Modified posterior musculofascial plate reconstruction decreases the posterior vesicourethral angle and improves urinary continence recovery in patients undergoing laparoscopic radical prostatectomy

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Abstract. The aim of this study was to evaluate the efficacy of our modified posterior musculofascial plate reconstruction (PMPR) procedure in laparoscopic radical prostatectomy (LRP). Prior to 2010, four operative procedures were used to expedite continence recovery: preserving the fascia covering the levator ani muscle, preserving the bladder neck, securing a functional urethral length by using a lateral-view dissection technique and suspending the vesicourethral anastomosis from the puboprostatic ligaments. Since February, 2010, a running suture between Denonvilliers' fascia (DF) and the median fibrous raphe (MFR, the fibrous tissue that lies immediately underneath the urethra) has also been used. In vesicourethral anastomosis, a double-armed running suture was performed. At the beginning of the anastomosis, the first stitches (at 1 and 11 o'clock positions on the bladder neck) were placed 1-2 cm dorsocephalad to the bladder neck (first through the seromuscular layer and then through the full thickness of the bladder neck). At the 5 and 7 o'clock positions of the urethra, the stitches were placed through the urethral mucosa as well as the the reconstructed musculofascial plate. The bladder shape was evaluated by postoperative cystography and the clinical results were compared between patients undergoing LRP without PMPR (group A) and those undergoing LRP with PMPR (group B). The cystograms demonstrated that the PMPR significantly shortened the vertical length of the bladder and significantly decreased the posterior vesicourethral angle. At 1, 3 and 6 months after LRP, the number of daily used pads was significantly lower in group B compared to that in group A and the time to achieve a pad-free status was significantly shorter in group B. Our modified PMPR procedure significantly improved the recovery of urinary continence following LRP and this improvement may be due in part to changes of the bladder shape.

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Introduction

Improving the oncological and functional outcome of laparoscopic radical prostatectomy (LRP) is crucial, as the patients' quality of life is significantly affected by the severity and duration of postoperative urinary incontinence. Since LRP is considered to be technically challenging, a relatively long time elapsed between its first application and its establishment as the treatment of choice for organ-confined prostate cancer (1). Early multi-institutional studies in Japan found the recovery of urinary function following LRP to be slower compared to that following retropubic radical prostatectomy (RRP) (2,3). The operative procedures used to improve the recovery of urinary continence following radical prostatectomy include preserving the fascia covering the levator ani muscle (4), preserving the bladder neck (4), preserving neurovascular bundles (NVBs) (5), securing a longer functional urethra (6,7), reconstructing the posterior musculofascial plate (PMPR) (8-10), suspending the vesicourethral anastomosis (11) and performing an anterior reconstruction (12).

Since December, 2008, when performing LRPs, we have been routinely preserving the fascia covering the levator ani muscle, preserving the bladder neck, securing a functional urethral length by using a lateral-view dissection technique (13) and suspending the vesicourethral anastomosis. However, as these four procedures did not appear to improve the recovery of urinary continence in LRP, in Feburary, 2010, we initiated the application of a PMPR procedure. Our procedure differs from the original Rocco stitch (8,9) in the aspects described below. Firstly, we used a running suture to connect the Denonvilliers' fascia (DF) with the fibrous tissue underneath the urethra (median fibrous raphe, MFR). Secondly, at the beginning of the vesicourethral anastomosis, the bladder wall was stitched 1-2 cm dorsocephalad to the bladder neck (at positions 1 and 11 o'clock on the bladder neck) and the musculofascial plate was stitched at 5 and 7 o'clock positions on the

urethra instead of using Rocco's second-layer stitch. Although it was previously reported that urinary continence was not improved by PMPR (14), in the present study we demonstrated that urinary continence was recovered significantly earlier in patients undergoing LRPs with our modified PMPR. We also evaluated the postoperative cystograms and compared the bladder shapes between patients undergoing LRP with PMPR and those undergoing LRP without PMPR.

Patients and methods

Patients. LRP is being performed at our institute since 2000. In the present study, we evaluated 32 patients undergoing LRP (retroperitoneal approach) who were operated on by a single surgeon (K.I.) between December, 2008 and September, 2011. Maximal preservation of the fascia covering the levator ani muscle, bladder neck preservation, apical dissection using a lateral view to secure functional urethral length and decrease the positive surgical margin at the apex, and suspension of the vesicourethral anastomosis by suturing to the puboprostatic ligaments were performed during all LRPs since December, 2008 (group A, n=13); our modified PMPR procedure was added to these previous procedures from January, 2010 onwards (group B, n=19). In group B, there was no change in the other operative procedures intended to expedite continence recovery. For all the patients included this study, the indication for LRP was T1-2 N0M0 prostate cancer. Clinical staging was determined by digital rectal examination and transrectal urtrasonography. Computed tomography and magnetic resonance imaging were performed in all the patients for the evaluation of lymph node metastasis and extracapsular extension of the prostate cancer. Radionuclide bone scanning was routinely performed in patients with prostate-specific antigen (PSA) levels ≥10 mg/dl.

Surgical procedure. Five port sites were created as shown in Fig. 1. Obturator lymph node dissection was performed in all the patients. Following lymph node dissection, the junction of the endopelvic fascia was bluntly incised as previously described (4). The fascia covering the levator ani muscle was carefully preserved to prevent muscle damage. The puboprostatic ligaments were severed close to the prostate to preserve their length, since they were later used for the anterior suspension of the vesicourethral anastomosis. The dorsal vein complex (DVC) was ligated twice using 2-0 absorbable sutures (Polysorb, 3/8, 32-mm needle; Covidien, Mansfield, MA, USA). The bladder neck was maximally preserved in all the patients. Following complete dissection of the posterior bladder neck, the vas deferens and seminal vesicles were identified and dissected. The seminal vesicles were retracted ventrally to expose the posterior DF. The DF was incised horizontally and the perirectal fat was exposed. In selected patients, the NVB was preserved. In the nerve-sparing technique, heat injury was avoided by using metal clips on blood vessels rather than an electronic coagulator. Following dissection of the dorsal side of the prostate, the DVC was incised with cold scissors and the urethra was exposed. Subsequently, the anterior side of the urethra was incised and the urethral catheter was exposed. At apical dissection, particularly dissection of the dorsal side of the prostatic apex, the lateral-view approach (13) was used,

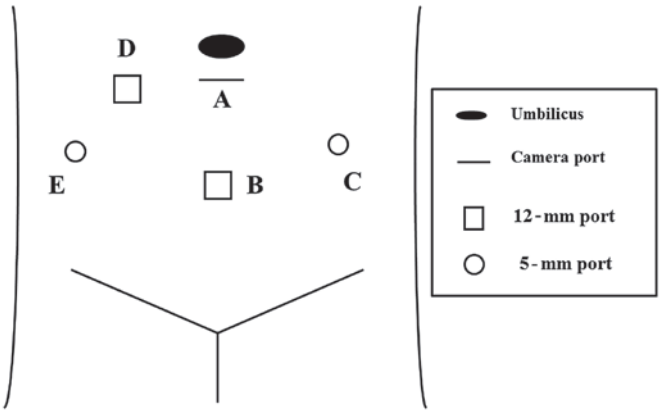

Figure 1. Schema of port sites. (A) The first port was created 3 cm below the umbilicus. Four other trocars were inserted: (B) a midline 12-mm trocar halfway between the umbilicus and the pubis; (C) a 5-mm trocar in the left iliac fossa; (D) a 12-mm trocar at the level of the umbilicus in the right pararectal fossa; and (E) a 5-mm trocar in the right iliac fossa. The surgeon used trocars B and C during the dissection and trocars B, C, D and E for handling the needle according to the required angle and direction.

as it enabled maximizing the functional urethral length and avoiding the incorrect incision of the prostatic apex. After the prostate was removed from the rectal bed, a running suture was placed between the DF and the fibrous tissue under the urethra (MFR) (Fig. 2). The MFR is connected to the cranial aspect of the rectourethralis muscle (RUM) and the RUM is connected to the dorsal aspect of the rhabdosphincter (RS). A vesicourethral anastomosis was then performed by placing double-armed running sutures (~8 sutures) with 2-0 absorbable sutures (Polysorb, 5/8, 27-mm needle). Two 2-0 absorbable ligatures were tied and used for the anastomosis. At the beginning of the anastomosis, the first stitches (at 1 and 11 o'clock on the bladder neck) were placed 1-2 cm dorsocephalad to the bladder neck (first through the seromuscular layer and then through the full thickness of the bladder neck) (Fig. 2). At the 5 and 7 o'clock positions of the urethra the stitches were placed through the urethral mucosa as well as the the reconstructed musculofascial plate. The middle of the running suture was secured with several LAPRA-TY® clips (Ethicon Inc., Bridgewater, NJ, USA). We attempted to push the needles thinly through the anterior urethra (15) and anchor them to the fascia covering the DVC to avoid laceration of the urethra. The double-armed running sutures were finally ligated at the anterior side of the urethra. For the anterior suspension, the vesicourethral anastomosis was then secured at the 1 and 11 o'clock positions of the puboprostatic ligament by using 2-0 absorbable sutures (Polysorb, 5/8, 27-mm needle). The anastomosis was confirmed to be watertight prior to the two pelvic drainage tubes being passed through the 5-mm ports and into the two iliac fossae.

Postoperative cystography. Cystography was performed on postoperative day 5 or 6. A total of 100 ml of saline solution containing contrast media was infused into the bladder and front-view and 45˚-semilateral-view images were captured. Provided there was no leakage or only a minor leakage at the anastomosis, the balloon catheter was removed. If leakage was detected, cystography was again performed 4 or 7 days later,

Table I. Comparison of preoperative background between groups A and B.

Variables	Group A (n=13)	Group B (n=19)	P-value
Age (years)	66.2±4.5	67.1±4.2	0.4778[a]
PSA level (ng/ml)	7.4±2.1	8.4±5.6	0.6590[a]
Clinical T stage (1c/2a/2b/2c)	4/7/2/0	12/4/3/0	0.1330[b]
Gleason's grade (biopsy)			0.4636[b]
3+3	2	8	
3+4	7	7	
4+3	2	2	
4+4	2	2	

[a]Mann-Whitney U test; [b]Chi-square test. PSA, prostate-specific antigen. Data are presented as means ± SD.

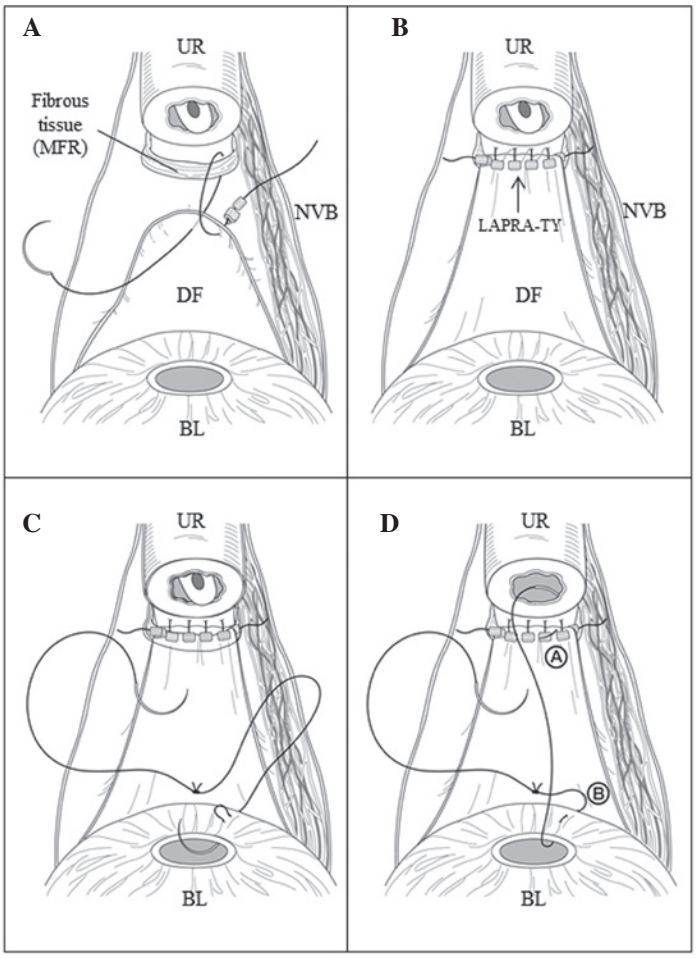

Figure 2. Schemas of our posterior musculofascial plate reconstruction. (A and B) Running suture between DF and the MFR. The running suture was secured by LAPRA-TY® clips. (C) Beginning of the vesicourethral anastomosis by double-armed running sutures with 2-0 absorbable Polysorb sutures. The first stitch (1 o'clock position on the bladder neck) was placed 1-2 cm dorsocephalad to the bladder neck through the seromuscular layer and the full thickness of the bladder neck. (D) Beginning of the vesicourethral anastomosis. The first stitch in the 5 o'clock position of the urethra was placed through the urethral mucosa as well as the MFR. These stitches approximated points 'A' and 'B' and possibly eliminated the need for Rocco's second-layer stitch. BL, bladder; DF, Denonvilliers' fascia; MFR, median fibrous raphe; UR, urethra; NVB, neurovascular bundle.

according to the severity of the leakage. The ratio between the longitudinal and horizontal length (L/H ratio) was measured in the front-view cystogram (Fig. 3); the anterior vesicourethral angle (AVUA) and the posterior vesicourethral angle (PVUA) were measured in the semilateral-view cystogram (Fig. 3). If the catheter removal was delayed due to leakage at the anastomosis, the final cystography session was used for the evaluation.

Factors for evaluation. The factors evaluated are listed in Tables I and II. The clinical and pathological stages were

Table II. Comparison of perioperative surgical results between groups A and B.

Variables	Group A (n=13)	Group B (n=19)	P-value
Operating time (min)	337±67	321±29	0.9084[b]
Blood loss[a] (ml)	1042±1022	897±569	0.9515[b]
Specimen weight (g)	36.0±15.9	34.0±12.2	0.8479[b]
pT stages (pT2a/2b/2c/3a/3b)	3/1/5/3/1	3/3/12/1/0	0.2945[c]
Gleason sum (5/6/7/8/9)	1/0/9/1/2	0/5/13/1/0	0.0961[c]
Surgical margin (-/+)	11/2	15/4	0.6866[c]
Nerve sparing (+/-)	4/9	8/11	0.5153[c]
Oral food intake (POD)	1.6±0.5	1.2±0.4	0.0302[b]
Catheter removal (POD)	8.4±3.0	8.2±2.4	0.9388[b]
Hospital stay (POD)	14.7±3.4	13.8±4.1	0.4836[b]

[a]Blood loss included urine volume. [b]Mann-Whitney U test. [c]Chi-square test. POD, postoperative days.

determined using the 2002 version of the TNM staging system. The daily pad usage (number of pads) at 1, 3, 6 and 12 months after LRP was used to evaluate the recovery of continence and incontinence-free survival rate was determined by the Kaplan-Meier method. The urinary function and urinary bother were also evaluated using the University of California-Los Angeles Prostate Cancer Index scoring system (16).

Statistical analysis. The results are presented as means ± standard deviation and the values of the variables of the different groups were compared using the Mann-Whitney U test. The independence of fit of categorical data was analyzed using the Chi-square test. Incontinence-free survival curves were constructed using the Kaplan-Meier method and the differences between these curves were assessed using the log-rank test. $P<0.05$ was considered to indicate a statistically significant difference.

Results

Preoperative factors. The preoperative factors did not differ significantly between groups A and B (Table I). The only perioperative factor that differed significantly between the two groups was the time until the initiation of oral food intake (Table II). The percentage of patients with leakage of the vesicourethral anastomosis that prevented removal of the urethral catheter did not differ significantly between groups A and B (23.1 vs. 33.3%, $P>0.05$).

Postoperative cystography. The representative postoperative cystograms are presented in Fig. 3. The L/H ratio was significantly higher in group B (93.9±11.2%) compared to that in group A (78.8±14.6%) (P=0.0028) and the PVUA in group B (117±11˚) was significantly narrower compared to that in group A (129±9˚) (P=0.0062). The AVUA in group B (138±10˚) appeared to be narrower compared to that in group A (145±8˚), although the difference was not statistically significant (P=0.0689).

Recovery of urinary continence. The number of pads used daily was significantly lower in group B compared to that in group A at 1 month (4.4±2.0 vs. 2.3±2.1, P=0.0141), 3 months (2.3±1.4 vs. 0.7±1.3, P=0.0026) and 6 months (1.1±1.0 vs. 0.3±0.9, P=0.0048) after LRP, but not at 12 months (0.5±0.9 vs. 0.2±0.5, P=0.4778) after LRP. The time required to achieve a daily pad usage of ≤1 was significantly shorter in group B compared to that in group A (data not shown). At 12 months after LRP, the percentage of patients with a daily pad usage of ≤1 was 76.9% in group A and 94.7% in group B. The time required to achieve a pad-free status (0 pads/day) was significantly shorter in group B (P=0.0352) (Fig. 4).

Urinary function and urinary bother. The preoperative urinary function score and the preoperative urinary bother score did not differ significantly between the two groups (Fig. 5), although the urinary function scores at 3 and 6 months after LRP were significantly higher in group B compared to those in group A (Fig. 5A) (P=0.0013 at 3 months and P=0.0007 at 6 months). These urinary function scores appeared to reflect the daily pad usage at those times. The urinary bother scores at 3 and 6 months after LRP were significantly higher in group B compared to those in group A (Fig. 5B) (P=0.0023 at 3 months and P=0.0061 at 6 months).

Discussion

Achieving early recovery of urinary continence following radical prostatectomy is crucial and early clinical studies evaluating continence recovery following LRP reported that recovery was slower compared to that following RRP (2,3). Although skilled laparoscopic surgeons have achieved excellent results regarding urninary continence following LRP, more experience (number of cases) is generally required to aquire a stable surgical technique in LRP compared to RRP or robot-assisted laparoscopic radical prostatectomy (RALP) (17-19). It is crucial for laparoscopic surgeons to develop simple surgical procedures that improve urinary continence recovery following LRP. In the present study, our

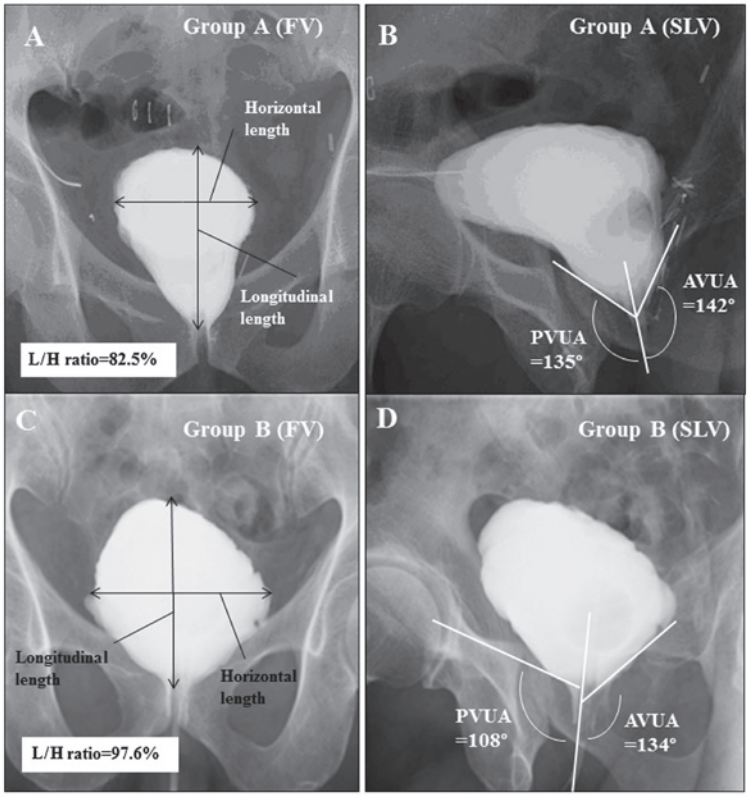

Figure 3. Representative postoperative cystograms. (A) Front view (FV) of a patient in group A. The figure demonstrates how the longitudinal and horizontal length (L/H) ratio was measured. (B) A semilateral view (SLV) of a patient in group A . The figure demonstrates the anterior vesicourethral angle (AVUA) and posterior vesicourethral angle (PVUA). The direction of the urethra was determined by the location of urethral catheter [(A) and (B) are cystograms of the same patient]. (C) FV of a patient in group B. The L/H ratio appeared to be higher in group B compared to that in group A. (D) SLV of a patient in group B. The AVUA and PVUA appeared to be narrower in group B compared to those in group A (C and D are cystograms of the same patient).

modified PMPR procedure was added to previous operative procedures with the intent to expedite continence recovery and significantly improved urinary continence. Nguyen *et al* (7) reported that their PMPR procedure restored the functional urethral length and led to early continence recovery. In that study, the functional urethral length determined by endorectal ultrasonography was decreased by 12.0-15.6 mm following prostatectomy and PMPR restored the urethral length by a mean of 2.0 mm in patients undergoing LRP or RALP. The dorsal aspect of the RS is attached to the RUM (20). There is fibrous tissue between the RUM and the dorsal side of the prostatic apex, referred to as MFR. The DF is connected to the RUM (20) and suturing the DF to the MFR restores the musculofascial plate. Therefore, the membranous urethra that lies within the RS is fixed to the musculofascial plate through the RS. The PMPR recreates the 'fixation point', restores the functional urethral length and may improve sphincteric function. Rocco and Rocco (21) also demonstrated the significance of the second layer of the original Rocco's plate reconstruction and reported that the functional urethral length may also be improved by the second-layer stitch and that the external sphincter may be returned to its original preoperative position.

The development of our modified PMPR procedure was prompted by two observations regarding the findings in postoperative cystograms prior to 2010: first, a significant number of patients undergoing LRP in our institute exhibited a higher longitudinal length of the bladder (compared to the horizontal length) in the front-view postoperative cystogram; and second, a significant number of those patients exhibited a slender funnel-shaped bladder neck (wide AVUA and PVUA) in the semilateral-view cystograms. These radiological findings appeared to be different from those in patients undergoing open RRP. Since the dissected area around the bladder is likely to be more limited in a laparoscopic compared to that in an open procedure (due to the relative lack of blunt dissection) and the bladder is not particularly mobile, the bladder neck may be difficult to pull down caudally during vesicourethral anastomosis in LRP, leading to the slender funnel-shaped bladder neck. Therefore, we hypothesized that early continence recovery may be achieved if the shape of the bladder following vesicourethral anastomosis, particularly that of bladder neck, is improved. When the dorsal upper side of the bladder is pulled down caudally by suturing the DF to the MFR, the longitudinal length of the bladder in the front-view cystogram may be shortened and the PVUA may decrease. Moreover, this procedure may relieve the anastomotic tension at the vesicourethral anastomosis. Our PMPR resulted in a lower L/H ratio and a narrower PVUA, compared to those in patients undergoing LRP without PMPR. In addition to the previously confirmed restoration of the functional urethral length by PMPR (7), the improvement of the PVUA may be one of reasons leading to early continence recovery. Since the percentage of patients with leakage from the vesicourethral anastomosis did not differ significantly between the

two groups in the present study, the leakage did not appear to be associated with continence recovery.

One of the differences between our PMPR and the Rocco stitch is that we used a running suture to attach the DF to the MFR. The running suture stabilizes the attachment, making its rupture unlikely. Coelho *et al* (22) reported that urinary continence following RALP may be improved by PMPR using a running suture to attach the DF to the MFR. In that study, the continence rates at 1 and 4 weeks after RALP were higher in patients with PMPR compared to those in patients without PMPR. Another difference between our procedure and Rocco's procedure is the second-layer suture. As shown in Fig. 2, the bladder was stitched 1-2 cm dorsocephalad to the bladder neck and the reconstructed musculofascial plate at the begining of the vesicourethral anastomosis instead of using the second-layer suture in Rocco's method. The purpose of this stitch was to approximate the bladder wall to the MFR 1-2 cm dorsocephalad to the bladder neck. We hypothesized that this procedure eliminated the need for Rocco's second-layer stitch, approximated points 'A' and 'B' (Fig. 2) and simplified the operative procedure. In the study conducted by Coelho *et al* (22), the posterior lip of the bladder neck (full thickness) and the vesicoprostatic muscle (23) were sutured to the posterior urethral edge and the reconstructed median raphe. The procedure described in that study is similar to ours.

In the present study, urinary continence was recovered earlier in patients with compared to those without PMPR, despite the similar clinical backgrounds and perioperative factors of the two groups. Since we did not modify other surgical procedures intented to improve continence recovery, our PMPR procedure appeared to exert a significant effect on the recovery of urinary continence. Previous studies reported that PMPR improves the recovery of urinary continence (7-10,22). In RALP, however, PMPR was not identified as an independent predictor of the early recovery of urinary continence in a multivariate analysis (14). Sano *et al* (24) suggested that the magnified stereoscopic view and maneuverable instruments in RALP may allow for the preservation of the sphincteric/supporting musculature and, therefore, that PMPR may not be an independent factor in the multivariate analysis. The authors of that study also suggested that plate reconstruction may be beneficial for early continence recovery following standard LRP in a community hospital (i.e., without the extensive fascia preservation possible in RALP). In addition, the percentage of patients with NVB preservation is high among RALP cases (14). Nerve preservation is reportedly a significant factor contributing to early continence recovery (25,26). The high rate of nerve preservation may be one of reasons due to which PMPR is not an independent predictor for the early continence recovery following RALP. In our cases, a nerve-sparing procedure was performed in 37.5% of the patients (bilateral, 3.1% and unilateral, 34.4%) and the percentage of nerve preservation was similar between groups A and B.

This study has several weak points. First, it is a non-randomized retrospective study conducted in a single institute. Second, the study spanned five years, during which time it is possible that the surgeon's surgical skills improved significantly. However, LRP was initiated in our institute in 2000 and the surgeon started performing LRPs as a main operator in

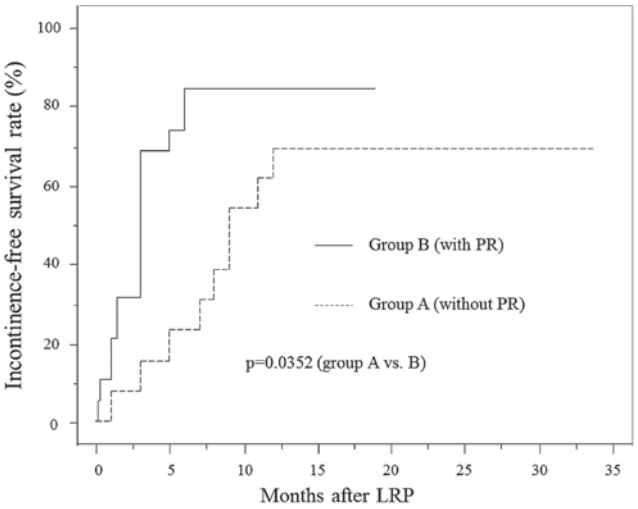

Figure 4. Incontinence-free survival rate. The pad-free status was defined as pads/day=0. The time to attain a continent status was significantly shorter for patients in group B compared to those in group A (P=0.0352). PR, plate reconstruction.

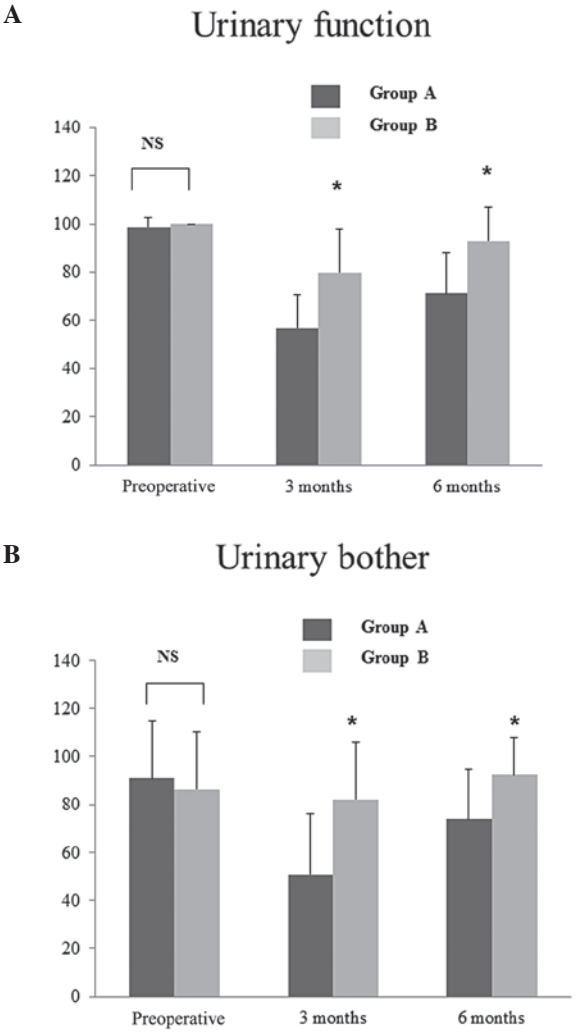

Figure 5. Urinary function and urinary bother scores in groups A and B. (A) The urinary function scores at 3 and 6 months following laparoscopic radical prostatectomy (LRP) were significantly higher in group B compared to those in group A. (B) The urinary bother scores at 3 and 6 months following LRP were significantly higher in group B compared to those in group A. *P<0.05 compared to group A.

2004. Therefore, it is likely that the surgical skills had already become stable by 2008. Third, the patient sample was limited and more patients undergoing LRP with our method should be evaluated to confirm our results. The evaluation of postoperative cystograms indicated that the improvement in the PVUA is a possible reason for the improved continence recovery associated with our PMPR procedure.

In conclusion, although several factors contribute to the recovery of urinary continence, our PMPR procedure combined with the modification of the vesicourethral anastomosis, was shown to improve the PVUA and exert a positive effect on the recovery of urinary continence following LRP.

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