

# Early Experience with Robot-Assisted Radical Prostatectomy Using the Toumai System: Outcomes from the First African Series of 134 Patients

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## Research Article

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# Abstract

## Background

Robot-assisted radical prostatectomy (RARP) is widely used for localized prostate cancer, offering enhanced precision and potential preservation of urinary and sexual function. Data on new robotic platforms in Africa are limited.

## Objective

To report the first African clinical series using the Toumai robotic system in Morocco, analyzing perioperative, oncological, and functional outcomes.

## Methods

We retrospectively analyzed 134 patients who underwent RARP with the Toumai system between May 2024 and November 2025. Preoperative data, perioperative parameters, pathological findings, functional outcomes, and postoperative PSA were collected. Urinary continence and erectile function were assessed at 1, 3, 6, 9, and 12 months postoperatively.

## Results

The mean age was 67.3 years and mean preoperative PSA was 13.47 ng/mL. Most patients were intermediate risk (52.2%). Mean operative time was 262.8 minutes, with low blood loss (65.9 mL) and one conversion to open surgery (0.75%). Mean hospital stay was 1.4 days. Postoperative complications were rare (14.9% Clavien–Dindo I–II, 1.5% major), with no mortality. Positive surgical margins occurred in 11.1%, and lymph node involvement in 8%. After a median follow-up of 6 months (IQR: 3–18 months), 19.5% of patients showed biochemical recurrence. Urinary continence improved progressively from 30.6% at 1 month to 60.9% at 9 months and 88.2% at 12 months. Spontaneous erectile function increased from 17.6% at 3 months to 41.2% at 12 months.

## Conclusion

RARP with the Toumai system is safe and feasible in an African setting, showing acceptable early oncological outcomes with short follow-up and progressive functional recovery. Early biochemical control and continence rates are encouraging, while erectile function recovery remains gradual, highlighting the impact of surgical experience and the need for structured rehabilitation and long-term follow-up.

## Introduction

In men, prostate cancer is among the most common cancers and represents a significant cause of morbidity and mortality. Among treatments for localized disease, radical prostatectomy, described by Young in 1904, remains a reference curative option [1]. Minimally invasive approaches, including robot-assisted surgery, have significantly changed operative practice, offering enhanced precision [2].

This technology provides high-definition three-dimensional visualization, more precise instrument manipulation, and greater accuracy of movements, contributing to preservation of the neurovascular structures and seminal vesicles and to a reduction in intraoperative complications [3]. Robotic systems such as the Da Vinci and Toumai systems, have expanded minimally invasive surgery by offering real-time visualization and reducing surgeon fatigue [4].

Robot-assisted radical prostatectomy (RARP) offers significant perioperative and functional advantages, with reduced blood loss and transfusion rates, a lower rate of positive surgical margins, and improved nerve preservation, promoting recovery of urinary continence and erectile function. The primary objective remains optimal oncological control while preserving these functions, constituting the “trifecta,” the achievement of which depends closely on surgeon experience and case volume [5–8].

We present here the first African series of 134 patients who underwent RARP performed with the Toumai system for prostate cancer in a private Moroccan center.

## **1. Methods**

### **1.1. Study population**

This retrospective study is based on prospectively collected data from 134 patients who underwent RARP with the Toumai system for localized prostate cancer in a private center in Casablanca between May 2024 and November 2025.

### **1.2. Data**

Preoperative data included: age, comorbidities, initial prostate specific antigen (PSA), biopsy Gleason score, clinical stage, and D’Amico risk classification.

Perioperative parameters analyzed included: operative time, console time, blood loss, use of transfusion, conversion to open surgery, and preservation of the neurovascular bundles (NVB). Pathological results were assessed on the surgical specimen, including: Gleason score, TNM stage, presence of positive surgical margins (PSM), and lymph node involvement. PSM were defined by the presence of tumor at the surgical margin, focal or extensive (> 1 cm).

Oncological follow-up was ensured by PSA measurement at 6 weeks, then every 3 months during the first year, and every 6 months from the second year onward. Biochemical recurrence (BCR) was defined as  $PSA \geq 0.2$  ng/mL. Biochemical recurrence-free survival (BRFS) was estimated using the Kaplan–Meier method, and patients without BCR were censored at their last available PSA follow-up

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The study was carried out while adhering to patient confidentiality and data protection regulations. All patients included in the study provided informed consent for the collection and use of their clinical data for scientific research purposes.

Patient information was anonymized to ensure confidentiality and protect their identity. No personally identifiable details were disclosed as part of this study.

### **1.3. Functional evaluation**

Urinary continence was assessed using a standardized questionnaire, classifying patients as: continent (no pads), mild incontinence (1–2 pads/day), moderate (3–4 pads/day), or severe ( $\geq 5$  pads/day).

Postoperative erectile function was assessed according to patients' ability to achieve and maintain an erection sufficient for sexual intercourse, with or without pharmacological treatment.

### **1.4. Surgical technique**

All procedures were performed using a four-arm transperitoneal robot-assisted approach with the Toumai robot.

Pelvic iliac lymph node dissection, was performed selectively according to the estimated risk of nodal involvement based on validated nomograms (Memorial Sloan Kettering Cancer Center (MSKCC)).

Prostatectomy began with entry into the space of Retzius, followed by anterior and lateral dissection of the prostate, opening of the bladder neck, then dissection of the seminal vesicles and vas deferens. Prostatic pedicles were controlled with clips. A urinary catheter was left in place, with placement of a pelvic drain according to intraoperative assessment. The degree of NVB preservation was not classified using a standardized system and was reported based on operative notes.

### **1.5. Statistical analysis**

All analyses and visualizations were performed using R software, version 4.3.2. Continuous variables were described as mean  $\pm$  standard deviation. Categorical variables were expressed as counts and percentages. Clinical, oncological, and functional outcomes were analyzed and presented descriptively.

## **2. Results**

Preoperative clinicoradiological characteristics of the 134 included patients are presented in Table 1. Mean age was 67.3 years (range: 50–84). The most frequent comorbidities were hypertension (28.4%), followed by diabetes (15.7%) and cardiovascular disease (8.2%). Mean preoperative PSA was 13.47 ng/mL (2.1–150).

Histological analysis of biopsies showed a predominance of intermediate-risk disease. Among the 108 patients with available data, targeted biopsy was performed in 71.3% of cases. According to D'Amico

classification, 52.2% of patients were intermediate risk, 24.6% were high risk.

Extracapsular extension (ECE) was suspected in 8.1% of patients, while seminal vesicle invasion (SVI) was suspected in 16.2%.

Table 1  
Preoperative clinicoradiological characteristics of patients undergoing RARP (n = 134)

| Variable                              | Value                                  |
|---------------------------------------|----------------------------------------|
| Age                                   | Mean age, years (range): 67.36 (50–84) |
| Comorbidities                         |                                        |
| Cardiovascular disease                | 11 (8.2%)                              |
| Hypertension                          | 38 (28.4%)                             |
| Diabetes                              | 21 (15.7%)                             |
| Preoperative PSA                      |                                        |
| Initial PSA, ng/mL (range)            | 13.47 (2.1–150)                        |
| Prostate                              |                                        |
| Prostate weight, g (range)            | 45.55 (19–194)                         |
| Systematic biopsies (n = 134)         |                                        |
| Gleason 3 + 3                         | 21 (15.7%)                             |
| Gleason 3 + 4                         | 48 (35.8%)                             |
| Gleason 4 + 3                         | 22 (16.4%)                             |
| Gleason 4 + 4                         | 16 (11.9%)                             |
| Gleason 4 + 5                         | 2 (1.5%)                               |
| Gleason 5 + 4                         | 2 (1.5%)                               |
| Gleason 5 + 5                         | 1 (0.7%)                               |
| Missing data                          | 22 (16.4%)                             |
| Targeted biopsy (n = 108)             |                                        |
| Yes                                   | 77 (71.3%)                             |
| No                                    | 31 (28.7%)                             |
| Missing data                          | 26 patients                            |
| D'Amico risk classification (n = 134) |                                        |
| Low risk                              | 16 (11.9%)                             |
| Intermediate risk                     | 70 (52.2%)                             |
| High risk                             | 33 (24.6%)                             |
| Missing data                          | 15 (11.2%)                             |

| Variable                                   | Value       |
|--------------------------------------------|-------------|
| Preoperative MRI (n = 111)                 |             |
| PIRADS 2                                   | 3 (2.7%)    |
| PIRADS 3                                   | 8 (7.2%)    |
| PIRADS 4                                   | 56 (50.5%)  |
| PIRADS 5                                   | 44 (37.6%)  |
| Number of MRI lesions                      |             |
| 1 lesion                                   | 48 (43.2%)  |
| 2 lesions                                  | 27 (24.3%)  |
| ≥ 3 lesions                                | 36 (32.4%)  |
| Extension suspected on MRI                 |             |
| Suspected ECE                              | 9 (8.1%)    |
| No suspected ECE                           | 102 (91.9%) |
| Suspected SVI                              | 18 (16.2%)  |
| No suspected SVI                           | 93 (83.8%)  |
| Neurovascular bundle preservation (n = 88) | 74 (84.1%)  |

## 2.1. Perioperative parameters and postoperative complications

Analysis of perioperative parameters and immediate recovery after RARP showed a mean operative time of 262.8 minutes (range: 140–630), including 203 minutes on the robotic console (100–585).

Conversion to open surgery was required in one case (0.75%) due to parietal bleeding that could not be adequately controlled laparoscopically, and estimated mean blood loss was 65.9 mL (50–100). Mean length of stay was 1.4 days [1–3], and the urinary catheter was maintained for a mean of 7 days (Table 2).

Immediate intraoperative complications were rare, occurring in only one patient (0.7%). Complications occurring within 30 postoperative days were classified according to the Clavien–Dindo system (Table 2). Among the 134 patients, minor complications (grades I–II) were most frequent, representing 14.9% of cases. One major grade III complication and one grade IV complication were reported, while no postoperative deaths (grade V) were observed.

Table 2  
Perioperative parameters and postoperative complications

| Parameter / Complication                        | Value / %       |
|-------------------------------------------------|-----------------|
| Mean operative time (min)                       | 262.8 (140–630) |
| Mean console time (min)                         | 203 (100–585)   |
| Conversion to open surgery                      | 1 (0.75%)       |
| Mean estimated blood loss (mL)                  | 65.9 (50–100)   |
| Mean length of hospital stay (days)             | 1.4 (1–6)       |
| Mean duration of bladder catheterization (days) | 7               |
| Intraoperative complications (n, %):            |                 |
| - Minor complications (Clavien–Dindo I–II)      | 20 (14.9%)      |
| - Major complications (Clavien–Dindo III–IV)    | 2 (1.5%)        |
| - Postoperative deaths (Clavien–Dindo V)        | 0 (0%)          |

## 2.2. Oncological outcomes

Oncological outcomes after RARP are presented in Table 3. Comparison between biopsy Gleason score and surgical specimen Gleason score was possible in 79 patients: 29.1% had upgrading, 55.7% showed no change, and 15.2% had downgrading.

Lymphadenectomy was performed in 71 patients among those with available data, with an overall lymph node positivity rate of 8%. Surgical margins were positive in 10 of 91 patients (11.0%). Regarding pathological stage, 64.8% of patients were classified as pT2 and 35.2% as  $\geq$ pT3 (Table 3).

## Postoperative PSA evolution and biochemical recurrence

Postoperative follow-up was performed using serial PSA measurements to assess early biochemical control after RARP (Table 4).

Median follow-up was 6 months (IQR: 3–18 months). At 6 weeks, biochemical control was achieved in 90.8% of patients, while BCR was observed in 9.2%. At 3 months, 83.8% of patients remained under biochemical control, whereas 16.2% had BCR. At 6 months, biochemical control was maintained in 80.5% of patients, while BCR was observed in 19.5%. At 9 months, 80.0% of patients remained under biochemical control, whereas 20.0% had BCR. Finally, at 12 months, biochemical control was maintained in 77.4% of patients, while 22.6% had BCR.

Kaplan–Meier analysis showed estimated BRFS rates of 85.3%, 79.4%, 74.6%, and 68.1% at 3, 6, 9, and 12 months, respectively (Fig. 1).

Table 3  
Oncological outcomes after RARP

| Variable                                                                                   | n (%)         |
|--------------------------------------------------------------------------------------------|---------------|
| Gleason score (n = 79)                                                                     |               |
| – Grade upgrading                                                                          | 23<br>(29.1%) |
| – Unchanged grade                                                                          | 44<br>(55.7%) |
| – Grade downgrading                                                                        | 12<br>(15.2%) |
| Lymphadenectomy performed (n = 95)                                                         | 71<br>(74.7%) |
| – Overall lymph node positivity rate (among the 71 patients who underwent lymphadenectomy) | 8%            |
| Positive surgical margins (n = 91)                                                         | 10<br>(11.1%) |
| – pT2 stage                                                                                | 59<br>(64.8%) |
| – > pT3 stage                                                                              | 32<br>(35.2%) |

Table 4  
Biochemical outcomes after RARP

| Follow-up | n   | PSA < 0.2 ng/mL, n (%) | PSA ≥ 0.2 ng/mL (BCR), n (%) |
|-----------|-----|------------------------|------------------------------|
| 6 weeks   | 109 | 99 (90.8%)             | 10 (9.2%)                    |
| 3 months  | 80  | 67 (83.8%)             | 13 (16.2%)                   |
| 6 months  | 77  | 62 (80.5%)             | 15 (19.5%)                   |
| 9 months  | 60  | 48 (80.0%)             | 12 (20.0%)                   |
| 12 months | 31  | 24 (77.4%)             | 7 (22.6%)                    |

Percentages were calculated according to the number of patients with available PSA measurements at each follow-up time point.

**Figure 1.** Kaplan-Meier curve for biochemical recurrence-free survival.

## 2.3. Functional outcomes

### 2.3.1. Urinary continence and erectile function

Functional outcomes after RARP, including urinary continence and erectile function, are presented in Table 5. Urinary continence improved over time. One month after surgery, 30.6% of patients were fully continent, 31.8% had mild incontinence, 36.5% moderate incontinence, and 1.8% severe incontinence. Continence rates increased to 34.9% at 3 months, 49.2% at 6 months, 60.9% at 9 months, and 88.2% at 12 months, reflecting a progressive improvement in urinary function (Table 5) (Fig. 2A).

Erectile function also showed gradual improvement. At 3 months postoperatively, 17.6% of patients had spontaneous erections, 28.2% required pharmacological or mechanical assistance, and 54.1% had no erections. The proportion of patients with spontaneous erections increased to 18.5% at 6 months, 26.8% at 9 months, and 41.2% at 12 months (Table 5) (Fig. 2B).

Table 5  
Functional Outcomes (Urinary Continence and Erectile Function)

| Category                         | 1 month (n = 85) | 3 months (n = 83) | 6 months (n = 65) | 9 months (n = 41) | 12 months (n = 34) |
|----------------------------------|------------------|-------------------|-------------------|-------------------|--------------------|
| Continence (0 pads)              | 26 (30.6%)       | 29 (34.9%)        | 32 (49.2%)        | 25 (60.9%)        | 30 (88.2%)         |
| Mild incontinence (1–2 pads)     | 27 (31.8%)       | 18 (21.7%)        | 13 (20.0%)        | 8 (19.5%)         | 7 (20.6%)          |
| Moderate incontinence (3–4 pads) | 31 (36.5%)       | 31 (37.3%)        | 15 (23.1%)        | 8 (19.5%)         | 3 (8.8%)           |
| Severe incontinence (≥ 5 pads)   | 1 (1.8%)         | 5 (6.0%)          | 5 (7.7%)          | 3 (7.3%)          | 4 (11.8%)          |
| Spontaneous erectile function    | -                | 15 (17.6%)        | 12 (18.5%)        | 11 (26.8%)        | 14 (41.2%)         |
| Assisted erectile function       | -                | 24 (28.2%)        | 13 (20.0%)        | 5 (12.2%)         | 5 (14.7%)          |
| No erectile function             | -                | 46 (54.1%)        | 40 (61.5%)        | 25 (61.0%)        | 15 (44.1%)         |

### 3. Discussion

RARP is widely used for localized prostate cancer. Systematic reviews and meta-analyses show that RARP reduces blood loss, transfusion requirements, and length of hospital stay compared to open surgery, with comparable short-term oncological outcomes [9, 10]. Randomized trials also show robotic surgery promotes faster recovery of urinary and erectile function without compromising oncological control [11]. Meta-analyses suggest RARP may outperform laparoscopic surgery in continence and erectile function due to better preservation of anatomical structures [12].

However, data from African series remain limited [13, 14]. This study evaluates perioperative, oncological, and functional outcomes of RARP with the Toumai in clinical practice. RARP with the Toumai system showed high feasibility and safety. The mean operative time (262.8 minutes), low blood

loss [65.9 mL], and low conversion rate to open surgery (0.75%) demonstrate precision, stability, and improved anatomical visualization. These results confirm RARP is a safe, reproducible technique, comparable to international series using established robotic platforms [4]. Meta-analyses show reduced blood loss and transfusion requirements, indicating the Toumai system can perform similarly to platforms like the Da Vinci [4, 9, 12]. The major complication rate (1.5%) is low, with most being minor and transient. These findings align with large RARP series where most complications are Clavien–Dindo I–II [15–18]. The absence of postoperative mortality supports the procedure's safety, even in an African setting with limited robotic access.

Regarding oncological control, the overall positive surgical margin rate (11%) observed in our cohort is lower than or comparable to that of large contemporary RARP series (15–16%) and is also lower than that observed after open prostatectomy in some population studies (13.6% vs 18.3%) [12, 19]. Meta-analyses confirm robotic surgery reduces positive margins, particularly in high-risk patients, while maintaining comparable oncological outcomes [20–22]. Indeed, large contemporary RARP series describe an overall positive margin rate around 15.7% (1,272 patients out of 8,095) [23]. Positive surgical margins after RARP have also been shown to be associated with preoperative factors, including higher PSA levels and a short interval between biopsy and surgery, even among low-risk patients [24]. These findings highlight the importance of careful surgical planning and optimization of surgical timing. The Gleason score upgrade observed in nearly 30% of patients reflects common preoperative underestimation of tumor grade [25].

In our series, the majority of patients demonstrated satisfactory early biochemical control after RARP with the Toumai system. The rate of biochemical recurrence was 9.2% at 6 weeks, increasing to 16.2% at 3 months and 19.5% at 6 months. This progressive increase in BCR over time likely reflects the occurrence of early biochemical recurrence in a subset of patients, particularly those with unfavorable pathological features such as positive surgical margins or advanced pathological stage, which are known predictors of recurrence [26]. At 9 and 12 months, the proportion of patients with BCR reached 20% and 22.6%, respectively, indicating a continued but moderate rise in recurrence during the first postoperative year. These findings are consistent with previous RARP series reporting that most biochemical recurrences occur within the first year following surgery [27].

Kaplan–Meier analysis demonstrated a progressive decline in biochemical recurrence-free survival after robot-assisted radical prostatectomy using the Toumai system. Early events contributed to an initial decrease in survival probability, followed by a more gradual slope over time. The estimated biochemical recurrence-free survival rates were 79.4% at 6 months and 68.1% at 12 months.

The number of patients at risk decreased progressively from 109 at 6 weeks to 31 at 12 months, reflecting the natural attrition associated with retrospective cohort follow-up. Despite this reduction, Kaplan–Meier methodology allowed appropriate estimation of time-to-event outcomes.

The relatively higher early biochemical recurrence rates observed in our series may be influenced by several factors. First, the short duration of follow-up may contribute to an overestimation of early PSA

relapse, particularly in the absence of confirmatory measurements or in cases of transient PSA fluctuations. Second, our cohort included a substantial proportion of intermediate- and high-risk patients, which may partly account for the observed recurrence rates. Third, the progressive decrease in the number of patients at risk over time may introduce attrition bias, potentially affecting the robustness of long-term estimates. Therefore, these findings remain preliminary and warrant confirmation with longer follow-up.

Urinary continence recovery in our series demonstrated a progressive improvement over time. One month after surgery, 30.6% of patients were fully continent, with a substantial proportion still experiencing moderate or severe incontinence. Continence rates increased steadily to 60.9% at 9 months and reached 88.2% at 12 months, reflecting a continuous recovery of urinary function over time [28]. Published studies also report progressive improvement in continence after RARP, with rates of 27% at 1 month, 53.4% at 3 months, 68.5% at 6 months, and 84.9% at 12 months [28], and other multicenter series showing rates above 80–90% at 12 months depending on patient characteristics [29, 30].

Our series represents an early experience with the Toumai system, which may explain slight differences in continence recovery dynamics compared to some international series. Surgical experience and the learning curve are known to influence functional outcomes. A cohort of 1,477 patients showed continence rates increased from 60% to 90% with accumulated experience [31]. Similarly, analyses of single-surgeon series have demonstrated significant improvement in continence rates at 3, 6, and 12 months with increasing experience [32]. Reviews on learning curves in robotic surgery further confirm that functional recovery, including continence, improves progressively with case volume, often beyond the initial learning phase [33].

Erectile function recovery in our series showed a gradual improvement over time. At 3 months, 17.6% of patients had spontaneous erections, increasing to 41.2% at 12 months, while the proportion of patients without erections remained substantial throughout follow-up. These findings are consistent with the literature, where erectile function recovery after RARP is described as a progressive and multifactorial process influenced by nerve-sparing techniques, patient age, and comorbidities. A meta-analysis demonstrated that nerve-sparing surgery significantly improves erectile recovery at 12 months [34]. In addition, sexual rehabilitation strategies, including early use of phosphodiesterase-5 inhibitors or vacuum devices, have been associated with improved functional outcomes at 12 months after RARP [35]. A large systematic review including more than 131,000 patients reported potency rates ranging from approximately 30–54% at 6 months and 41–59% at 12 months, highlighting the variability across studies and confirming that erectile recovery is generally slower and less predictable than urinary continence recovery [36]. Overall, our results align with these observations, demonstrating gradual improvement in erectile function while emphasizing the importance of longer follow-up and optimized postoperative rehabilitation.

This African series of 134 patients demonstrates that RARP performed with the Toumai system is safe and feasible, with overall satisfactory perioperative and oncological outcomes. Postoperative

biochemical control was achieved early, and the positive surgical margin rate is comparable to international series. Urinary and erectile functional recovery was progressive but moderate, reflecting our center's early experience and the impact of the learning curve on functional outcomes. Limitations of the study include its retrospective design, the absence of a control group, and the relatively short follow-up, which limits the assessment of long-term oncological outcomes. In addition, the progressive decrease in the number of patients with available follow-up data over time represents a potential source of bias, particularly for functional and oncological outcomes, and may lead to an overestimation of recovery rates. Although this is a single-center study, it represents the first African experience with the Toumai system, highlighting the novelty of these findings while cautioning against overgeneralization. Despite these limitations, this series provides valuable data in the African context and confirms that RARP with the Toumai system is a credible alternative to established platforms, provided there is appropriate training and management of the learning curve. Long-term prospective follow-up with a larger cohort is needed to fully assess oncological durability and functional recovery, optimizing the technique and setting realistic patient expectations.

## Conclusion

This first African experience confirms the feasibility of RARP using the Toumai system, providing early evidence of its safe implementation in a resource-limited setting.

## Declarations

### Author contributions:

**Y. Ahallal and N. Assaid: Wrote and finalizing the manuscript**

**A. Bakka, K. Belkadi, H. El Neil, R. Samlali: reviewing the manuscript**

**Conflict of Interest: The authors declare that there is no conflict of interest.**

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## Figures

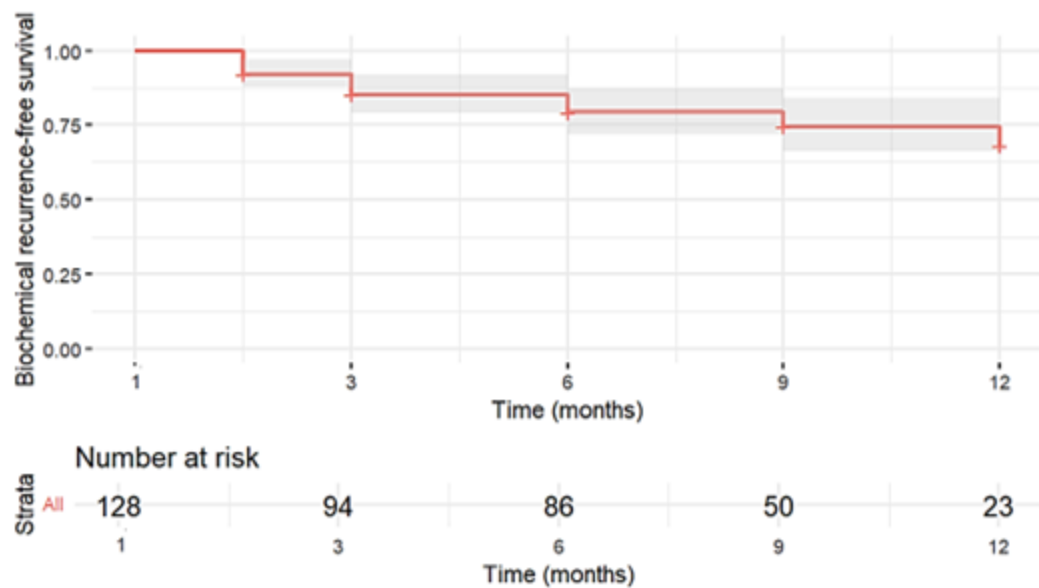


Figure 1

Kaplan-Meier curve for biochemical recurrence-free survival.

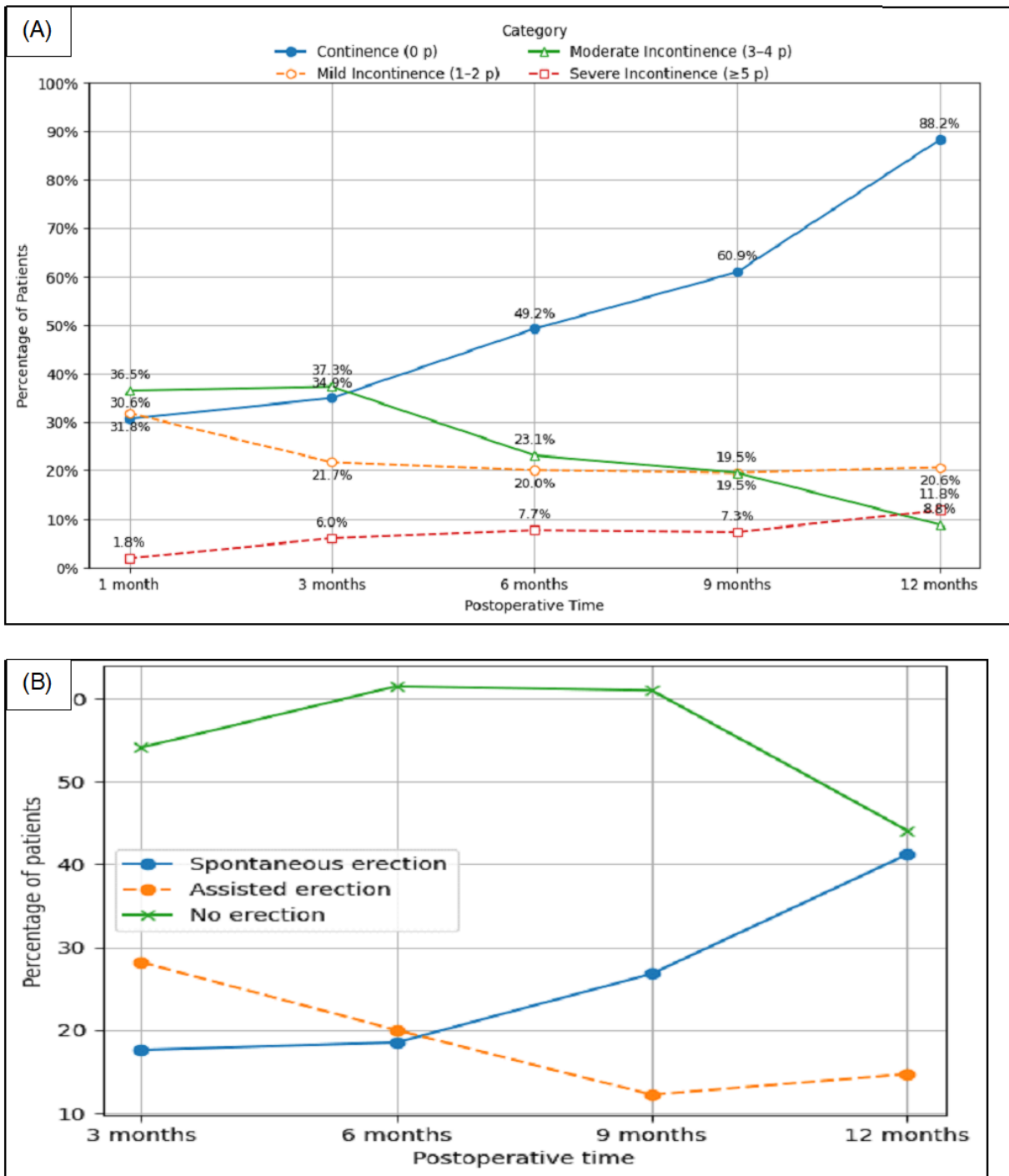


Figure 2

(A) Outcomes of urinary continence following RARP. (B) Outcomes of erectile function following RARP.