

Early urinary continence recovery after extraperitoneal Retzius-space-sparing robot-assisted radical prostatectomy: a single-center retrospective cohort study

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Abstract

We compared early urinary continence recovery after extraperitoneal Retzius-space-sparing and conventional robot-assisted radical prostatectomy. The Retzius-space-sparing procedure used a transvesical, posteriorly directed dissection within the extraperitoneal access, whereas conventional surgery used the standard anterior dissection. This single-center retrospective cohort included 263 men operated on by one surgeon between January 2024 and December 2025, of whom 198 underwent conventional surgery and 65 underwent the Retzius-space-sparing technique. Social continence was defined as the use of no more than one pad per day and was assessed within 24 hours after catheter removal and at 1, 3, 6 months postoperatively. Membranous urethral length was longer in the Retzius-space-sparing group (1.7 vs 1.6 cm; $P = 0.001$). Continence rates were higher with the Retzius-space-sparing technique at 1 month (81.5% vs 59.6%; $P = 0.002$) and 3 months (93.8% vs 73.7%; $P = 0.001$), but not within 24 hours or at 6 months. After adjustment for prespecified covariates, the odds of continence were higher at 1 month (odds ratio, 3.22; 95% CI, 1.49–6.96) and 3 months (odds ratio, 5.48; 95% CI, 1.82–16.54). In a repeated-measures generalized estimating equation model across all assessments, the adjusted odds ratio was 2.48 (95% CI, 1.55–3.97). In this retrospective cohort, extraperitoneal Retzius-space-sparing robot-assisted radical prostatectomy showed a faster return of early urinary continence than conventional surgery.

INTRODUCTION

Oncologic outcomes after robot-assisted radical prostatectomy (RARP) are now well characterized [1], and attention has correspondingly shifted toward functional recovery, of which urinary continence is among the determinants most consistently reported by patients to affect postoperative quality of life. Continence after prostatectomy depends not only on the external urethral sphincter but also on the anterior periurethral supporting structures surrounding it, including the puboprostatic ligaments, arcus tendineus, anterior detrusor apron, and anterior fibromuscular stroma. Together these structures maintain urethral coaptation and limit displacement of the sphincteric mechanism [2].

This anatomical understanding has motivated surgical strategies that preserve these structures rather than divide and subsequently reconstruct them. Such preservation has been pursued from both posterior and anterior routes. The posterior Retzius-sparing approach, performed transperitoneally, leaves the space of Retzius and its anterior contents intact and has achieved markedly higher early continence rates than the conventional transperitoneal anterior approach [3, 4]. Its adoption, however, requires a posterior corridor whose orientation differs substantially from the anterior dissection familiar to most surgeons, which raises practical questions regarding the learning curve and generalizability beyond experienced centers.

Approaches that retain the conventional anterior corridor while limiting disruption of the same structures offer an alternative. The Hood technique established this principle from the anterior route, preserving the detrusor apron, puboprostatic ligament complex, arcus tendineus, and endopelvic fascia, and reported

early return of continence without compromising margin rates [5]. The feasibility and safety of the extraperitoneal anterior route were established early [6, 7], and a modified conventional anterior approach preserving Retzius space subsequently improved early functional outcomes relative to the standard anterior technique [8]. Both the Hood technique and the modified anterior preservation technique were performed transperitoneally. Pooled comparative data point the same way, favoring extraperitoneal access and Retzius sparing over the conventional transperitoneal anterior approach for continence recovery [9]. These preservation strategies differ conceptually from reconstructive techniques, which divide the anterior supporting structures and restore them at the end of the procedure [10, 11].

The technique evaluated here is best regarded as a variant of these anterior preservation techniques, applied within the extraperitoneal corridor rather than as a new operation. Head-to-head data on extraperitoneal Retzius-space-sparing versus conventional RARP nevertheless remain sparse, and few of the available studies allow for membranous urethral length (MUL), which predicts continence recovery more reliably than almost any other preoperative measure. We therefore compared early continence recovery between extraperitoneal Retzius-space-sparing RARP and conventional RARP in a single-center retrospective cohort drawn from the consecutive practice of one surgeon, adjusting for MUL and other prespecified covariates and modeling all follow-up assessments jointly to account for repeated measures.

MATERIALS AND METHODS

Consecutive men who underwent RARP at Shandong Provincial Hospital between January 2024 and December 2025 were identified for this retrospective, single-center cohort study. Patients with preoperative urinary incontinence, missing baseline data, or incomplete follow-up were excluded. Of 315 patients, 52 were excluded (26 for preoperative incontinence or missing baseline data and 26 for incomplete follow-up), leaving 263 patients (conventional RARP, $n = 198$; extraperitoneal Retzius-space-sparing RARP, $n = 65$) (Fig. 1).

The study was approved by the Ethics Committee of Shandong Provincial Hospital (SWYX: No. 2026 – 836) and conducted in accordance with the Declaration of Helsinki. The same committee waived the requirement for written informed consent because of the retrospective design and use of anonymized data.

Surgical technique

A single senior surgeon performed every case on a four-arm da Vinci Si platform (Intuitive Surgical, Sunnyvale, CA, USA), and the two techniques shared the same extraperitoneal access, port configuration, and docking sequence. With the patient in the Trendelenburg position, an extraperitoneal working space was established through a 3-cm infraumbilical midline incision by blunt development and balloon dilation. Carbon dioxide insufflation was then established to maintain the working space. Ports

comprised one 10-mm camera port with a 30° lens, three 8-mm robotic ports, and a 12-mm assistant port, and an 18-Fr urethral catheter was placed. Working instruments were monopolar scissors, bipolar forceps, and Cadiere forceps.

Conventional RARP

In conventional RARP, the fatty and areolar tissue over the bladder neck, anterior prostate, and endopelvic fascia was cleared to expose the anterior retropubic operative field and puboprostatic ligaments. We incised the endopelvic fascia bilaterally, divided the puboprostatic ligament complex, and suture-ligated the prostatic venous plexus lying beneath those ligaments (dorsal venous complex, DVC) with a 2 – 0 barbed suture. The bladder neck was then taken down, and the plane between the prostate and Denonvilliers' fascia was opened posteriorly as the seminal vesicles were mobilized and the vasa deferentia divided. The dissection was performed along an intrafascial plane to undertake nerve-sparing. The lateral pedicles were controlled and the dissection was carried to the apex, where the urethra was divided. Preoperative oncologic risk dictated how far the pelvic lymph node dissection extended, drawing on prostate-specific antigen (PSA), International Society of Urological Pathology (ISUP) grade group, clinical stage, and pelvic magnetic resonance imaging (MRI) findings.

After specimen removal, posterior reconstruction was performed with a running 3 – 0 barbed (V-Loc) suture. A running double-armed 3 – 0 V-Loc suture completed the vesicourethral anastomosis, starting posteriorly. The 18-Fr catheter was exchanged for a 20-Fr three-way catheter before completing the anterior and lateral walls. Anastomotic integrity was confirmed with 150 mL of saline irrigation, and a pelvic drain was placed.

Extraperitoneal Retzius-space-sparing RARP

Extraperitoneal Retzius-space-sparing RARP used a transvesical, posteriorly directed dissection while preserving the anterior Retzius-space contents and periurethral supportive structures. In this study, Retzius-space sparing refers specifically to preservation of the anterior detrusor apron, puboprostatic ligament complex, endopelvic fascia, and periurethral supportive tissues. The common extraperitoneal working space was established as described above. After the bladder neck was exposed, the anterior bladder neck was opened, the catheter balloon deflated and its tip withdrawn, and the posterior bladder wall was opened to expose the vasa deferentia and seminal vesicles. Denonvilliers' fascia was left intact while the posterior plane was opened up behind the seminal vesicles and the prostate, carried forward to the apex. The dissection therefore proceeded from the prostatic base toward the apex without opening the anterior support structures.

The neurovascular bundles were spared by working in the intrafascial plane between the prostatic capsule and the prostatic fascia, again dissecting from base to apex. The detrusor apron was preserved rather than divided, and the puboprostatic ligament complex and endopelvic fascia were left intact. The

DVC was not routinely suture-ligated; selective bipolar coagulation or limited suture ligation was used only when necessary. Care was taken to preserve the anterior periurethral supportive tissues and functional urethral length. The apex was freed and the urethra divided. Posterior reconstruction and the vesicourethral anastomosis were then performed identically to the conventional procedure.

Outcome assessment

Continence recovery served as the primary outcome, taken to mean social continence, that is, the use of no more than one pad per day. The catheter removal protocol was identical in both groups. Continence was assessed within 24 h after catheter removal and at 1, 3, and 6 months postoperatively, during outpatient visits or structured telephone interviews using a standardized question regarding the number of pads used per day.

Covariates

Prespecified preoperative covariates were age, body mass index (BMI), PSA, prostate volume, MUL, preoperative ISUP grade group, clinical T stage, diabetes mellitus, hypertension, coronary artery disease, and preoperative androgen-deprivation therapy (ADT). MUL was traced on mid-sagittal T2-weighted MRI along the urethral axis, running from the prostatic apex down to the upper edge of the penile bulb, while prostate volume came from the ellipsoid formula. A single radiologist, blinded to both surgical technique and postoperative continence outcomes, took all measurements. No data were missing for the prespecified preoperative covariates in the final analytic cohort, and no imputation was performed. Operative time, lymph node yield, and positive surgical margin status were also recorded.

Statistical analysis

Conventional RARP was the reference group. Continuous data appear as mean $\pm$ standard deviation (SD) or median (interquartile range [IQR]), with group differences tested by the independent-samples t-test or the Mann-Whitney U test according to distribution. Age and measured body weight are additionally given as mean, SD, and range. Categorical comparisons relied on the Yates-corrected chi-square test, switching to Fisher's exact test whenever an expected cell count fell below 5. At each assessment we also calculated unadjusted odds ratios (ORs) with 95% confidence intervals (CIs); the underlying continence counts and these unadjusted ORs appear in Supplementary Table 1.

Adjusted ORs for continence within 24 h after catheter removal and at 1 and 3 months came from separate multivariable logistic regression models, each controlling for the full set of prespecified preoperative covariates, with ISUP grade group and clinical T stage entered as ordinal terms and continuous covariates left in their original units. No 6-month model was fitted, since incontinence at that time point was rare. Full model coefficients are given in Supplementary Table 2.

All four assessments entered a single multivariable generalized estimating equation (GEE) model, specified with a binomial distribution and a logit link, and carrying the covariates used in the logistic models plus time point as an added categorical term. Before fitting, the continuous covariates (age, BMI, PSA, prostate volume, and MUL) and the preoperative ISUP grade group were standardized so that their effects could be reported per 1-SD increase, while clinical T stage entered as an ordinal variable in its original scale. We specified an exchangeable working correlation structure, reflecting the assumption that a given patient's repeated assessments are roughly equally correlated with one another, and used robust standard errors so that the validity of inference would not hinge on that assumption; independence and first-order autoregressive structures were then tried as a sensitivity check. Because all 263 patients completed all four assessments, the dataset for this analysis was a complete 1052 observations with no missing follow-up and therefore no need for imputation. This primary GEE model captures the population-averaged relationship between surgical technique and continence recovery over the repeated follow-up assessments, while any change in the technique effect over time is instead addressed through the separate, time-specific logistic models described above.

Potential confounding by calendar time was examined by comparing the distribution of surgery dates between the two techniques and by adding time since the first procedure (in months) to the primary logistic models, with calendar month computed as elapsed days divided by 30.4375. We also split the conventional group at its median surgery date to describe how case mix and continence changed within that group over the study period; these descriptive comparisons were not used to draw inferences about differences in the technique effect itself.

For the adjusted point estimates and the confidence limits nearest the null, E-values were derived by applying the square-root transformation of the OR to approximate a risk ratio for a common outcome [12], a sensitivity measure that captures how strong unmeasured confounding would need to be to explain the observed association (Supplementary Table 3).

All analyses were carried out in Python 3.11 with the statsmodels and SciPy packages, using two-sided tests throughout and a significance threshold of $P < 0.05$.

RESULTS

Patient characteristics

Of 263 patients, 198 underwent conventional RARP and 65 underwent extraperitoneal Retzius-space-sparing RARP. Data are presented as conventional versus Retzius-space-sparing RARP unless otherwise specified. MUL was longer in the Retzius-space-sparing group (1.6 vs 1.7 cm; $P = 0.001$). Preoperative ADT was recorded in 7.1% versus 15.4% of patients ($P = 0.074$), and positive surgical margins occurred in 19.2% versus 9.2% ($P = 0.094$). Table 1 gives the remaining baseline, operative, and pathological characteristics.

Table 1
Baseline, operative, and pathological characteristics.

Characteristic	Conventional (n = 198)	Retzius-space-sparing (n = 65)	P value
Baseline characteristics			
Age (years)	68.0 (63.0–73.0)	67.0 (61.0–72.0)	0.118
BMI (kg/m ²)	24.9 ± 2.7	25.1 ± 2.7	0.649
PSA (µg l ⁻¹)	14.3 (8.5–31.6)	13.1 (8.3–23.0)	0.234
Prostate volume (mL)	59.8 (45.4–84.8)	55.6 (44.5–74.1)	0.325
MUL (cm)	1.6 (1.4–1.7)	1.7 (1.6–1.8)	0.001
ISUP grade group			0.160
Grade 1	41 (20.7%)	16 (24.6%)	
Grade 2	23 (11.6%)	12 (18.5%)	
Grade 3	58 (29.3%)	10 (15.4%)	
Grade 4	57 (28.8%)	18 (27.7%)	
Grade 5	19 (9.6%)	9 (13.8%)	
Clinical T stage			0.159
T1	18 (9.1%)	12 (18.5%)	
T2	168 (84.8%)	48 (73.8%)	
T3	11 (5.6%)	5 (7.7%)	
T4	1 (0.5%)	0 (0.0%)	
Preoperative ADT	14 (7.1%)	10 (15.4%)	0.074
Diabetes mellitus	40 (20.2%)	16 (24.6%)	0.562
Hypertension	82 (41.4%)	30 (46.2%)	0.599
Coronary artery disease	48 (24.2%)	14 (21.5%)	0.782
Operative data			
Data are median (IQR), mean ± SD, or n (%). Retzius-space-sparing denotes extraperitoneal Retzius-space-sparing RARP. Age: 68.0 ± 7.0 years (range 50–82) versus 66.5 ± 7.1 years (52–80); body weight: 72.0 ± 8.9 kg (50–99) versus 72.8 ± 9.2 kg (53–93), respectively. Continuous variables: t-test or Mann–Whitney U test; categorical variables: Yates-corrected chi-square or Fisher's exact test. ADT, androgen-deprivation therapy; BMI, body mass index; IQR, interquartile range; ISUP, International Society of Urological Pathology; MUL, membranous urethral length; PSA, prostate-specific antigen; RARP, robot-assisted radical prostatectomy; SD, standard deviation.			

Characteristic	Conventional (n = 198)	Retzius-space-sparing (n = 65)	P value
Baseline characteristics			
Operative time (min)	177.5 (150.0–210.0)	170.0 (145.0–190.0)	0.064
Lymph nodes retrieved	4.0 (2.0–6.0)	5.0 (3.0–6.0)	0.227
Pathological outcome			
Positive surgical margins	38 (19.2%)	6 (9.2%)	0.094
Data are median (IQR), mean $\pm$ SD, or n (%). Retzius-space-sparing denotes extraperitoneal Retzius-space-sparing RARP. Age: 68.0 $\pm$ 7.0 years (range 50–82) versus 66.5 $\pm$ 7.1 years (52–80); body weight: 72.0 $\pm$ 8.9 kg (50–99) versus 72.8 $\pm$ 9.2 kg (53–93), respectively. Continuous variables: t-test or Mann–Whitney U test; categorical variables: Yates-corrected chi-square or Fisher's exact test. ADT, androgen-deprivation therapy; BMI, body mass index; IQR, interquartile range; ISUP, International Society of Urological Pathology; MUL, membranous urethral length; PSA, prostate-specific antigen; RARP, robot-assisted radical prostatectomy; SD, standard deviation.			

Continence recovery rates

The Retzius-space-sparing group was more often continent at 1 month (59.6% vs 81.5%; $P = 0.002$) and at 3 months (73.7% vs 93.8%; $P = 0.001$). Neither the 24-h assessment (31.8% vs 41.5%; $P = 0.200$) nor the 6-month assessment (98.0% vs 95.4%; $P = 0.369$) showed a between-group difference (Fig. 2).

Multivariable logistic regression

After adjustment for prespecified covariates, the OR for continence within 24 h after catheter removal was 1.47 (95% CI: 0.79–2.76; $P = 0.228$). The adjusted odds of continence favored Retzius-space-sparing RARP at 1 month (OR: 3.22; 95% CI: 1.49–6.96; $P = 0.003$) and at 3 months (OR: 5.48; 95% CI: 1.82–16.54; $P = 0.003$) (Table 2).

Table 2
Adjusted association between surgical technique and social continence.

Assessment	Adjusted OR (95% CI)	P value
After catheter removal [⊠]	1.471 (0.785–2.756)	0.228
1 month	3.223 (1.493–6.958)	0.003
3 months	5.480 (1.815–16.543)	0.003
[⊠] Within 24 h after catheter removal; other assessments were at the stated postoperative months. Outcome: social continence (≤ 1 pad/day). ORs compare Retzius-space-sparing with conventional RARP. Each model included 263 patients and adjusted for age, BMI, PSA, prostate volume, MUL, ISUP grade group, clinical T stage, diabetes, hypertension, coronary artery disease, and preoperative ADT. Full coefficients and covariate coding appear in Supplementary Table 2. ADT, androgen-deprivation therapy; BMI, body mass index; CI, confidence interval; ISUP, International Society of Urological Pathology; MUL, membranous urethral length; OR, odds ratio; PSA, prostate-specific antigen; RARP, robot-assisted radical prostatectomy.		

Generalized estimating equation analysis

In the GEE model across all four time points, the population-averaged odds of continence recovery were higher with extraperitoneal Retzius-space-sparing RARP (OR, 2.48; 95% CI, 1.55–3.97; $P < 0.001$). The odds of continence fell with higher preoperative ISUP grade group (OR, 0.79; 95% CI, 0.62–0.99; $P = 0.044$) and with preoperative ADT (OR, 0.48; 95% CI, 0.25–0.92; $P = 0.028$). Averaged over the two surgical groups, the modeled odds of continence at 1, 3, and 6 months all exceeded those at the 24-h assessment (Table 3).

Table 3
Generalized estimating equation analysis of social continence.

Variable	Adjusted OR (95% CI)	P value
Patient and treatment characteristics		
Age	0.947 (0.744–1.206)	0.660
BMI	0.929 (0.739–1.167)	0.526
PSA	0.984 (0.802–1.208)	0.877
Prostate volume	0.818 (0.637–1.050)	0.115
MUL	1.144 (0.930–1.408)	0.202
ISUP grade group	0.787 (0.623–0.994)	0.044
Clinical T stage	0.868 (0.499–1.511)	0.617
Diabetes mellitus	1.310 (0.812–2.114)	0.269
Hypertension	1.014 (0.677–1.518)	0.946
Coronary artery disease	0.880 (0.544–1.423)	0.603
Preoperative ADT	0.477 (0.246–0.923)	0.028
Retzius-space-sparing RARP	2.479 (1.547–3.972)	< 0.001
Postoperative assessment		
1 month	3.987 (2.974–5.344)	< 0.001
3 months	8.276 (5.567–12.304)	< 0.001
6 months	84.981 (38.971–185.311)	< 0.001
Binomial model with logit link, exchangeable working correlation, and robust standard errors; 263 patients, 1052 assessments. Outcome: social continence (≤ 1 pad/day). ORs for age, BMI, PSA, prostate volume, MUL, and ISUP grade group are per 1-SD increase; clinical T stage is per category. Reference categories: conventional RARP, absence of each binary condition, and within 24 h after catheter removal. Retzius-space-sparing denotes extraperitoneal Retzius-space-sparing RARP. ADT, androgen-deprivation therapy; BMI, body mass index; CI, confidence interval; ISUP, International Society of Urological Pathology; MUL, membranous urethral length; OR, odds ratio; PSA, prostate-specific antigen; RARP, robot-assisted radical prostatectomy; SD, standard deviation.		
<i>Figures are embedded below at reduced resolution for review. Print-resolution files are supplied separately.</i>		

Surgery date and temporal trends

Both techniques were performed between January 2024 and December 2025. Median surgery dates were 15.3 versus 14.0 months after the first procedure ($P = 0.209$). Additional adjustment for calendar time yielded similar estimates at 1 month (OR: 3.21; 95% CI: 1.49–6.91; $P = 0.003$) and 3 months (OR:

5.48; 95% CI: 1.81–16.55; $P = 0.003$). Within the conventional group, each calendar half included 99 patients. The proportion continent at 1 month was 67.7% in the earlier half and 51.5% in the later half. No patient in the earlier half had clinical T3 disease, against 11 in the later half, and positive margins rose from 12 to 26.

Sensitivity analyses

E-values for the 1- and 3-month associations were 2.99 and 4.11 for the point estimates and 1.74 and 2.03 for the confidence limits closest to the null (Supplementary Table 3). Refitting the GEE model with alternative working correlation structures produced ORs of 2.14 (95% CI: 1.33–3.45; $P = 0.002$) with independence and 2.21 (95% CI: 1.40–3.49; $P < 0.001$) with first-order autoregression, compared with 2.48 (95% CI: 1.55–3.97; $P < 0.001$) with the exchangeable structure.

DISCUSSION

In this single-center retrospective cohort, men who underwent extraperitoneal Retzius-space-sparing RARP were more likely to be continent at 1 and 3 months postoperatively than those who underwent conventional RARP, and the GEE analysis across all four time points yielded a population-averaged adjusted OR of 2.48.

The two techniques differ in how much of the periurethral anatomy they disturb, and this likely accounts for what we observed. Incising the endopelvic fascia bilaterally, taking down the puboprostatic ligament complex, and suture-ligating the dorsal venous complex are all routine in the conventional extraperitoneal anterior approach, and each can undermine the anterior support of the membranous urethra and thereby blunt the passive continence mechanism [5, 13, 14, 15]. Extraperitoneal Retzius-space-sparing RARP instead avoids bilateral endopelvic fascia incision and minimizes disruption of the anterior detrusor apron, puboprostatic ligament complex, dorsal venous complex, and periurethral supportive tissues, which could help maintain urethral stability during early recovery [2, 16]. Beyond this anatomical rationale, the approach offers a practical advantage in that it preserves the familiar extraperitoneal anterior corridor while limiting dissection around the anterior urethral support complex.

MUL differed between groups and is an established preoperative predictor of continence recovery [17, 18, 19, 20]. The longer MUL in the Retzius-space-sparing group could have favored its outcomes. The association between technique and early continence persisted after adjustment for MUL, but this adjustment cannot exclude residual confounding from measurement error, model specification, or unmeasured anatomical factors. The 0.1-cm difference in group medians should therefore be considered when interpreting the comparison.

The closest comparisons come from anterior techniques built around preserving periurethral support. Three principles link the present technique to both the Hood technique and the modified anterior preservation approach: the endopelvic fascia is left uncut bilaterally, the detrusor apron and puboprostatic ligament complex stay intact, and the dorsal venous complex is not routinely suture-

ligated [5, 8]. The present technique follows these principles within an extraperitoneal corridor and should be regarded as a variant rather than a new operation. The original Hood series included 300 patients without a control arm [5], whereas the present cohort provides a concurrent comparison with conventional extraperitoneal RARP. A systematic review of comparative studies also reported favorable continence outcomes with extraperitoneal and Retzius-sparing approaches [9]. Reports of the posterior transperitoneal Retzius-sparing approach provide additional context [3, 4, 21, 22, 23]. Dynamic MRI findings support the relevance of periurethral structures [24], and MUL has been associated with continence after Retzius-sparing surgery [25]. These findings are consistent with the anatomical rationale of the present technique, but differences in patient selection, operative approach, and continence definitions prevent direct numerical comparison or conclusions about the independent contribution of the surgical corridor.

The largest absolute between-group difference was observed at 1 month. Perioperative edema, hematoma, and catheter-related discomfort may influence continence immediately after catheter removal, but these mechanisms were not measured in this study. At 6 months, continence rates exceeded 95% in both groups, and the between-group comparison yielded $P = 0.369$. The observed pattern supports an association with better early continence outcomes. It does not establish equivalence at 6 months or determine longer-term continence outcomes.

In the GEE model, continence odds were lower with higher preoperative ISUP grade group and with preoperative ADT. Higher-grade disease may require wider resection and reduced nerve-sparing, which are relevant to postoperative continence [26, 27]. The ISUP effect estimate corresponds to a one-SD increase in grade group, approximately 1.3 grade groups. Only 24 patients received preoperative ADT, so its association was imprecisely estimated. Androgen deprivation alters body composition and reduces lean mass [28], but we did not measure sphincter muscle mass and cannot offer a mechanism for this association.

The association persisted after additional adjustment for calendar time and under alternative GEE working correlation structures. Taken together, these analyses indicate that the fitted associations hold up across the specifications we examined. The E-values speak only to how strong an unmeasured confounder would have to be. They say nothing about selection bias, measurement error, or model misspecification, and residual confounding arising from the nonrandomized choice of technique and from unmeasured surgical factors cannot be ruled out.

Several limitations bear on how these results should be read. First, the retrospective design and nonrandomized technique selection introduce risks of selection bias and unmeasured confounding. The extent of nerve-sparing was not available as a standardized patient-level variable and could not be included in the models. Second, a single experienced surgeon at a single center accounts for the entire series, so how far these results extend to other operators and settings is unclear. Surgical experience may influence the relationship between anatomy and continence recovery [29]. Third, continence in the conventional group declined over calendar time alongside a shift toward more advanced disease.

Adjustment for surgery date cannot fully account for such changes in case mix or other temporal factors. Fourth, patients with incomplete follow-up were excluded, so the complete-case findings may be affected by selection bias. Fifth, follow-up was limited to 6 months, and erectile and sexual function were not assessed. Long-term functional and oncologic outcomes require further evaluation.

In conclusion, patients who underwent Retzius-space-sparing extraperitoneal RARP had higher odds of urinary continence at 1 and 3 months once prespecified preoperative covariates, MUL included, were taken into account. No between-group difference was detected at 6 months. Prospective multicenter studies with standardized reporting of nerve-sparing and longer functional and oncologic follow-up are needed to confirm these findings.

Declarations

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

SUPPLEMENTARY INFORMATION

Supplementary Tables 1–3, containing the continence counts and unadjusted odds ratios, the full logistic regression coefficients, and the E-value sensitivity analyses, are provided in Online Resource 1.

Author Contribution

Q.F. conceived the study and supervised its design and coordination. Y.Z. performed the statistical analysis and drafted the manuscript. Y.H. collected and managed the clinical data. Y.L. contributed to the statistical analysis. T.D. revised the manuscript critically for important intellectual content. Y.Z. and Y.H. contributed equally to this work. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

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Figures

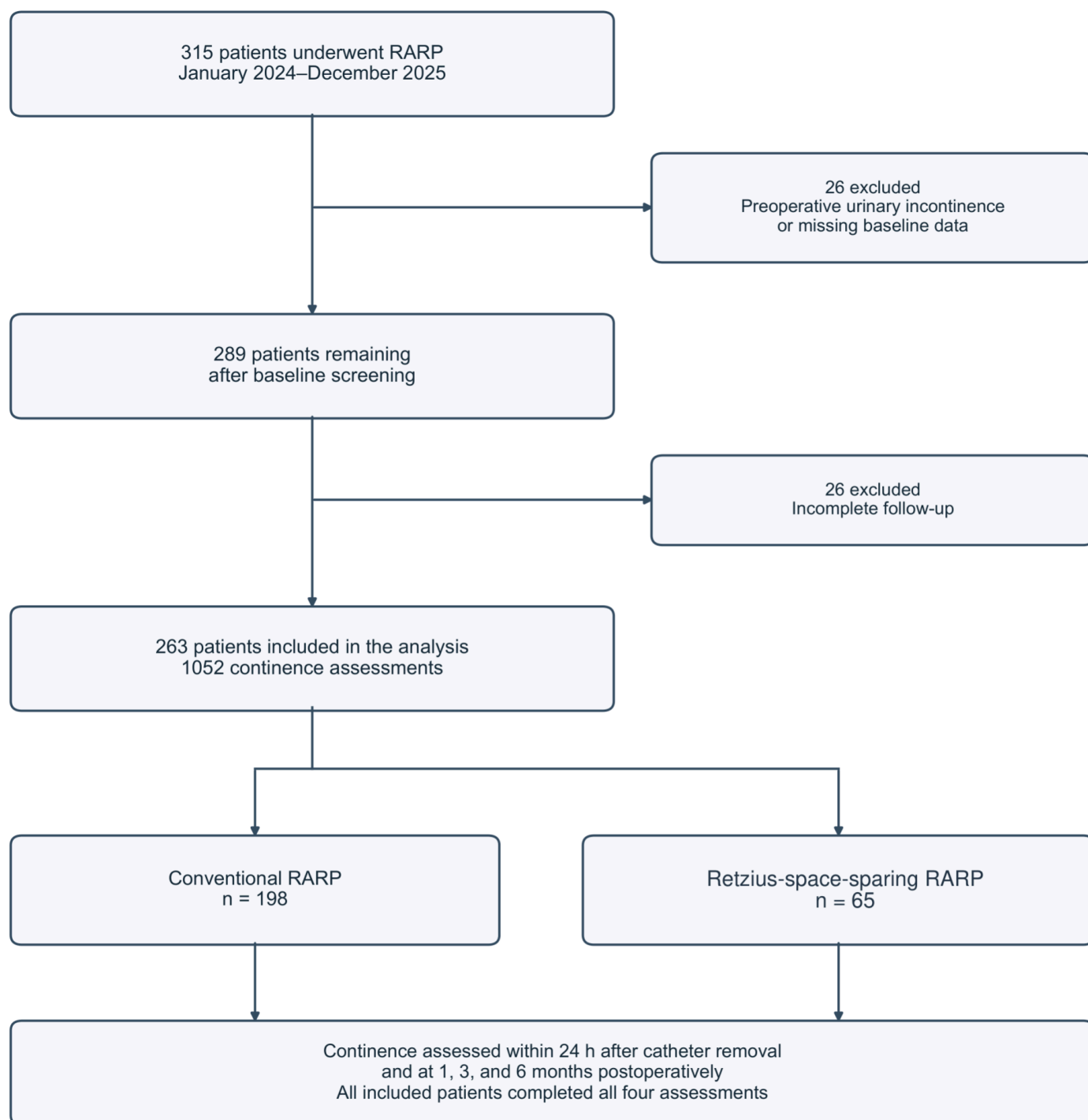


Figure 1

Flow of patients through the study. Of 315 men who underwent robot-assisted radical prostatectomy between January 2024 and December 2025, 26 were excluded for preoperative urinary incontinence or missing baseline data and a further 26 for incomplete follow-up, leaving 263 patients who contributed 1052 continence assessments. Boxes on the central axis give the cohort at each stage and boxes to the right give the exclusions; the two lower boxes give the technique groups, and the bottom box states the assessment schedule, which every included patient completed

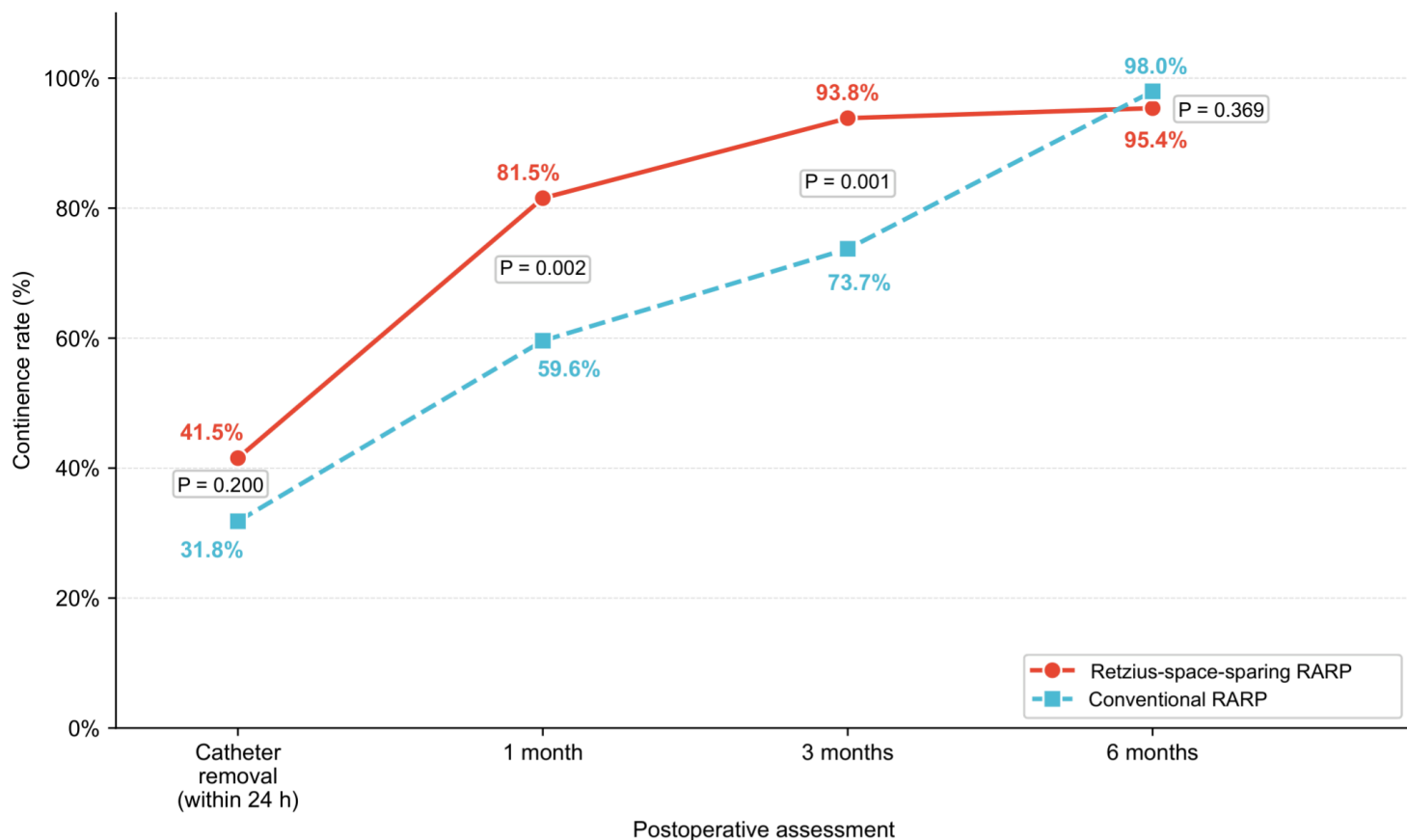


Figure 2

Social continence after conventional and extraperitoneal Retzius-space-sparing robot-assisted radical prostatectomy. Social continence was defined as the use of no more than one pad per day and was assessed within 24 h after catheter removal and at 1, 3, and 6 months postoperatively. Circles joined by a solid line give the Retzius-space-sparing group and squares joined by a dashed line the conventional group, with the continence rate printed beside each point. Boxed values give the between-group P value at that assessment, from the chi-square test with Yates' correction or Fisher's exact test

Supplementary Files

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