International Urology and Nephrology (2019) 51:1157–1165
https://doi.org/10.1007/s11255-019-02118-0

UROLOGY - ORIGINAL PAPER

Morphologic changes after bladder neck intussusception in laparoscopic radical prostatectomy contribute to early postoperative continence

Lin Yao[1,2] · Yuke Chen[1,2] · He Wang[3] · Wei Yu[1,2] · Yu Fan[1,2] · Yang Yang[1,2] · Yunxiang Xiao[1,2] · Jihong Duan[1,2] · Qian Zhang[1,2] · Zhisong He[1,2,4] · Shiliang Wu[1,2,4]

Received: 24 December 2018 / Accepted: 26 February 2019 / Published online: 8 April 2019

Abstract

Purpose To explore the mechanism and efficacy of the modified bladder neck intussusception in laparoscopic radical prostatectomy (LSRP) on postoperative early continence.

Methods We prospectively collected clinical information of prostate cancer patients who underwent LSRP with modified bladder neck intussusception ($n=10$) and non-intussusception ($n=10$). At postoperative 1 month, the prostate-specific antigen (PSA), pad test, real-time magnetic resonance imaging (rt-MRI), and flow rate were performed. At postoperative 3 months, the PSA, pad test, international prostate symptom score (IPSS), overactive bladder symptom score (OABSS), incontinence questionnaire short form (ICI-Q-SF), and quality of life (Qol) were recorded.

Results The intussusception and non-intussusception patients had similar baseline characteristics. At postoperative 3 months, intussusception patients had lower OABSS than non-intussusception patients ($P=0.038$). The non-intussusception patients suffered from more severe incontinence ($P=0.026$). The continence rate of intussusception patients was significantly higher (90% vs. 20%, $P=0.005$). And intussusception patients had significantly lower Qol scores ($P=0.038$). According to the morphologic analysis by rt-MRI, there were 7/10 non-intussusception patients and 2/10 intussusception patients having funnel-shaped bladder necks at Valsalva movement. The intussusception patients had larger angle between anterior and posterior wall at bladder neck ($P=0.029$) and longer length of functional posterior urethra ($P=0.029$). During micturition, the intussusception bladder neck was found to move less dynamically on *X*-axis and *Y*-axis, but the difference did not reach significance.

Conclusions The modified technique of bladder neck intussusception in laparoscopic radical prostatectomy prolongs the length of functional posterior urethra and is effective to improve postoperative early continence.

Keywords Prostate cancer · Radical prostatectomy · Urinary incontinence · Magnetic resonance imaging

Abbreviations

LSRP	Laparoscopic radical prostatectomy
PSA	Prostate-specific antigen
IPSS	International prostate symptom score
OABSS	Overactive bladder symptom score
ICI-Q-SF	Incontinence questionnaire short form
Qol	Quality of life
rt-MRI	Real-time magnetic resonance imaging
FIESTA	Fast imaging employing steady-state acquisition
AAP	Anterior and posterior wall
ALR	Angle between left and right wall
ANU	Angle between bladder neck and posterior urethral

Lin Yao, Yuke Chen, and He Wang contributed equally to this manuscript.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11255-019-02118-0) contains supplementary material, which is available to authorized users.

✉ Zhisong He
wyj7074@sohu.com

✉ Shiliang Wu
wushiliangjsh@263.net

Extended author information available on the last page of the article

Introduction

According to the WHO report in 2012, the incidence rate of prostate cancer was estimated at 10.5% in Asian countries [1]. The incidence of prostate cancer has shown a steady growing trend as the population ages and longevity increases [2]. Radical prostatectomy is the gold standard treatment for localized prostate cancer [3]. The goal of radical prostatectomy is eradication of cancer while preserving continence and, whenever possible, potency [3]. Studies concerning radical prostatectomy suggested that postoperative urinary incontinence mostly impacts on life quality and treatment satisfaction of patients regardless of oncologic outcomes and sexual function [4, 5]. According to the published literatures, approximately 10–30% of patients still suffered from urinary incontinence at postoperative 1 year [6, 7]. And the highest incidence rate of urinary incontinence occurred at postoperative 2 to 6 months [8, 9]. Therefore, it is imperative for surgeons to restore satisfactory urinary continence of prostate cancer patients at early postoperative stage.

Although multiple factors, for example, old age, high body mass index (BMI), large prostate volume, have been associated with postoperative incontinence, several established surgical techniques contribute to urinary continence after radical prostatectomy [10]. For instance, the clinical significance of the bladder neck preservation for postoperative urinary continence had been repeatedly reported [11, 12]. In Freire et al. [12] study, 228 out of 348 (65.6%) patients who underwent bladder neck preservation reached urinary continence at postoperative 4 months. In 2002, Walsh et al. [13] first described bladder neck intussusception as Lembert sutures at bladder neck reconstruction to prevent a filling bladder from pulling open. The continence rate of patients who underwent intussusception was 82% at postoperative 3 months [13]. In 2004, Wille et al. [14] verified the intussusception of bladder neck in 139 patients who underwent open radical prostatectomy. And the continence rate at postoperative 3 months was 77% [14]. Further, Tan et al. [10] adapted the intussusception technique to robot-assisted laparoscopic radical prostatectomy, and concluded that intussusception of the bladder neck improved urinary function during the early recovery period.

Magnetic resonance imaging (MRI) allows high soft-tissue resolution evaluation of the whole pelvic compartments, and has proved a reliable technique for accurate diagnosis of pelvic floor dysfunction. Meanwhile, real-time MRI (rt-MRI) with steady-state sequences allows detailed anatomic and functional evaluation of the lower urinary tract [15]. Muto et al. explored the morphologic changes in 10 patients with orthotopic ileal neobladder with rt-MRI for the first time [16]. Series of studies reported the efficacy of the bladder neck intussusception on restoring early postoperative continence, but there was no analysis on the definite mechanism of the technique [10, 13, 17]. In the present study, we modified the bladder neck intussusception technique to restore early postoperative continence in laparoscopic radical prostatectomy. With the help of rt-MRI, we also assessed the postoperative morphologic changes of the lower urinary tract.

Patients and methods

Data source

From March 2016 through April 2017, we prospectively included clinical information of prostate cancer patients who underwent laparoscopic prostatectomy with modified bladder neck intussusception (intussusception group, $n=10$) and non-intussusception (non-intussusception group, $n=10$) by two separated surgeons with similar surgical experience, respectively. Patients who had a primary urethral stricture, incontinence, neurogenic disease, and neoadjuvant androgen deprivation therapy, and those with incomplete data were excluded. All the patients were preoperatively provided with the validated questionnaires included international prostate symptom score (IPSS), overactive bladder symptom score (OABSS), international consultation on incontinence questionnaire short form (ICI-Q-SF), and quality of life (Qol) [18, 19]. The medical information concerning age, BMI, prostate volume, prostate-specific antigen (PSA), biopsy Gleason score, past history, operative time, blood loss, and surgical pathology was recorded. At postoperative 1 month, the serum PSA examination, pad test, rt-MRI, and flow rate for micturition were performed. The rt-MRI was mainly used to investigate the relationship between anatomy and symptoms [16]. At postoperative 3 months, the outcomes of serum PSA, pad test, IPSS, OABSS, ICI-Q-SF, and Qol were recorded [17, 18]. When a patient did not have urine leakage but suffered from the fear of leakage, the value of ICI-Q-SF was recorded as 1 or 2 only calculated from Qol. The continence was defined as no pad/one safety liner per 24 h [18]. The study was approved by the Ethics Committee of Peking University First Hospital. Informed consents were obtained from all individual participants included in the study.

Surgical technique

In order to form a bladder neck matched with the residual urethra, the bladder neck was reconstructed at 5-o'clock and 7-o'clock, respectively, with running 3-0 absorbable sutures to full-thickness. In the next steps, we make some modifications. A suture at the 6-o'clock of the bladder neck was placed to facilitate the exposure of the posterior bladder wall. Four to six running buttressing sutures were placed at the lateral ligaments of bladder and then fat tissue around the prostate bed to provide solid supports to the posterior bladder wall at its neck and to avoid ureteral injury (Fig. 1a). And an absorbable hemoclip was used to fix the running buttressing suture being loosely tied but not the strangulating tissue (Fig. 1b). These sutures prevent the bladder neck from pulling open as the bladder fills. Care must be taken to be certain that the absorbable hemoclip would not be pulled into the anastomosis in the following steps. Following posterior intussusception, the stay suture at the bladder neck is removed. After releasing the tension between bladder neck and urethra, a second running 3-0 buttressing suture was orderly performed at 5, 6, 7, and 9-o'clock to make the mucosa-to-mucosa urethrovesical anastomosis. At this point, a catheter was placed through the bladder neck without inflated with saline. Then the second running 3-0 buttressing suture was continued to be orderly performed at 11, 1, 3, and 5-o'clock to complete the urethrovesical anastomosis (Fig. 1c). The catheter was infiltrated with 20 mL saline. A third running buttressing sutures was placed about 2 cm lateral to the bladder neck on each side with 4–6 stitches, and once again it was tied loosely (Fig. 1d). At this point, the bladder neck should be located beneath the anterior hood of tissue that was created by the anterior stitch, like a turtle that had pulled its head inside its shell. This tissue must not act like a collar with the bladder neck protruding, because this would lead to tissue ischemia, resulting in bladder neck contracture. By contrast, for non-intussusception patients, only the bladder neck reconstruction and urethrovesical anastomosis were performed. The surgery was finished after a leakage test and the placement of a drainage tube. Routinely, the drainage tube was removed at postoperative 2 days, and the

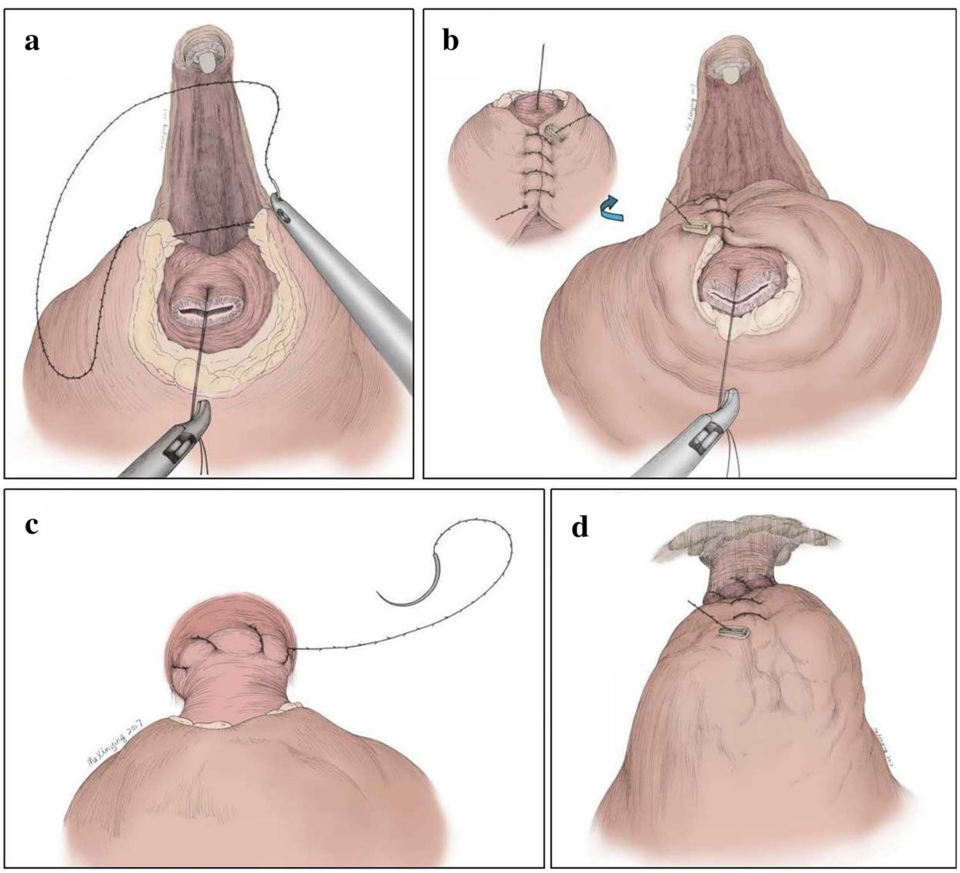

Fig. 1 The surgical technique for the modified bladder neck intussusception. **a** Four to six running buttressing sutures were started at the lateral ligaments of bladder and then fat tissue around the prostate bed to support the posterior bladder wall at its neck (**a**). **b** An absorbable hemoclip was used to fix the running buttressing suture being loosely tied but not strangulating tissue. **c** After releasing the tension between bladder neck and urethral, a second running 3-0 buttressing sutures at 5, 6, 7, and 9-o'clock was orderly performed to make the mucosa-to-mucosa urethrovesical anastomosis. At this point, a catheter was placed through the bladder neck without inflated with saline. Then the second running 3-0 absorbable sutures at 11, 1, 3, and 5-o'clock were orderly performed to complete the urethrovesical anastomosis (**c**). The catheter was infiltrated with 20 mL saline; d: A third running buttressing sutures was placed about 2 cm lateral to the bladder neck on each side with 4–6 stitches, and once again it was tied loosely

catheterization was place until postoperative 2 weeks. In the present study, the laparoscopic prostatectomy plus bladder neck intussusception or non-intussusception was independently completed by two separated surgeons.

Morphologic parameters of the urinary system by rt-MRI

Multiple-parameters MRI with a 3.0-tesla superconducting machine was used for micturition real-time imaging. The patients were instructed to orally receive 500 mL water 30 min before the examination to ensure a sufficiently distended bladder. Image acquisition was started at the beginning of micturition and stopped at the end of micturition. During micturition, the sagittal slice orientation with a fast imaging employing steady-state acquisition (FIESTA) sequence was used. Rt-MRI images were obtained every 3 s from the start to the end of voiding. Morphologic parameters of the urinary system on rt-MRI were evaluated for profilometry analysis by two experienced radiologists. The bladder indexes were recorded as (1) funnel-shaped change of the bladder neck or not at Valsalva movement (Supplementary Fig. 1), (2) angle between anterior and posterior wall (AAP) (Supplementary Fig. 2a), (3) angle between left and right wall (ALR) (Supplementary Fig. 2b), (4) relative and actual length of posterior urethra (Supplementary Fig. 2c), (5) angle between bladder neck and posterior urethral (ANU) (Supplementary Fig. 2d), and (6) movements of the bladder neck along the *X*-axis and *Y*-axis [16, 20].

Statistical analysis

We used SPSS v14.0 software (IBM Corp, Armonk, NY) for statistical analysis. The Kolmogorov–Smirnov test determined the normality of the continuous variables. Median and range presented continuous variables, and the Mann–Whitney *U* test compared the differences between the two groups. Frequency and percentile were used to present categorical or ranked variables, and the Fisher exact test was used to test the differences. All reported P values were two sided, and $P < 0.05$ was considered statistically significant.

Results

Patient characteristics

Table 1 lists the demographic and clinical characteristics of the whole study cohort. The median age of the study cohort was 63 years (range 51–71 years). The study cohort had the median prostate volume and PSA of 36.2 mL (range 19.5–56.4 mL) and 8.69 ng/ml (range 4.48–45.24 ng/mL). According to outcomes of the surgical pathology, the positive margin occurred on 2 patients. There were 3 case, 2 cases, 9 cases, and 3 cases having the pathological stage of T2a, T2b, T2c, and T3a. The baseline of clinicopathologic characteristics, including age, prostate volume, PSA, biopsy pathology, surgical time and blood loss, and surgical pathology were similar between the intussusception and non-intussusception groups.

Postoperative function of the lower urinary tract

Table 2 shows the function of lower urinary tract of the study cohort at postoperative 1 month and 3 months. At postoperative 1 month, the continence rates of intussusception patients and non-intussusception patients were 7 of 10 and 1 of 10 ($P = 0.002$). There was no significant difference in maximum flow rate between the two groups (median: 20.0 mL/s vs. 19.0 mL/s, $P = 0.286$). When it comes to postoperative 3 months, intussusception patients had similar IPSS score with non-intussusception patients (median: 7 vs. 7, $P = 0.456$), and lower OABSS than non-intussusception patients (median: 2 vs. 6, $P = 0.038$). The non-intussusception patients suffered from more severe incontinence than intussusception patients (median [range] of ICI-Q-SF: 12 (2–19) vs. 2 (1–7), $P = 0.026$). Meanwhile, the continence rate of intussusception group was 90% (9/10), which is significantly higher than the 20% (2/10) of non-intussusception patients ($P = 0.005$). And the Qol values of intussusception patients were significantly lower than that of non-intussusception patients (median [range]: 6 (1–8) vs. 1 (1–5), $P = 0.038$).

Morphologic analysis of lower urinary tract

Table 3 presents the morphologic analysis of the lower urinary tract for the study cohort at postoperative 1 month. According to the morphologic analysis of lower urinary tract by rt-MRI (Supplementary Video), there were 7 of 10 non-intussusception patients and 2 of 10 intussusception patients having funnel-shaped bladder necks of filling bladders ($P = 0.025$) (Fig. 2a, d). Compared with non-intussusception patients, intussusception patients had larger angle between anterior and posterior wall at bladder neck (median: 90.8 degree vs. 107.5 degree, $P = 0.029$) (Fig. 2b, e). The intussusception patients had significantly longer length of functional posterior urethra than non-intussusception patients (range [median]: 29.59 (18.34–34.97) millimeter vs. 19.93 (9.12–23.01) millimeter, $P = 0.029$) (Fig. 2c, f). During micturition, the intussusception bladder neck was found to move less dynamically on *X*-axis and *Y*-axis than the non-intussusception bladder neck, but the difference did not reach significance.

Table 1 Demographic and clinical characteristics of the whole study cohort

Characteristics	Total ($n=20$)	Non-intussusception ($n=10$)	Intussusception ($n=10$)	*P*
Age (years), median (range)	63 (51–77)	66 (59–77)	61 (51–76)	1.000
BMI (kg/m^2), median (range)	23.89 (19.03–31.35)	23.89 (19.03–28.73)	24.22 (21.77–31.35)	1.000
PV (mL), median (range)	36.2 (19.5–56.4)	36.2 (26.0–41.1)	37.2 (19.5–56.4)	1.000
PSA (ng/mL), median (range)	8.69 (4.48–45.24)	7.2 (4.48–45.24)	15.54 (7.33–37.38)	1.000
Biopsy Gleason score, *n* (%)				0.773
3+3	6 (30.0)	3 (30.0)	3 (30.0)	
3+4	5 (25.0)	3 (30.0)	2 (20.0)	
4+3	4 (20.0)	1 (10.0)	3 (30.0)	
≥ 8	5 (25.0)	3 (30.0)	2 (20.0)	
Surgical information				
Operative time (min), median (range)	94 (64–119)	104 (92–116)	75 (64–119)	0.286
Blood loss (ml), median (range)	50 (10–200)	50 (10–200)	10 (10–100)	0.592
Positive margin, *n* (%)	2 (14.3)	1 (14.3)	1 (14.3)	1.000
Gleason score, *n* (%)				0.836
3+3	2 (10.0)	1 (10.0)	1 (1.0)	
3+4	9 (45.0)	5 (50.0)	4 (40.0)	
4+3	4 (20.0)	1 (10.0)	3 (30.0)	
≥ 8	5 (25.0)	3 (30.0)	2 (20.0)	
Pathological stage, *n* (%)				1.000
T2a	3 (15.0)	2 (20.0)	1 (10.0)	
T2b	2 (10.0)	1 (10.0)	1 (10.0)	
T2c	9 (45.0)	5 (50.0)	4 (40.0)	
T3a	3 (15.0)	1 (10.0)	2 (20.0)	
T3b	3 (15.0)	1 (10.0)	2 (20.0)	

The Mann–Whitney *U* test was used to compare the differences of continuous variables; the Fisher exact test was used to compare the differences of categorical or ranked variables

BMI body mass index, *PV* prostate volume, *PSA* prostate-specific antigen

Discussion

Within the last decade, numerous surgical techniques have been suggested to restore the early urinary continence in patients who underwent radical prostatectomy [10–14]. In 2002 and 2004, Walsh et al. [13] and Wille et al. [14] performed the surgical method of bladder neck intussusception in open radical prostatectomy to prevent a filling bladder from pulling open. Tan et al. [10] further performed the intussusception technique in robot-assisted laparoscopic radical prostatectomy, and suggested that the technique improved urinary function during the early recovery period. However, the detailed mechanisms of the intussusception technique in improving postoperative early continence have not been extensively studied. In the present study, we modified the bladder neck intussusception technique in laparoscopic radical prostatectomy. We also assessed the efficacy of our modified technique in combination of postoperative morphologic changes by rt-MRI.

In the present study, intussusception of the bladder neck resulted in a significantly greater continence rate of 9/10 at postoperative 3 months. Meanwhile, the difference in continence rate was complemented by the significantly reduced scores of patient-reported questionnaires (ICI-Q-SF, Qol, and OABSS) in intussusception group. The results of our study were consistent with the published literatures [10, 13, 14]. We further performed the morphologic analysis to uncover the definitive mechanism behind the earlier return of continence with intussusception of the bladder neck.

First of all, the functional posterior urethra was significantly prolonged for the intussusception patients, since the use of buttressing sutures prevented the bladder neck from pulling apart in filling status. According to the established theory, the length of functional urethral length contributed to urinary continence [21, 22]. Last but not the least, during micturition, the intussusception bladder neck was found to move non-significantly less dynamically on *X*-axis and *Y*-axis than the non-intussusception bladder neck. As the perspective by Wille et al., a securely fixed bladder neck to the urethra with buttressing sutures counted for decreasing straining of the sphincter and better sphincter function [14].

Table 2 Postoperative function of lower urinary tract

Variables	Postoperative 1 month		*P*	Postoperative 3 months		*P*
	Non-intussusception ($n=10$)	Intussusception ($n=10$)		Non-intussusception ($n=10$)	Intussusception ($n=10$)	
IPSS, median (range)	–	–	–	7 (5–10)	7 (2–9)	0.456
OABSS, median (range)	–	–	–	6 (2–8)	2 (0–6)	0.038
ICI-Q-SF, median (range)	–	–	–	12 (2–19)	2 (1–7)	0.026
Qol, median (range)	–	–	–	6 (1–8)	1 (1–5)	0.038
Pad count, *n* (%)			0.002			0.005
No pad/one safety liner	1 (10.0)	7 (70.0)		2 (20.0)	9 (90.0)	
1	2 (20.0)	3 (30.0)		4 (40.0)	1 (10.0)	
≥ 2	7 (70.0)	0 (0.0)		4 (40.0)	0 (0.0)	
Continence *n* (%)[a]	1 (20.0)	7 (70.0)	0.002	2 (20.0)	9 (90.0)	0.005
Qmax (ml/s), median (range)	20.0 (16.0–28.0)	19.0 (15.0–34.0)	0.286	–	–	–
Qmean (ml/s), median (range)	12.0 (9.0–13.0)	10.0 (9.0–18.0)	1.000	–	–	–
RU (ml), median (range)	–	–		0 (0–15)	0 (0–20)	1.000

The Mann–Whitney *U* test was used to compare the differences of continuous variables; the Fisher exact test was used to compare the differences of categorical or ranked variables

IPSS international prostate symptom score, *OABSS* overactive bladder symptom score, *ICI-Q-SF* international consultation on incontinence questionnaire short form, *Qol* quality of life, *Qmax* maximal flow rate, *Qmean* mean flow rate, *RU* residual urine;

[a]Continence is measured as no pad/one safety liner per 24 h

Table 3 morphologic analysis of lower urinary tract at postoperative 1 month

Variables	Non-intussusception ($n=10$)	Intussusception ($n=10$)	*P*
The funnel-shaped bladder neck, *n* (%)	7 (70.0)	2 (20.0)	0.025
AAP (degree), median (range)	90.8 (78.3–107.9)	107.5 (93.4–124.7)	0.029
ALR (degree), median (range)	95.3 (82.2–105.2)	102.5 (89.3–117.3)	0.286
rLPU (mm), median (range)	16.3 (7.78–22.77)	25.78 (13.87–28.81)	0.103
LFPU (mm), median (range)	19.93 (9.12–23.01)	29.59 (18.34–34.97)	0.029
Movements of the anastomosis during micturition (mm), median (range)			
X-axis	1.82 (0.18–2.88)	0.88 (0.56–1.37)	1.000
Y-axis	2.01 (0.93–2.43)	1.27 (0.46–3.33)	0.286
ANU (mm), median (range)	23.0 (9.1–25.1)	17.6 (14.8–28.9)	1.000

The Mann–Whitney *U* test was used to compare the differences of continuous variables; the Fisher exact test was used to compare the differences of categorical or ranked variables

AAP angle between anterior and posterior wall, *ALR* angle between left and right wall, *rLPU* relative length of posterior urethra, *LFPU* length of functional posterior urethra, *ANU* angle between bladder neck and posterior urethral, *mm* millimeter

And morphologic research in combination with the urodynamic studies is imperative in future.

When intussuscepting the bladder neck, Walsh et al. and Wille et al. placed buttressing sutures at the edges of the posterior bladder wall, where the bladder was previously attached to the prostate [13, 14]. Of note, in our modified technique, running buttressing sutures started at the lateral ligaments of bladder. Meanwhile, we reported the method of bladder neck intussusception in laparoscopic surgery for the first time. According to Sridhar et al. study, providing myo-/fascio-ligamentous support to the posterior urethrovesical anastomosis improved postoperative early continence [23]. Rocco et al. and Coelho et al. reconstructed the residual Denonvilliers fascia and vesicoprostatic muscle to support posterior urethrovesical anastomosis [24, 25]. And the benefits of these myo-/fascio-ligamentous reconstructions on postoperative continence were verified in previous studies [21–23]. In Walsh et al. and Wille et al. studies, the continence rates at postoperative 3 months were 82% (37/45) and 77% (98/139), respectively. And continence was defined as the use of no or one pad daily in both the above studies. In the present study, continence was defined as the use of no pad or one safety liner daily, and the continence rate at postoperative 3 months in intussusception group was 90% (9/10)

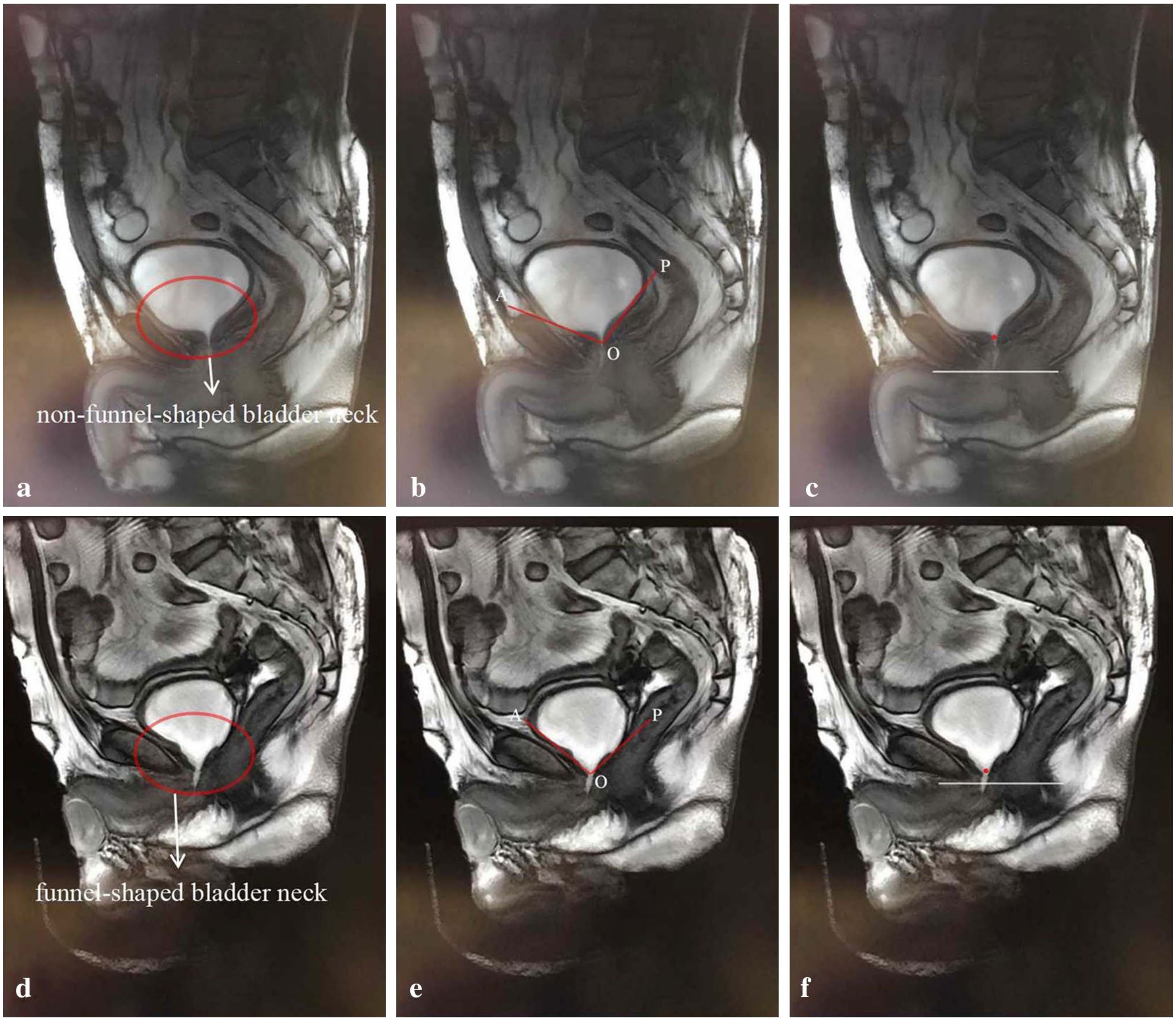

Fig. 2 the morphologic analysis of the lower urinary tract. **a** The intussusception bladder tended to have a non-funnel-shaped bladder neck, **b** larger angle between anterior and posterior wall at bladder neck (the degree of angle AOP), (**c**) and longer length of functional posterior urethra (the urethral length between the red dot and the horizontal line), **d** the non-intussusception bladder tended to have a funnel-shaped bladder neck, **e** smaller angle between anterior and posterior wall at bladder neck (the degree of angle AOP), (**f**) and shorter length of functional posterior urethra (the urethral length between the red dot and the horizontal line)

[18]. Meanwhile, Tan et al. [10] adapted the intussusception technique to robot-assisted surgery, and approximately two-thirds of patients had complete continence within weeks after surgery. The laparoscopic surgery carries several perceived advantages over the open surgery including minimal invasion, better vision, and greater range of motion [26]. In the last decade, robot-assisted surgery has been rapidly adopted for its relative shorter learning curve than laparoscopy, tremor reduction, motion scaling, and three-dimensional vision [27]. However, the surgeons in the present study have prior experience in laparoscopic surgery which retains better tactile feedback.

The present study had some limitations. Within the follow-up duration, none of bladder neck contracture and upper urinary tract dilation was recorded. And longer follow-up was ongoing. Meanwhile, the evidence level of our study was decreased for its property of non-randomized controlled trial. The laparoscopic prostatectomy plus bladder neck intussusception or non-intussusception were independently completed by two separated surgeons with similar experience. Therefore, the process of grouping was mainly determined by the preference of patients towards the two surgeons. To address some methodological concerns, we collected data prospectively and the baseline characteristics of the two groups appeared similar. Also, the interpretation of our study was limited by its relatively small sample size. And randomized controlled trials with larger sample size are imperative in future.

Conclusion

The modified technique of bladder neck intussusception in laparoscopic radical prostatectomy prolongs the length of functional posterior urethra and is effective to improve postoperative early continence.

Acknowledgements This work was supported by Grants from the National Key R&D Program of China to Shiliang Wu (Grant number 2018YFC2002200).

Author contributions Study Concepts: Zhisong He and Shiliang Wu. Study Design: Wei Yu, Zhisong He, and ShiliangWu. Data Acquisition: Lin Yao, Yuke Chen, and He Wang. Quality Control of Data and Algorithms: Yuke Chen and Yu Fan. Data Analysis and Interpretation: Yuke Chen and Yu Fan. Statistical Analysis: Yuke Chen and Yu Fan. Manuscript Preparation: Yang Yang, Jihong Duan, Yunxiang Xiao, and Yu Fan. Manuscript Editing: Yuke Chen. Manuscript Review: Qian Zhang, Wei Yu, and Shiliang Wu.

Compliance with ethical standards

Conflict of interest The authors of the present manuscript have no conflicts of interest.

References

1. Chen R, Ren S, Chinese Prostate Cancer Consortium et al. (2014) Prostate cancer in Asia: a collaborative report. Asian J Urol 1(1):15–29
2. Siegel RL, Miller KD, Jemal A (2016) Cancer statistics, 2016. CA Cancer J Clin 66:7–30
3. Mottet N, Bellmunt J, Bolla M et al (2017) EAU-ESTRO-SIOG guidelines on prostate cancer. Part 1: screening, diagnosis, and local treatment with curative intent. Eur Urol 71(4):618–629
4. Liss MA, Osann K, Canvasser N et al (2010) Continence definition after radical prostatectomy using urinary quality of life: evaluation of patient reported validated questionnaires. J Urol 183:1464–1468
5. Donovan JL, Hamdy FC, Lane JA et al (2016) ProtecT study group. Patient-reported outcomes after monitoring, surgery, or radiotherapy for prostate cancer. N Engl J Med 375(15):1425–1437
6. Begg CB, Riedel ER, Bach PB et al (2002) Variations in morbidity after radical prostatectomy. N Engl J Med 346:1138–1144
7. Prabhu V, Sivarajan G, Taksler GB, Laze J, Lepor H (2014) Long-term continence outcomes in men undergoing radical prostatectomy for clinically localized prostate cancer. Eur Urol 65:52–57
8. Dalela D, Jeong W, Prasad MA et al (2017) A pragmatic randomized controlled trial examining the impact of the retzius-sparing approach on early urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol 72(5):677–685
9. Sanda MG, Dunn RL, Michalski J et al (2008) Quality of life and satisfaction with outcome among prostate-cancer survivors. N Engl J Med 358:1250–1261
10. Tan HJ, Xiong S, Laviana AA et al (2016) Technique and outcomes of bladder neck intussusception during robot-assisted laparoscopic prostatectomy: a parallel comparative trial. Urol Oncol 34(12):529.e1–529.e7
11. Nyarangi-Dix JN, Radtke JP, Hadaschik B et al (2013) Impact of complete bladder neck preservation on urinary continence, quality of life and surgical margins after radical prostatectomy: a randomized, controlled, single blind trial. J Urol 189(3):891–898
12. Freire MP, Weinberg AC, Lei Y et al (2009) Anatomic bladder neck preservation during robotic-assisted laparoscopic radical prostatectomy: description of technique and outcomes. Eur Urol 56:972–980
13. Walsh PC, Marschke PL (2002) Intussusception of the reconstructed bladder neck leads to earlier continence after radical prostatectomy. Urology 59(6):934–938
14. Wille S, Varga Z, von Knobloch R, Hofmann R (2005) Intussusception of bladder neck improves early continence after radical prostatectomy: results of a prospective trial. Urology 65(3):524–527
15. Kobi M, Flusberg M, Paroder V, Chernyak V (2018) Practical guide to dynamic pelvic floor MRI. J Magn Reson Imaging 47(5):1155–1170
16. Muto S, Kamiyama Y, Ide H et al (2008) Real-time MRI of orthotopic ileal neobladder voiding: preliminary findings. Eur Urol 53(2):363–369
17. Bellangino M, Verrill C, Leslie T et al (2017) Systematic review of studies reporting positive surgical margins after bladder neck sparing radical prostatectomy. Curr Urol Rep 18(12):99
18. Nambiar AK, Bosch R, Cruz F et al (2018) EAU Guidelines on assessment and nonsurgical management of urinary incontinence. Eur Urol 73(4):596–609
19. Galfano A, Di Trapani D, Sozzi F et al (2013) Beyond the learning curve of the Retzius-sparing approach for robot-assisted laparoscopic radical prostatectomy: oncologic and functional results of the first 200 patients with ≥ 1 year of follow-up. Eur Urol 64(6):974–980
20. Chen Y, Yang Y, Yu W et al (2018) Urodynamic characteristics of pelvic lipomatosis with glandular cystitis patients correlate with morphologic alterations of the urinary system and disease severity. Neurourol Urodyn 37(2):758–767
21. Mikhail MS, Rosa H, Palan P, Anderson P (2005) Comparison of preoperative and postoperative pressure transmission ratio and urethral pressure profilometry in patients with successful outcome following the vaginal wall patch sling technique. Neurourol Urodyn 24(1):31–34
22. el-Bahnasawy MS, Osman Y, Gomha MA, Shaaban AA (2005) Persistent and occasional nocturnal enuresis in orthotopic urinary diversion: is there a urodynamic difference? BJU Int 96(9):1373–1377
23. Sridhar AN, Abozaid M, Rajan P et al (2017) Surgical techniques to optimize early urinary continence recovery post robot assisted radical prostatectomy for prostate cancer. Curr Urol Rep 18(9):71
24. Rocco F, Gadda F, Acquati P et al (2001) Personal research: reconstruction of the urethral striated sphincter. Arch Ital Urol Androl 73(3):127–137
25. Coelho RF, Chauhan S, Orvieto MA et al (2011) Influence of modified posterior reconstruction of the rhabdosphincter on early recovery of continence and anastomotic leakage rates after robot-assisted radical prostatectomy. Eur Urol 59(1):72–80
26. Nossiter J, Sujenthiran A, Charman SC et al (2018) Robot-assisted radical prostatectomy vs laparoscopic and open retropubic radical prostatectomy: functional outcomes 18 months after

diagnosis from a national cohort study in England. Br J Cancer 118(4):489–494
27. Light A, Karthikeyan S, Maruthan S et al (2018) Peri-operative outcomes and complications after laparoscopic vs robot-assisted dismembered pyeloplasty: a systematic review and meta-analysis. BJU Int. https://doi.org/10.1111/bju.14170

Affiliations

Lin Yao[1,2] · Yuke Chen[1,2] · He Wang[3] · Wei Yu[1,2] · Yu Fan[1,2] · Yang Yang[1,2] · Yunxiang Xiao[1,2] · Jihong Duan[1,2] · Qian Zhang[1,2] · Zhisong He[1,2,4] · Shiliang Wu[1,2,4]

Lin Yao
poparies@163.com

Yuke Chen
yukecc1989@163.com

He Wang
jimmy9527@126.com

Wei Yu
yuweif@126.com

Yu Fan
dantefanbmu@126.com

Yang Yang
goldflamingo@126.com

Yunxiang Xiao
xyxlzh@sina.com

Jihong Duan
duanjjj@263.net

Qian Zhang
zhangqian@bjmu.edu.cn

1 Department of Urology, Peking University First Hospital, 8 Xishiku Street, Xicheng District, Beijing 100034, China

2 Institute of Urology, National Urological Cancer Center, Peking University, 8 Xishiku Street, Xicheng District, Beijing 100034, China

3 Department of Radiology, Peking University First Hospital, Beijing, China

4 Institute of Urology, National Urological Cancer Center, Peking University First Hospital, Peking University, 8 Xishiku Street, Xicheng District, Beijing 100034, China