphincter muscle and the prostate fascia[4-6]. The cavernous nerves in NVB finally reaching the corpora cavernosa were directly related to potency. The continence is influenced by the anatomical integrity and innervation of the male urethra rhabdosphincter[7]. Although no definite conclusion had been concurred by now, it is well known that the key for better results for RP is the understanding of the anatomy[8].

The sheath of prostate (Figure 1A) was firstly shown by Oelrich[9] in the study of urethral sphincter muscle in the male during all the literature we can reviewed, but has no exact definition. Thereafter, the

term of sheath of prostate appears in a few anatomy textbooks[10-11], but still without exact definition. Summing up all these description, the sheath of prostate should be regarded to all the surrounding structures overlapping the prostatic capsule consisting of visceral pelvic fascia (periprostatic fascia) laterally, sphincter urethrae muscle anteriorly and the Denonvillier fascia posteriorly[9-12]. We postulated that preserving the sheath of prostate in RP can keep all the periprostatic structures including prostatic fascia, NVB, Denonvillier fascia and sphincter urethrae muscle integrity, that may lead to a better functional results. So, we applied this surgical methods to clinic with three-dimensional camera systems assistant laparoscopic radical prostatectomy (3D-LRP), which could apply a better vision of actual anatomy in surgery. We defined this refined surgery as the sheath of prostate preservation LRP (SPP-LRP).

## Methods

### Patient's selection criteria

SPP-LRP was performed in 39 consecutive male patients diagnosed as clinically localized prostate cancer from January 2016 to December 2018. These patients were highly selected from 218 diagnosed as prostate cancer and underwent RP during this time in our hospital [17.88%] to evaluate this refined surgery. The inclusion criteria were as followed: Gleason score  $\leq 7$ , total prostate-specific antigen (tPSA)  $\leq 10$  ng/ml, positive in no more than 3 needles in 12 needles by systematical puncture biopsy, less than 50% tumor core involvement, clinical stage T1-2, good potency or mild erectile dysfunction (International Index of Erectile Function [IIEF-5]  $\geq 12$ ). None of them had contraindications for general anesthesia. The chief surgeon of all these surgeries were professor Weng Guobin with high-volume surgeons for RP. Patients were fully informed about all risks of procedure and signed the consent forms preoperatively.

### Surgical procedure

After general anesthesia, the patients were placed in a Trendelenburg position with a F 16 foley catheterization. The preperitoneal space was prepared as Stolzenburg described [8,19]. Usually, four trocars were applied in the present operations. The first 10-mm camera trocar was located 0.5-1.0cm just caudal to the umbilicus. The second and third 12mm trocars were lateral to the rectus muscle about 2cm below the camera trocar on the right and left side respectively. The fourth trocar was placed approximately 2cm median to the right anterior superior iliac spine. The three-dimensional camera systems used was KARL STORZ-endoscope system (KARL STORZ GmbH & Co. KG, Tuttlingen, Germany).

The fatty and areolar tissue were swept gently from the endopelvic fascia, the anterior surface of the bladder neck and the prostate. The bilateral endopelvic fascia was incised, and the levator ani muscle was separated from the prostate completely along to the apex of the prostate. At the apex of the prostate, the muscular fibers were separated away bluntly. After dissecting the puboprostatic ligament, the dorsal venous complex (DVC) was ligated by 20cm 2-0 Spiral PGA-PCL (Ethicon Inc., Somerville, NJ, USA) without excision.

The connecting part (A point) between the base of the prostate and the bladder neck was identified by repeated traction on the catheter and palpation with ultrasonic scalpel. At the cranial 1/3 point (C point) of the line between the A point and the puboprostatic ligament (B point), a transverse incision was made from the 11 to 1 o'clock position of the pre-prostatic fascia (the anterior layer of the sheath of the prostate), then blunt and sharp dissections were performed bilaterally in the plane until the anterior portion of the prostatic capsule was exposed. Along the surface of the prostate capsule exposed, dissections were performed between the bladder neck and the prostate to expose the anterior and bilateral connection part of the bladder neck and the urethra. Then the anterior 1/2 of the connection was dissected by ultrasonic scalpel, followed by pulling out the catheter. After the posterior of the connection was dissected, the bilateral deferent ducts were revealed and severed. After completely mobilization of the bilateral seminal vesicles, the Denonvilliers' fascia was opened horizontally and dissection between the anterior and posterior layer of the Denonvilliers' fascia straight to the prostate apex was performed to mobilize the posterior portion of the prostate.

Then the intrafascial dissection technique[4,5] was performed to mobilize the both bilateral side of the prostate between the prostatic capsule and the prostatic fascia (visceral layer of the pelvic fascia) from the base to the apex. Hemostasis was done only by suture with 3-0 coaed Vicryl plus (Ethicon Inc., Somerville, NJ, USA) and the prostatic fascia was kept intact bilaterally to avoid any injury on NVB.

The attachment of the prostate to the anterior pre-prostatic fascia was dissected with ultrasonic scalpel along the plane between the prostatic capsule and the prostatic fascia bilaterally. It was a potential plane that could hardly be dissected bluntly especially at the base of the prostate. This dissection was performed until the apex and the anterior wall of the urethra were exposed.

After traction to the left and slightly anticlockwise rotation of the right portion of the prostate, the right side of the prostatic apex was dissected bluntly by ultrasonic scalpel along the surface of the prostatic capsule until the right wall of the urethra. The same performance was conducted to dissect the left side of the prostatic apex and expose the left wall of the urethra. Then the urethra was incised just closed to the prostatic apex under direct vision in order to retain the functional urethra long enough. At this stage, the prostate was excised completely and put into the specimen bag.

A running anastomosis between the vesical neck and the urethra using a 25-cm, 2-0 Monocryl (Ethicon Inc., Somerville, NJ, USA) was performed[19,20]. A F-20 foley catheter was conducted, and the bladder was filled with 200-ml saline to test the integrity of the reconstruction.

Then a running suture was performed to anastomose the bilateral prostatic fascia and anterior prostatic fascia (the lateral and anterior layer of the sheath of prostate) to anterior wall of the bladder neck, which was aimed to recover the periprostatic structures anatomically.

All of the patients in this study were highly selected and were not indicated to undergo standard pelvic lymph node dissection. Therefore, bilateral obturator lymph node biopsy was performed instead.

The sheath of prostate preserving surgical procedures were showed in accessory video file attached.

## Pathology and anatomy

After the surgery, all biopsies were performed and analyzed by Pathologist and compared with the biopsies from intrafascial radical prostatectomy in order to illustrate the sheath of prostate intuitively. All biopsies were taken through the procedure of paraffin methods and stained by hematoxylin-phloxine-saffron. Sections were made in horizontal plane.

## Follow-up

The follow-up center of our hospital perform the evaluation of the continence and potency outcomes out all the patients at 1, 3, 6 and 12 months after the surgery. According to the definition of Sexual Health Inventory for Men questionnaire (SHIM) proposed by Cappeller[13], continence (Grade 0, G0) was defined as no need for pads or occasional urine leakage (1 pads/day) during daily normal activity. Grade 1 (G1) was 2-3 pads/day and Grade 3 (G3) was more than 3 pads/day.

## Statistics

GraphPad Prism Version 5.01 (GraphPad Software, California, USA) was used to calculate all the data. The measurement data are expressed by mean±standard deviation (SD) and the enumeration data are expressed by number and percentage.

# Results

The SPP-LRP was performed in these 39 consecutive patients by Prof. Weng with a mean operation time of  $108.3\pm 35.2$  min. And the follow-up data were available in all of them. The general characteristics of these patients and surgery were summarized in Table 1. There were no conversion in any patient. The mean estimated blood loss was  $129.3\pm 46.4$  ml and none of them needed transfusion. The catheter was removed 7 days after the surgery if the 6-day postoperative cystography reveal no paravasation. There were no relevant postoperative complications requiring surgical or medical intervention presented.

The postoperative histopathological results are listed in Table 2. Despite exclusively including patients with clinical stage T1-2, there were still 6 cases (15.4%) which were actually pT3a postoperatively, but no pT3b or pT4 tumors. Likewise, Gleason score $\geq 8$  were found in 8 cases (20.5%). Among them, 2 cases (6.1%) in pT2 and 1 case (16.7%) in pT3 presented positive resection margins for tumor (R1) postoperatively, who were treated with radiotherapy after continence recovery (2 cases at 1 month and 1 case at 3 months postoperatively) . Only 1 case (pT3a, Gleason score 8) suffered pelvic lymph node metastasis, who had androgen deprivation treatment postoperatively. No biochemical relapse was observed after 1-year follow-up.

The SHIM questionnaire[13] was used to evaluate the continence recovery and the results were revealed in Table 3, that showed an increasing continence recovery rate during follow-up. The early continence

recovery rate (supposed to be 3 months postoperatively) was 71.8% and 87.2% after 1 and 3 months separately. Furthermore, after 6 months postoperatively, there was no patients suffered G2 incontinence, and 97.4% were continent after 12 months postoperatively.

Similarly, the rate of potency recovery, that was sufficient for intercourse, was also increasing during follow-up (Table 3). The early potency recovery rate was 61.5% and 82.1% after 1 and 3 months postoperatively separately, and that was 92.3% after 12 months postoperatively.

## **Anatomy results**

The anatomical examination of the prostate after the SPP-LRP was revealed in Figure 2: The posterior and bilateral prostatic capsule was intact without any structure of the prostatic fascia or NVB outside. The anterior portion, consist of transverse smooth muscle and connective tissue , was the anterior fibromuscular zone of the prostate. The pre-prostatic sphincter muscle was absent at the pre-prostatic portion (Figure 2A), but that was shown as the coarse longitudinal muscle fibers by the anatomical examination of the prostate after the intra-fasical LRP(Figure 2B). Still, a potential plane lies between transverse smooth muscle and the longitudinal muscle, and this potential plane continues with the prostatic capsule(Figure 2B).

## **Discussion**

The better understanding of the anatomical structures surrounding the prostate leads to the refinement of radical prostatectomy especially for clinically localized prostate cancer, that consequently improve the surgical technique, oncological and functional results after surgery[7-18]. Recent and well accepted modifications were the intrafacial nerve-sparing RP technique including the maximal preservation of NVB, rectourethralis muscle, pubo-prostatic ligament and prostate fascia, that results in good functional results without affection of the oncological results[4-6,19-20]. Efforts are still being made, mostly focused on the maximal preservation of the surrounding structures of prostate, to make a perfect functional outcome for localized prostate cancer.

It is well accepted that the sphincter urethrae muscle in male is a distinct muscular structure rather than part of the pelvic floor musculature, but the exact structure and innervation of the sphincter urethrae muscle in male is still controversial in literatures. Some researchers advocated that the sphincter urethrae muscle, also termed the external urethral sphincter, is a Omega-shaped, dorsally incomplete collar muscular coat ventral and lateral to the membranous urethra and just caudally to the prostate apex[8,21-22]. And it is considered to be the most important structure related to postoperative incontinence. Therefore, it is obligatory for Urologists to identify and preserve this Omega-shaped muscle during RP no matter what kind of surgery technique is used. However, despite this, along with NVB preservation and intrafasical techniques, postoperative incontinence is still unavoidable in some patients[3], especially in the early stage of 3 months postoperatively. This demonstrated that there must be some other anatomical structures or interactive process responsible for urinary continence.

A different description of the sphincter urethrae muscle was reported by Strasser and Oelrich et al[7,9]. They described this muscle as a muscular coat ventral and lateral to membranous urethra and prostate, extending from the bulb of the penis towards the base of the bladder, and the core is the Omega-shaped loop around the urethra( Figure 1B, 1C and 1D). And the pre-prostatic portion of the sphincter muscle is surrounded by a quantity of connective tissue, which extend from peripheral prostate fascia (organic portion of pelvic fascia), was further described histologically[9]. Furthermore, McNeal et al termed the pre-prostatic portion of the sphincter muscle as the pre-prostatic sphincter, and described that the the preprostatic sphincter located just anterior to the surface of the anterior fibromuscular zone of the prostate, which was introduced to be entirely non-glandular and without importance for prostatic function and pathology[23].

As mentioned above, the sheath of prostate can be term as all the structures that enclose the prostate just external to prostate capsule. Anatomically, the sheath of prostate consists of periprostatic fascia laterally, sphincter urethrae muscle anteriorly and the Denonvillier fascia posteriorly. Herein, the present novel technique for radically dissecting the prostate preserving the sheath of prostate might achieve to maintain all the enveloping periprostatic structures. Laterally and posteriorly, the same as intrafacial RP technique[4-6], the periprostatic fascia, the Denonvillier fascia and the NVB were all preserved. Anteriorly, the preprostatic sphincter was preserved. Along with the preservation of the Omega-shaped sphincter urethrae muscle caudal to the apex of the prostate and the anatomical reconstruction of the base of the bladder and preprostatic sphincter, the muscular sphincter urethrae coat was kept intact. Cranially, the sparing dissection of the bladder neck can preserve the vesical sphincter[8]. Furthermore, the DVC was sutured in order to reduce bleed during surgery without mutilation, that could maintain the puboprostatic ligaments intact. And the puboprostatic ligaments were considered to support the sphincter urethrae muscle and fix the urethra in the functional place[8]. The postoperative pathology identified these structures (Figure 2),and confirmed that there is a potential plane between the prostate and these structures, which makes it feasible to preserve the sheath of prostate in RP technically.

The present refinement of SPP-LRP was aimed to achieve a perfect functional results. And the present follow-up data confirm a preferable continence recovery rate from the first month to one year postoperatively. The present follow-up results also demonstrate a good potency recovery rate. In oncological aspect, it is well accepted that intrafacial technique was not a risk factor for positive resection margins for tumor in adequately selected patients undergoing RP, and the positive resection margins rates were reported in pT2 and pT3 tumors of 4.5% to 6.9% and 29.4% to 34%, respectively[4-6,20]. Similarly, in the present selected patients undergoing SPP-LRP, the positive resection margins rates (R1) were 6.1% and 16.7% in pT2 and pT3 tumors, which indicated a worthy oncological results. Furthermore, the patient with R1 received radiotherapy after relatively early continence recovery (2 cases at 1 month and 1 case at 3 months postoperatively).

Despite all these preferable results in technical, oncological and functional aspects, the limitations of the present report are obvious: limited number of patients, absence of a control group, relative short follow-up

period and adequately selected patients. A control perspective clinical trial is being designed to evaluate this technique, a mandatory long-term follow-up for these patients is still proceeding.

## Conclusions

SPP-LRP is a practical and worth-promoting technique for RP. The initial results are preferable and promising in technical, oncological and functional aspects. And the early continence recovery make it possible for patients with R1 to receive postoperative radiotherapy at early stage. A control perspective clinical trial and a long-term follow-up are mandatory to confirm the results.

## Abbreviations

laparoscopic radical prostatectomy by preservation of the sheath of prostate:SPP-LRP; Radical prostatectomy:RP; erectile dysfunction:ED; the neurovascular bundles:NVB; three-dimensional camera systems assistant laparoscopic radical prostatectomy:3D-LRP; total prostate-specific antigen :tPSA; International Index of Erectile Function: IIEF-5; the dorsal venous complex: DVC; Sexual Health Inventory for Men questionnaire: SHIM; standard deviation: SD; positive resection margins for tumor: R1;

## Declarations

### **Ethics approval and consent to participate:**

This report was approved by Ethnic Committee of Ningbo Urology & Nephrology Hospital, Ningbo, Zhejiang, China. Patients were fully informed about all risks of procedure and signed the consent forms preoperatively.

### **Consent for Publication:**

Written consent from the all the patient's legal representative for publication was obtained.

### **Availability of data and material:**

All data and material were listed in the present manuscript.

### **Competing interests:**

The authors declare no conflict of interests.

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### **Authors' contributions:**

LS and GW wrote this manuscript, GW was the chief surgeon, WG and GW were the assistant surgeon, YY was the pathologist, LS were responsible for data processing and follow-up. We were all responsible for

writing and editing the manuscript.

## Acknowledgements:

Not applicable

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## Tables

Table1 The general characteristics of these 39 patients and surgery

	Mean±SD
Age(years)	61.6±7.4
Body mass index(BMI, Kg/m <sup>2</sup> )	24.3±2.1
Pre-operative Total PSA (ng/ml)	6.7±2.9
Prostate volume(ml)	46.2±20.7
Operation duration time(min)	108.3±35.2
Estimated blood loss(ml)	129.3±46.4
Transfusion(cases)	0

Table 2 Post-operative pathological stage, positive resection margins (R1)

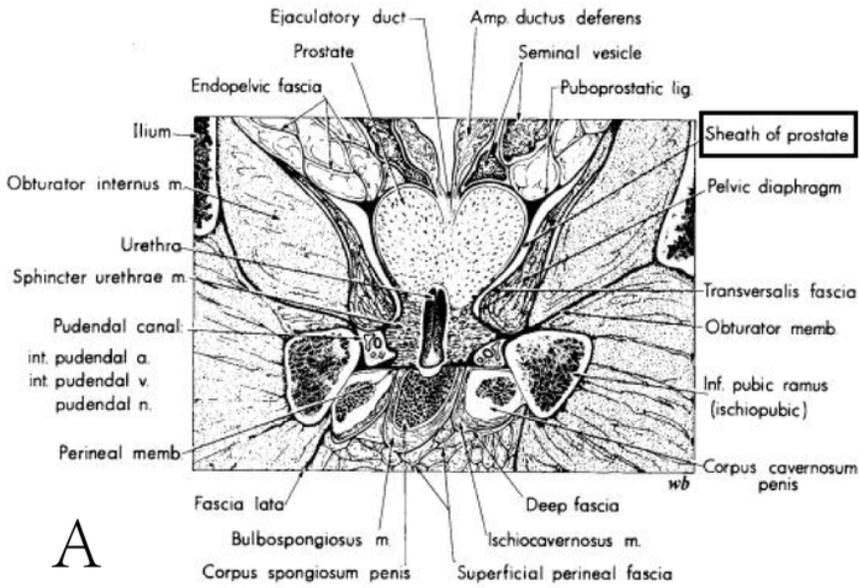
	N(cases)	percentage
pT2a	7	17.9%
pT2b	16	41.1%
pT2c	10	25.6%
pT3a	6	15.4%
N0	38	97.4%
N1	1	2.6%
Post-operative Gleason score		
6	5	12.8%
7	26	66.7%
≥8	8	20.5%
R1 in pT2	2/33	6.1%
R1 in pT3	1/6	16.7%

R1: positive resection margins for tumor

Table 3 Post-operative continence and potency recovery of SPP-LRP

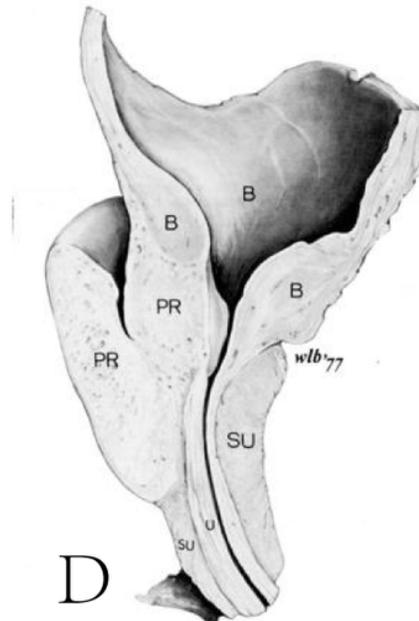
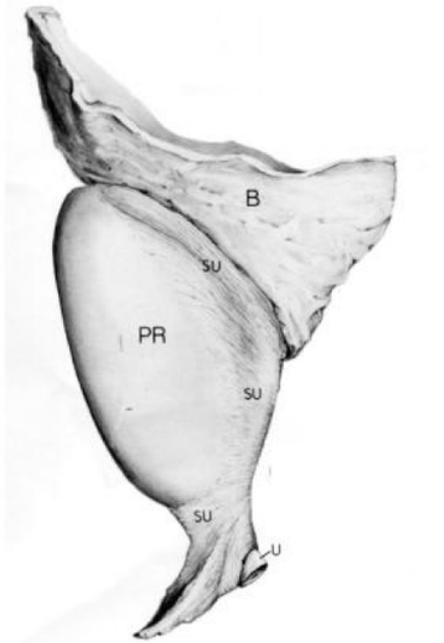
Continence recovery											
1 month			3 months			6 months			12 months		
G0	G1	G2	G0	G1	G2	G0	G1	G2	G0	G1	G2
28	9	2	34	4	1	36	3	0	38	1	0
71.8%	23.1%	5.1%	87.2%	10.2%	2.6%	92.3%	7.7%	0%	97.4%	2.6%	0%
Potency recovery (IIEF≥12 and be able to complete intercourse)											
1 month			3 months			6 months			12 months		
24(61.5%)			32 (82.1%)			34 (87.2%)			36 (92.3%)		

## Figures



A

B



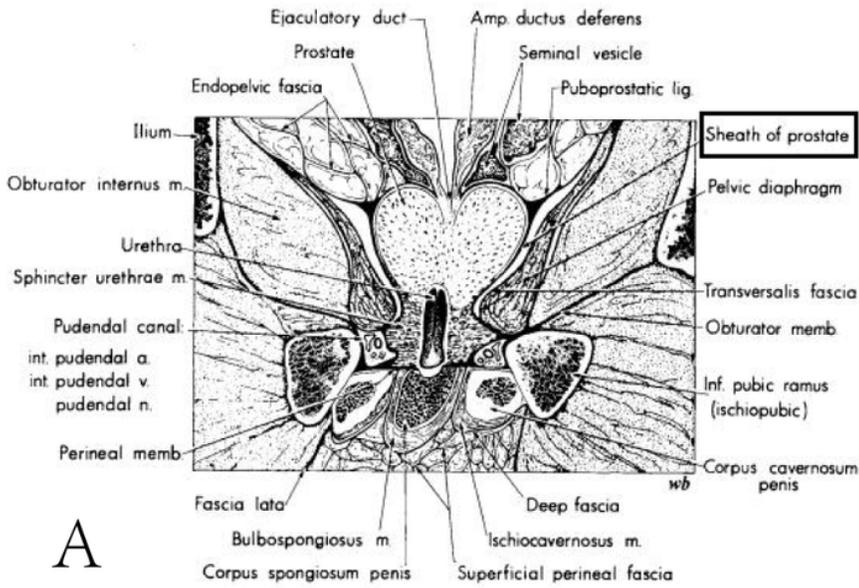
C

D

**Figure 1**

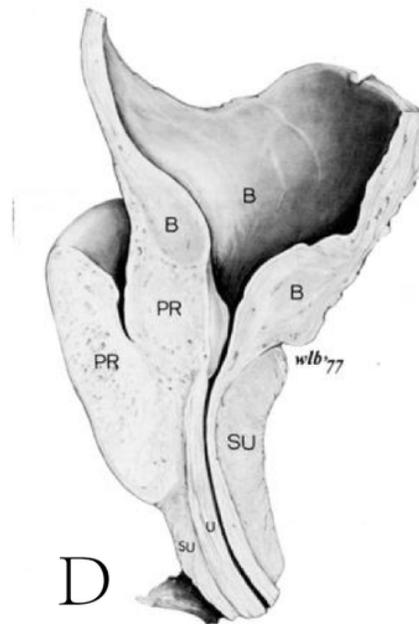
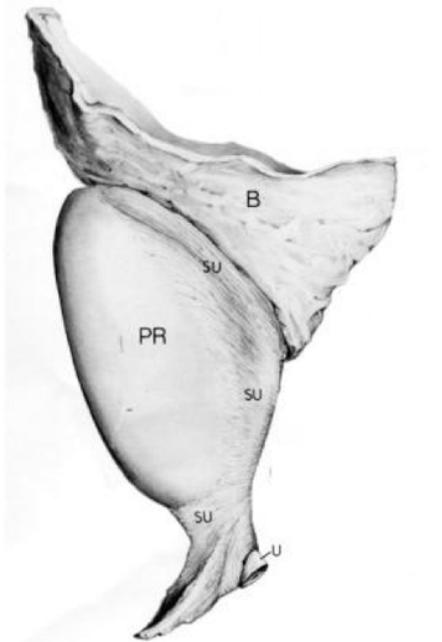
This figure was revealed by Oelrich[9], demonstrated the anatomy of the sheath of prostate and the urethral sphincter muscle. A: Frontal section of male pelvis at right angles to pennis membrane, through the membranous urethra, demonstrating relations of fascial planes in the pelvis, urogenital hiatus, and perineum. The sheath of prostate was firstly described in this figure, which was highlighted by black blank, but without exact definition. B: Oblique view of prostate (PR) and urethra (U) with urethral sphincter muscle (SU) removed in a male, 25 years. x 2. C: Lateral view of bladder (B), urethral sphincter muscle, and prostate in a male, 21 years. x 2. D: Median section of bladder, urethra, prostate and urethral sphincter

demonstrating extent of contact between urethra and the urethral sphincter muscle in a male, 21 years. x 2.



A

B



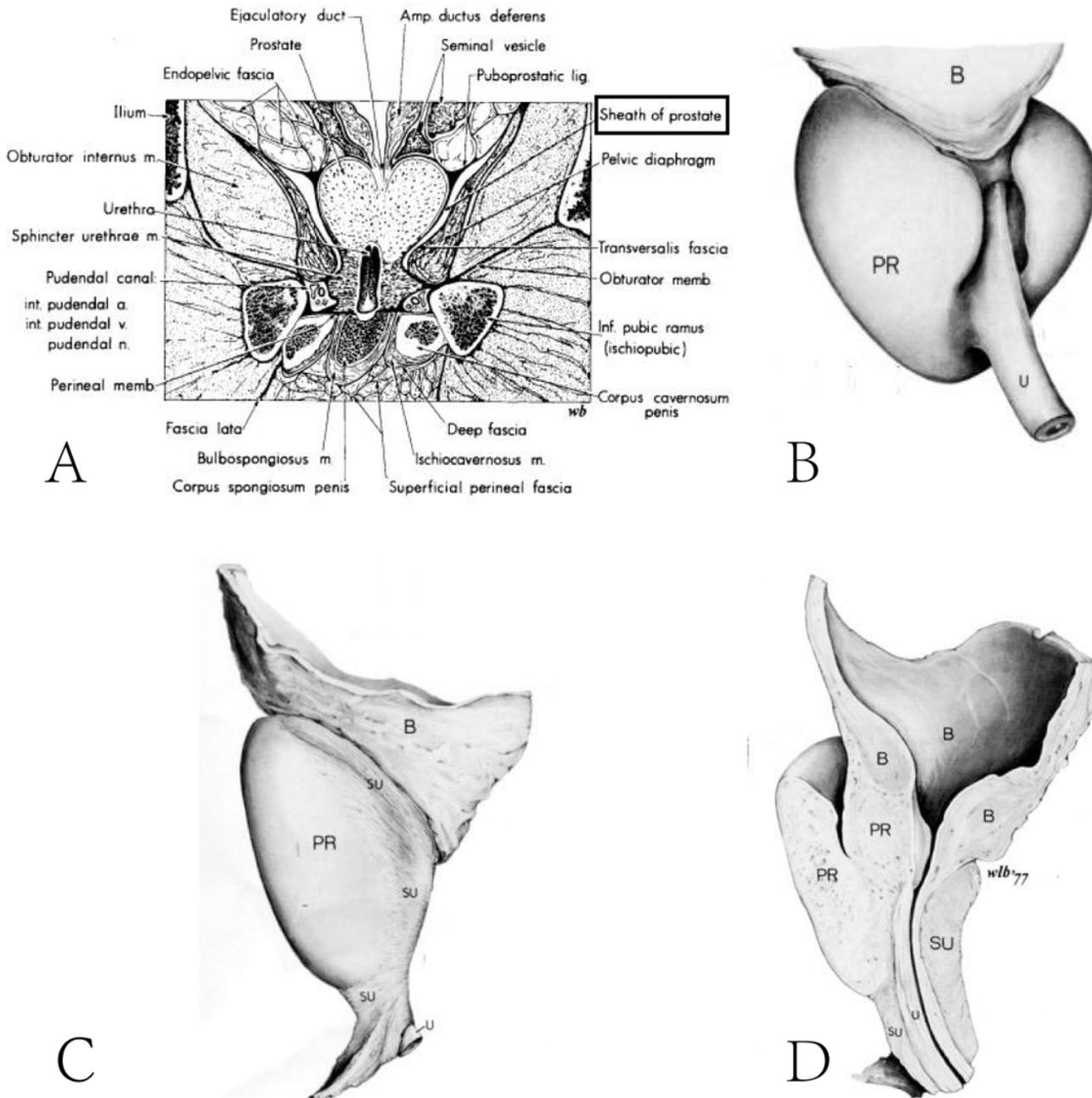
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**Figure 1**

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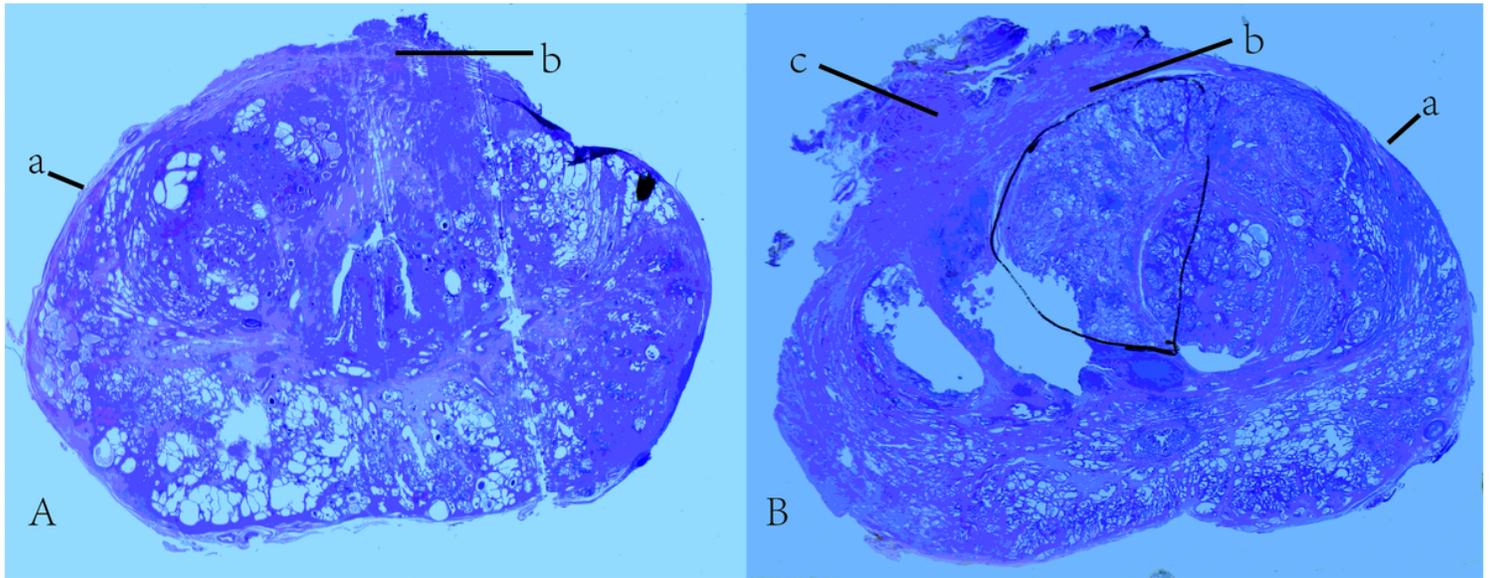
and prostate in a male, 21 years. x 2. D: Median & ion of bladder, urethra, prostate and urethral sphincter demonstrating extent of contact between urethra and the urethral sphincter muscle in a male, 21 years. x 2.



**Figure 1**

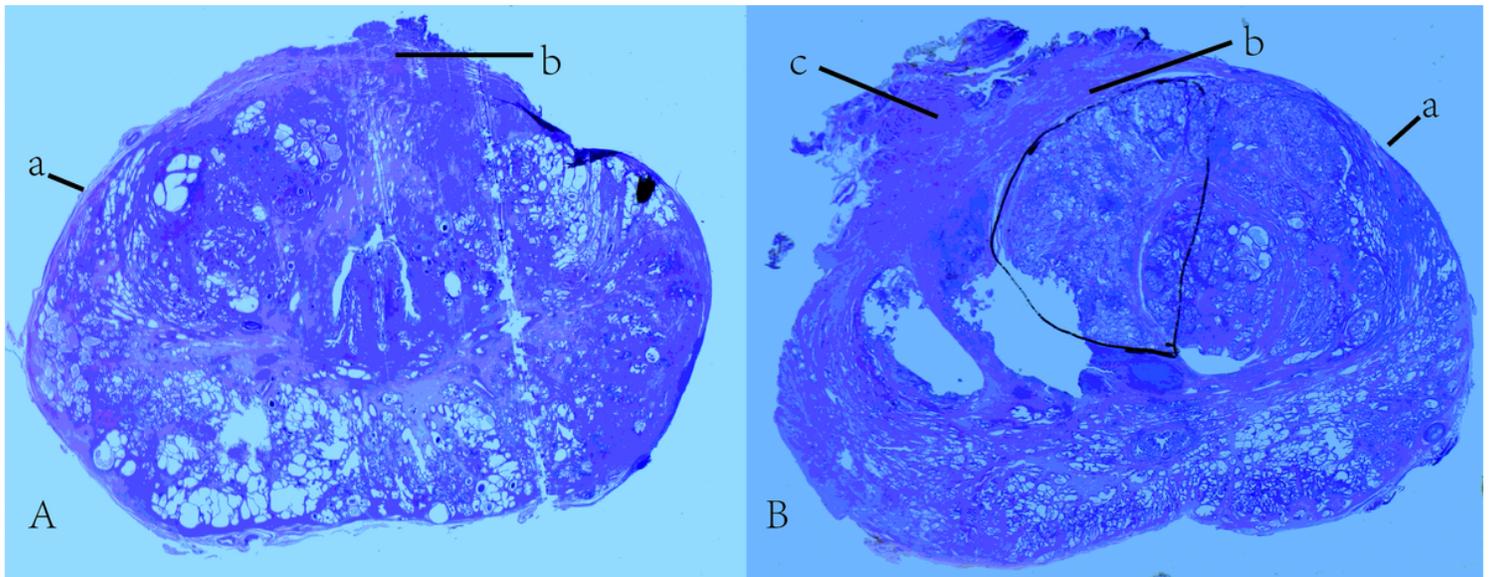
This figure was revealed by Oelrich[9], demonstrated the anatomy of the sheath of prostate and the urethral sphincter muscle. A: Frontal section of male pelvis at right angles to panned membrane, through the membranous urethra, demonstrating relations of fascial planes in the pelvis, urogenital hiatus, and perineum. The sheath of prostate was firstly described in this figure, which was highlighted by black blank, but without exact definition. B: Oblique view of prostate (PR) and urethra (U) with urethral sphincter

muscle (SU) removed in a male, 25 years. x 2. C: Lateral view of bladder (B), urethral sphincter muscle, and prostate in a male, 21 years. x 2. D: Median section of bladder, urethra, prostate and urethral sphincter demonstrating extent of contact between urethra and the urethral sphincter muscle in a male, 21 years. x 2.



**Figure 2**

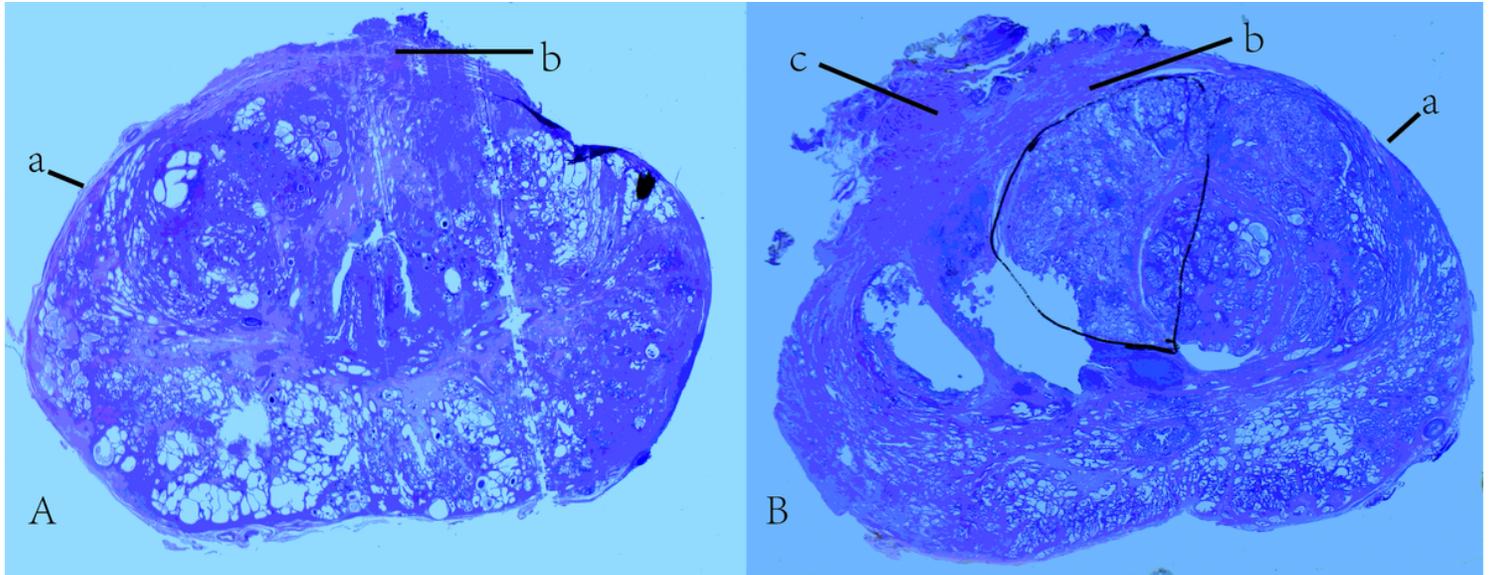
Biopsy of the prostate after RP. A: The anatomical examination of the prostate after SPP-LRP; B: The anatomical examination of the prostate after intra-fascial LRP. a: the prostate capsule; b: the anterior fibromuscular zone of the prostate, which consist of transverse smooth muscle and connective tissue; c: the pre-prostatic sphincter muscle, which was shown as the coarse longitudinal muscle fibers.



**Figure 2**

Biopsy of the prostate after RP. A: The anatomical examination of the prostate after SPP-LRP; B: The anatomical examination of the prostate after intra-fascial LRP. a: the prostate capsule; b: the anterior

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