

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

journal homepage: [www.elsevier.com/locate/ajur](http://www.elsevier.com/locate/ajur)

## Review

# Erectile function after laparoscopic versus robotic-assisted radical prostatectomy: A systematic review and meta-analysis

Ana J. Pina <sup>a,\*</sup>, Vitor C. Melo <sup>a</sup>, Vinícius W. Carlos <sup>a</sup>,  
Luca S. Tristão <sup>b</sup>, Clara L. Santos <sup>b</sup>, Wanderley M. Bernardo <sup>c</sup>,  
Aguinaldo C. Nardi <sup>a</sup>



<sup>a</sup> Faculdade de Medicina de Bauru da Universidade de São Paulo (FMBRU), Bauru, SP, Brazil

<sup>b</sup> Faculdade de Ciências Médicas de Santos do Centro Universitário Lusíada (FCMS-UNILUS), Santos, SP, Brazil

<sup>c</sup> Faculdade de Medicina da Universidade de São Paulo (FMUSP), São Paulo, SP, Brazil

Received 31 May 2024; accepted 27 August 2024

Available online 19 October 2024

## KEYWORDS

Prostatic neoplasm;  
Robotic-assisted  
surgical procedure;  
Minimally invasive  
surgical procedure;  
Laparoscopic surgical  
procedure;  
Erectile dysfunction

**Abstract** *Objective:* Prostate cancer is a common malignancy in men over 50 years old, and radical prostatectomy, particularly via laparoscopic and robotic-assisted techniques, significantly impacts quality of life, especially in terms of erectile dysfunction. This systematic review and meta-analysis aimed to evaluate the preservation of erectile function following robotic-assisted and laparoscopic radical prostatectomy, with a separate analysis of randomized clinical trials and non-randomized studies.

*Methods:* This review was carried out using randomized and non-randomized studies involving adult patients diagnosed with localized prostate cancer undergoing radical prostatectomy, according to Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines and registered in PROSPERO. Applicable literature from PubMed, Cochrane, Embase, and the Latin American and Caribbean Health Sciences Literature database was analysed. The bias in randomized clinical trials was assessed using the Cochrane Risk of Bias 2.0 tool, and observational studies were evaluated via the Newcastle-Ottawa Scale. The statistical analysis was performed using Review Manager version 5.4.

*Results:* Our analysis included 13 studies involving 6281 patients. Comparative meta-analysis of non-randomized studies demonstrated that robotic techniques were significantly more effective in preserving erectile function at 3 months (risk difference [RD] 0.05, 95% confidence interval [CI] 0.00–0.11;  $p=0.040$ ), 6 months (RD 0.10, 95% CI 0.03–0.17;  $p=0.006$ ), and 12 months postoperatively (RD 0.06, 95% CI 0.02–0.10;  $p=0.002$ ).

*Conclusion:* Robotic-assisted surgery showed greater preservation of erectile function

\* Corresponding author.

E-mail address: [ana2000pina@usp.br](mailto:ana2000pina@usp.br) (A.J. Pina).

Peer review under responsibility of Tongji University.

<https://doi.org/10.1016/j.ajur.2024.10.002>

2214-3882/© 2025 Editorial Office of Asian Journal of Urology. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

3 months, 6 months, and 12 months after radical prostatectomy. However, additional studies with meticulous methodological criteria are necessary for future analysis.

© 2025 Editorial Office of Asian Journal of Urology. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Introduction

Prostate cancer (PCa) is one of the most common neoplasms worldwide, mainly affecting men aged 50 years or older. The incidence among men increased during the early 1990s due to the emergence of prostate-specific antigen, which increased the detection of asymptomatic PCa cases [1]. Global data from 2020 indicate a total of 1 414 259 cases of PCa and 375 304 reported deaths, with a worldwide incidence of 30.7 per 100 000 people [2]. Estimates for new cases in the United States in 2023 are 288 300, with PCa alone accounting for 29% of cancer diagnoses [3].

It is important to note that PCa cases correlate with the gross domestic product and the Human Development Index. Therefore, regions and countries with high gross domestic product and Human Development Index have a higher number of PCa cases due to greater availability of diagnostic tools. Additionally, other factors such as alcohol consumption and smoking also increase the risk of developing advanced PCa [2].

Therefore, early diagnosis and adoption and expansion of the best interventions for localized PCa become essential, including laparoscopic radical prostatectomy (LRP) and robotic-assisted radical prostatectomy (RARP), representing minimally invasive surgical procedures. The first RARP was performed in the 2000s, providing a three-dimensional view and the use of articulated laparoscopic instruments, which offer greater precision compared to human hand dexterity [4].

The treatment of PCa is of unquestionable importance, with post-surgical quality of life being a vital element. As indicated by studies, such as that of Hilger et al. [5], erectile dysfunction is a significant functional consequence in patients who undergo radical prostatectomy, profoundly impacting psychological health and well-being. Despite robotic-assisted surgery being associated with less blood loss, reduced hospital stay, and fewer overall complications [6], the lack of high-quality evidence raises questions about its functional benefits, particularly regarding the preservation of erectile function post-procedure.

This systematic review and meta-analysis aims to evaluate erectile function preservation after RARP and LRP, analyzing randomized clinical trials (RCTs) and non-randomized studies separately. By consolidating existing evidence, the aim of this study is to provide a comprehensive and evidence-based analysis of functional differences between these two surgical techniques, aiding in clinical decision-making and improving the treatment of patients with localized PCa.

## 2. Methods

This systematic review and meta-analysis is in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines [7] and is registered in PROSPERO [8] under registration number CRD42024504235.

### 2.1. Search strategy

The review started from the following clinical question, structured using the population, intervention, comparison, outcome, study design (PICOS) criteria:

- (P) adult patients (>18 years) diagnosed with localized PCa;
- (I) RARP;
- (C) LRP;
- (O) sexual potency;
- (S) RCTs and non-randomized studies, including prospective and retrospective comparative studies.

Searches were conducted in PubMed, Cochrane, Embase, and the Latin American and Caribbean Health Sciences Literature databases. The following search strategy was used: (prostatic neoplasms OR prostate cancer OR prostate neoplasms OR prostatic cancer) AND (robotic OR robotics OR robot OR robotically).

Two independent authors (Pina AJ and Melo VC) assessed the titles and abstracts of the studies, and those meeting the inclusion criteria were selected for this review. In case of disagreement, a third author (Carlos VW) was consulted.

### 2.2. Eligibility criteria

Articles were included based on the following eligibility criteria:

- (I) analysis of erectile function after radical prostatectomy;
- (II) radical prostatectomy via laparoscopic and robotic-assisted approaches for patients with localized PCa;
- (III) full-text articles, with no language restrictions;
- (IV) for the articles derived from the same study, only the largest and most recent study was included.

### 2.3. Data extraction

Data extraction was performed individually by two authors (Pina AJ and Melo VC). The following data were recorded:

- (1) initial data: first author, year of publication, study design, and sample size;
- (2) participant characteristics: age, body mass index, preoperative prostate-specific antigen, prostate volume, preoperative erectile function, preoperative Gleason score (biopsy), clinical and pathologic stage, and positive surgical margin;
- (3) erectile function preservation rates according to follow-up periods;
- (4) nerve preservation rates.

#### 2.4. Quality assessment analysis of selected studies and statistical analysis

Two authors (Pina AJ and Tristão LS) performed the bias analysis of RCTs and non-randomized studies using the Cochrane Risk of Bias 2.0 tool (Supplementary Table 1) [9] and Newcastle-Ottawa Scale (Supplementary Table 2) [10], respectively. Studies with Newcastle-Ottawa Scale scores of 8–9, 4–7, and 1–3 were considered high, moderate, and low quality, respectively.

Statistical analysis was performed using Review Manager version 5.4 (The Cochrane Collaboration; London, United Kingdom). Dichotomous variables were expressed as risk difference (RD) with 95% confidence interval (CI) and were pooled using the Mantel-Haenszel method. The random effects model was used if  $I^2 > 50\%$  and the fixed effects model was used if  $I^2 < 50\%$ . A  $p$ -value of  $< 0.05$  was considered statistically significant. The certainty of the evidence and risk of bias were assessed with the GRADEpro GDT (Evidence Prime, Inc., Hamilton, Ontario, Canada) (Supplementary Table 3).

### 3. Results

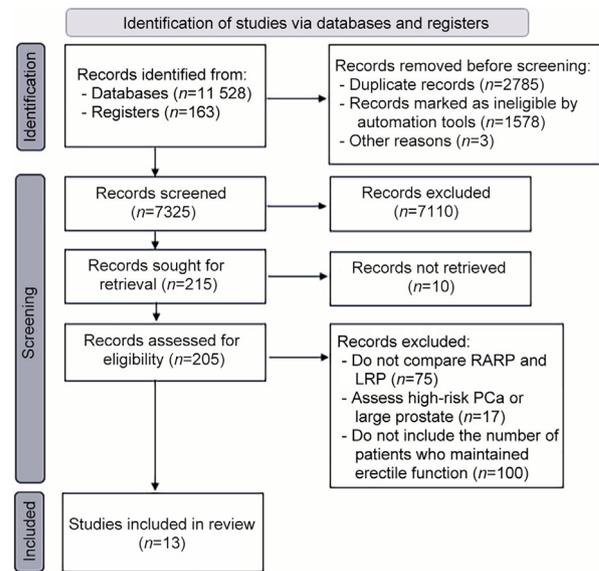
Searches conducted until December 2024 retrieved 7325 articles after removing duplicates, records marked as ineligible by automation tools, or for other reasons, and 215 of these were selected based on the abstracts. Ultimately, 13 articles were included (Fig. 1), involving 6281 patients, with 3694 undergoing RARP and 2587 undergoing LRP in the analysis. Among these 13 articles, four were RCTs and nine were non-randomized studies. Two RCTs represented the same study [11,12], so the most recent one was included [11]. The characteristics of the studies were detailed in Supplementary Table 4 and the demographic and clinical data of the patients were described in Table 1.

#### 3.1. Results of RCTs

The meta-analysis of three RCTs showed no significant difference in erectile function preservation in patients undergoing RARP compared to LRP at 3 months postoperatively (Fig. 2A: RD 0.28, 95% CI  $-0.02$ – $0.58$ ;  $p=0.060$ ; certainty of evidence: very low).

#### 3.2. Results of non-randomized studies

At 3 months postoperatively, the meta-analysis of non-randomized studies with the entire cohort showed significant data favoring RARP (Fig. 2B: RD 0.05; 95% CI



**Figure 1** Flow diagram of search strategy. RARP, robotic-assisted radical prostatectomy; LRP, laparoscopic radical prostatectomy; PCa, prostate cancer.

0.00–0.11;  $p=0.040$ ; certainty of evidence: very low). However, in non-randomized studies with patients undergoing nerve preservation, the meta-analysis showed no significant difference between RARP and LRP (Fig. 2C: RD 0.10, 95% CI  $-0.02$ – $0.22$ ;  $p=0.10$ ; certainty of evidence: very low).

At 6 months postoperatively, both the meta-analysis of non-randomized studies considering the entire cohort and the meta-analysis restricted to patients undergoing nerve preservation showed superiority of RARP over LRP (Fig. 3A: RD 0.10, 95% CI 0.03–0.17;  $p=0.006$ ; certainty of evidence: low, and Fig. 3B: RD 0.14, 95% CI 0.04–0.24;  $p=0.008$ ; certainty of evidence: very low).

The meta-analysis of non-randomized studies evaluating the entire patient cohort at 12 months postoperatively showed that more patients undergoing RARP maintained erectile function compared to laparoscopic surgery (Fig. 4A: RD 0.06, 95% CI 0.02–0.10;  $p=0.002$ ; certainty of evidence: low). However, the meta-analysis of non-randomized studies that analyzed only patients undergoing nerve-sparing surgery, either bilateral or unilateral, in the same period showed no significant difference (Fig. 4B: RD 0.09, 95% CI  $-0.05$ – $0.23$ ;  $p=0.2$ ; certainty of evidence: very low).

### 4. Discussion

This systematic review demonstrated that at 3, 6, and 12 months postoperatively, in non-randomized studies considering the entire cohort, there was greater maintenance of erectile function in patients undergoing RARP. The same result was found in the meta-analysis of non-randomized studies considering patients undergoing unilateral or bilateral nerve preservation at 6 months postoperatively.

In this article, we incorporated data from a substantial number of patients extracted from various studies, both

**Table 1** Characteristics of patients.

Study	Case, n (RARP/ LRP)	Age, year		Preoperative PSA, ng/mL		Gleason score (biopsy), n		Clinical stage, n		Pathologic stage, n		PSM, n		Preoperative IIEF-5 score		Nerve-sparing, n	
		RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP
Asimakopoulos et al. [22]	64/64	59.6 (±5.4) <sup>a</sup>	61.1 (±5.1) <sup>a</sup>	8.9 (5.8–9.2) <sup>b</sup>	7.37 (1.5–9.15) <sup>b</sup>	- 5: 1 - 6: 45 - 7: 6	- 5: 2 - 6: 45 - 7: 13	- T1: 14 - T2: 38	- T1: 25 - T2: 35	- T2a: 7 - T2c: 36 - T3a: 8 - T3 total: 9	- T2a: 5 - T2c: 47 - T3a: 8 - T3b: 0 - T3 total: 8	- Overall: 6 - pT2a: 0 - pT2c: 4 - pT3a: 2 - pT3b: 0	- Overall: 8 - pT2a: 1 - pT2b: 2 - pT3a: 4 - pT3b: 1	23.23 (3.52) <sup>e</sup>	22.73 (3.49) <sup>e</sup>	- All the pro- cedures were per- formed with the intent of BiNS dissection	- All the pro- cedures were per- formed with the intent of BiNS dissection
Porpiglia et al. [11]	60/60	63.9 (6.7) <sup>c</sup>	64.7 (5.9) <sup>c</sup>	6.9 (4.2) <sup>c</sup>	8.3 (6.5) <sup>c</sup>	- 2–6: 25 - 7: 32 - 8–10: 3	- 2–6: 35 - 7: 20 - 8–10: 5	—	—	- T2: 38 - T3: 22	- T2: 38 - T3: 22	- Overall: 16 - pT2: 5 - pT3: 11	- Overall: 12 - pT2: 6 - pT3: 6	20.2 (4.8) <sup>e</sup>	18.9 (6.8) <sup>e</sup>	- BiNS: 11 - UINS: 18 - BiN-S: 6	- BiNS: 14 - UINS: 15 - BiN-S: 6
Stolzenburg et al. [24]	547/171	65 (59–69) <sup>b</sup>	65 (59–70) <sup>b</sup>	7.7 (5.6–12.1) <sup>b</sup>	8.1 (6.0–11.0) <sup>b</sup>	- 5: 1 - 6: 188 - 7: 258 - 8: 61 - 9: 35 - 10: 4	- 5: 0 - 6: 55 - 7: 83 - 8: 23 - 9: 9 - 10: 1	—	—	- T1c: 1 - T2a: 25 - T2b: 5 - T2c: 309 - T3a: 120 - T3b: 64 - T4: 4	- T1c: 0 - T2a: 13 - T2b: 0 - T2c: 101 - T3a: 45 - T3b: 27 - T4: 1	- Rx: 2 - R0: 426 - R1: 101	- Rx: 0 - R0: 162 - R1: 26	14.4 (13.8 –15.0) <sup>b</sup>	15.0 (14.0 –16.0) <sup>b</sup>	- None: 201 - uNS: 52 - bNS: 277	- None: 77 - uNS: 16 - bNS: 95
Hakimi et al. [15]	75/75	59.8 (42–71) <sup>b</sup>	59.6 (43–72) <sup>b</sup>	8.4 <sup>c</sup>	7.5 <sup>c</sup>	- ≤6: 34 - 7: 40 - ≥8: 1	- ≤6: 44 - 7: 28 - ≥8: 3	—	—	- T2: 64 - T3: 11	- T2: 71 - T3: 4	- pT2: 7 - pT3: 2	- pT2: 9 - pT3: 1	—	—	- None: 2 - uNS: 7 - bNS: 51	- None: 8 - uNS: 10 - bNS: 45
Ploussard et al. [25]	1009/1377	62.7 <sup>c</sup>	62.7 <sup>c</sup>	9.2 <sup>c</sup>	9.8 <sup>c</sup>	- 6: 606 - 7: 333 - 8–10: 70	- 6: 905 - 7: 405 - 8–10: 67	- T1c: 825 - T2a, T2b: 157 - T2c, T3: 26 - >T1c: 183	- T1c: 1115 - T2a, T2b: 223 - T2c, T3: 39 - >T1c: 262	- T0: 8 - T2a: 110 - T2b: 14 - T2c: 453 - T3a: 325 - T3b, T4: 99	- T0: 8 - T2a: 141 - T2b: 35 - T2c: 631 - T3a: 417 - T3b, T4: 145	- Overall: 316 - pT2: 113 - pT3: 201	- Overall: 366 - pT2: 135 - pT3: 231	Bilateral preservation: 17.7	Bilateral preservation: 17.6	- None: 205 - UINS: 93 - BiNS: 711	- None: 332 - UINS: 180 - BiNS: 866
Berge et al. [28]	210/210	61.7 (40–76) <sup>a</sup>	61.7 (42–76) <sup>a</sup>	9.0 (2.3 –40.0) <sup>a</sup>	8.6 (2.3–28.0) <sup>a</sup>	- ≤6: 91 - 7: 115 - ≥8: 4	- ≤6: 76 - 7: 126 - ≥8: 7	—	—	- T2: 132 - T3: 77	- T2: 146 - T3: 63	- 62	- 48	—	—	- None: 53 - UIN-S: 66 - BiN-S: 90	- None: 38 - UIN-S: 67 - BiN-S: 105
Park et al. [27]	183/144	63 (44–75) <sup>b</sup>	67 (38–77) <sup>b</sup>	4.98 (0.05 –51.46) <sup>b</sup>	5.84 (0.08 –41.26) <sup>b</sup>	- ≤6: 87 - 3+4: 43 - 4+3: 19 - ≥8: 34	- ≤6: 74 - 3+4: 28 - 4+3: 16 - ≥8: 26	- T1a, T1b: 0 - T1c: 54 - T2a, T2b: 38	- T1a, T1b: 2 - T1c: 48 - T2a, T2b: 32	- T0: 0 - T2a, T2b: 30 - T2c: 97 - T3a: 43 - T3b: 11 - T4: 2	- T0: 1 - T2a, T2b: 25 - T2c: 64 - T3a: 40 - T3b: 12 - T4: 2	- Overall: 25 - pT0: 0 - T2a, T2b: 0 - pT2c: 14 - pT3a: 6 - pT3b: 3 - pT4: 2	- Overall: 22 - pT0: 0 - T2a, T2b: 0 - pT2c: 6 - pT3a: 10 - pT3b: 4 - pT4: 2	16 (0–25) <sup>b</sup>	11 (0–25) <sup>b</sup>	- None: 21 - uNS: 44 - bNS: 112	- None: 61 - uNS: 29 - bNS: 54
İnkaya et al. [26]	778/48	62.3 (6.5) <sup>c</sup>	63.8 (5.8) <sup>c</sup>	8.6 (8.9) <sup>c</sup>	9.2 (4.9) <sup>c</sup>	- <7: 323 - 3+4: 299 - 4+3: 98 - 8: 32 - 9–10: 25	- <7: 13 - 3+4: 21 - 4+3: 10 - 8: 3 - 9–10: 2	—	—	- T2: 456 - T3: 322	- T2: 29 - T3: 17	- Overall: 128 - pT2: 46 - pT3: 84	- Overall: 6 - pT2: 2 - pT3: 4	16 (7.6) <sup>c</sup>	13.7 (4.3) <sup>c</sup>	620	40
Wu et al. [30]	816/276	66.1 (6.7) <sup>c</sup>	66.8 (6.4) <sup>c</sup>	0–5: 94 <sup>d</sup> ; 6 –10: 285 <sup>d</sup> ; 11–20: 233 <sup>d</sup> ; >20: 204 <sup>d</sup>	0–5: 32 <sup>d</sup> ; 6 –10: 95 <sup>d</sup> ; 11 –20: 82 <sup>d</sup> ; >20: 67 <sup>d</sup>	- 2–6: 142 - 3+4: 274 - 4+3: 160 - 8–10: 240	- 2–6: 37 - 3+4: 89 - 4+3: 53 - 8–10: 97	- T1: 195 - T2: 436 - T3, T4: 185	- T1: 75 - T2: 133 - T3, T4: 68	- T1: 237 - T2: 432 - T3a: 76 - T3b: 71	- T1: 83 - T2: 137 - T3a: 30 - T3b: 26	—	—	—	—	—	—
Cheng et al. [31]	68/68	66.2 <sup>c</sup>	67.0 <sup>c</sup>	≤10: 49 <sup>d</sup> ; 10 –20: 15 <sup>d</sup> ; ≥20: 4 <sup>d</sup>	≤10: 47 <sup>d</sup> ; 10 –20: 12 <sup>d</sup> ; ≥20: 9 <sup>d</sup>	- ≤6: 47 - 7: 10 - 8–10: 11	- ≤6: 56 - 7: 8 - 8–10: 4	- T1: 25 - T2: 33 - T3: 10	- T1: 49 - T2: 14 - T3: 4	- T0: 2 - T2: 11 - T2b: 5	- T0: 1 - T2: 14 - T2b: 3	- Overall: 24 - ≤pT2: 11 - ≥pT3: 12	- Overall: 29 - ≤pT2: 21 - ≥pT3: 8	—	—	—	—

(continued on next page)

Table 1 (continued)

Study	Case, n (RARP/ LRP)		Age, year		Preoperative PSA, ng/mL		Gleason score (biopsy), n		Clinical stage, n		Pathologic stage, n		PSM, n		Preoperative IIEF-5 score		Nerve-sparing, n	
	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP	RARP	LRP
Willis et al. [29]	174/175	58.1 (6.3) <sup>c</sup>	58.0 (6.7) <sup>c</sup>	5.7 (2.9) <sup>c</sup>	6: 97 7: 22 8-9: 2	6: 115 7: 41 8-9: 4	T1c: 99 T2a: 22 T2b: 0	T1c: 128 T2a: 29 T2b: 4	T2c: 34 T3a: 13 T3b: 3	T2: 91 T3: 30	T2: 130 T3: 31	Overall: 22 pT2: 6 pT3: 15	Overall: 22 pT2: 12 pT3: 9	—	—	—	—	None: 12 UJN-S: 35 BIN-S: 86
Park et al. [32]	44/52	62.7 (46–71) <sup>a</sup>	65.7 (38–77) <sup>a</sup>	9.14 (1.86–29.5) <sup>a</sup>	6: 25 7: 13 ≥8: 6	6: 34 7: 18 ≥8: 10	T1a, T1b: 0 T1c: 3 T2a, T2b: 19 T2c: 13	T1a, T1b: 2 T1c: 6 T2a, T2b: 19 T2c: 18	T0: 0 T1a, T1b: 2 T2a, T2b: 7 T2c: 23	T0: 1 T1a, T1b: 2 T2a, T2b: 19 T2c: 11	T0: 1 T1a, T1b: 2 T2a, T2b: 10 T2c: 7	T2a, T2b: 0 pT2c: 4 pT3a: 3 pT3b: 0 pT4a: 2	T2a, T2b: 0 pT2c: 2 pT3a: 7 pT3b: 3 pT4a: 1	—	—	—	—	—

RARP, robotic-assisted radical prostatectomy; LRP, laparoscopic radical prostatectomy; IIEF-5, International Index of Erectile Function 5; PSA, prostate-specific antigen; NS, nerve-sparing; BINS, bilateral infratfascial NS; UJNS, unilateral infratfascial NS; BiN-S, bilateral interfascial NS; UJN-S, unilateral interfascial NS; uNS, unilateral NS; PSM, positive surgical margin; Rx, margins that could not be assessed for tumor involvement; R0, no residual tumor; R1, microscopic residual tumor; —, not reported.

<sup>a</sup> Values are presented as mean (range).  
<sup>b</sup> Values are presented as median (range).  
<sup>c</sup> Values are presented as mean (standard deviation) or mean.  
<sup>d</sup> Values are presented as n.

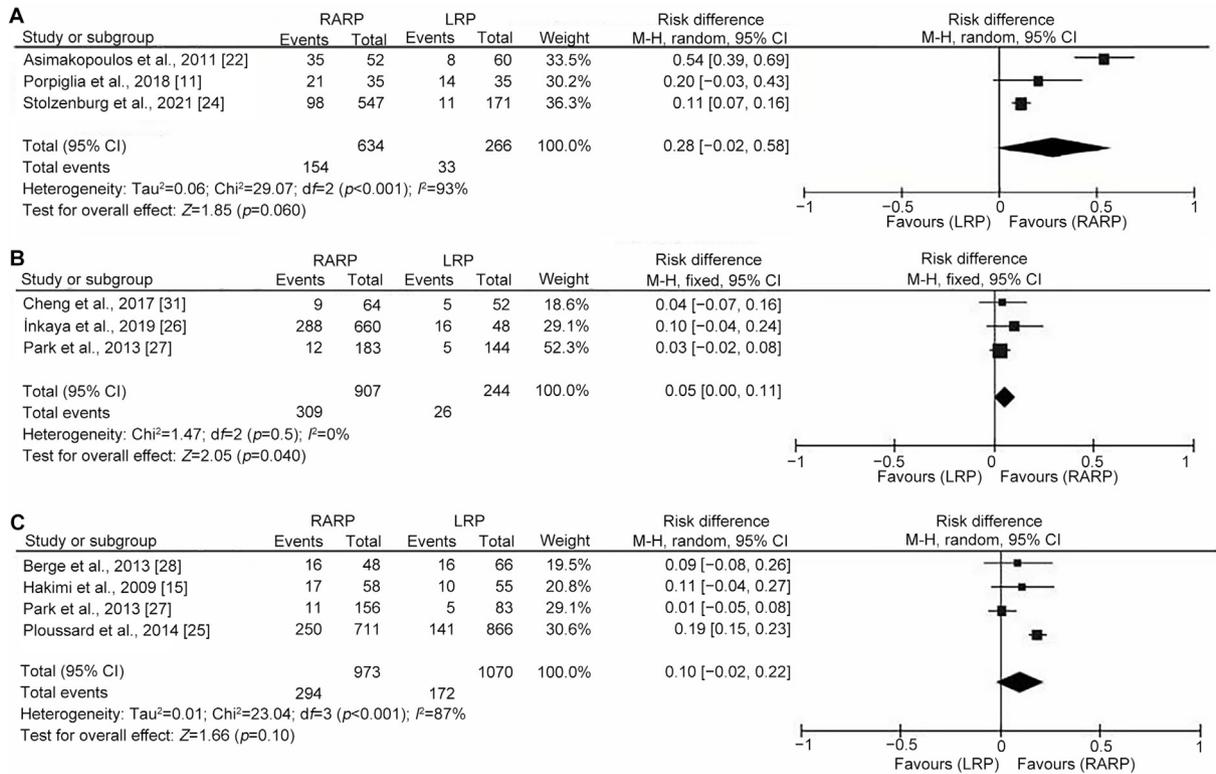
randomized and non-randomized. A careful distinction was made between RCTs and non-randomized studies to ensure the reliability of the results, given the potential influence of study design on functional outcomes. Furthermore, within the analysis of non-randomized studies, the data of patients who underwent nerve-sparing surgery were separated, as this could introduce bias into the comparative analysis of erectile function.

The importance of nerve preservation for sexual potency was first described in 1863 by Eckhard [13], who observed it in animal models. Currently, through the evolution of different techniques, bilateral preservation of nerves to the maximum extent represents one of the main techniques to achieve better functional outcomes, even though the return of sexual potency is a multifactorial outcome [14]. In this sense, erectile function in certain studies is only assessed from bilateral nerve preservation, as observed in the cohort study by Hakimi et al. [15]. However, other studies do not make a distinction regarding nerve preservation, considering in the analysis those who were not subjected to nerve-sparing surgery, which results in higher chances of sexual dysfunction [16,17]. Therefore, it is important to distinguish these studies as done in this systematic review.

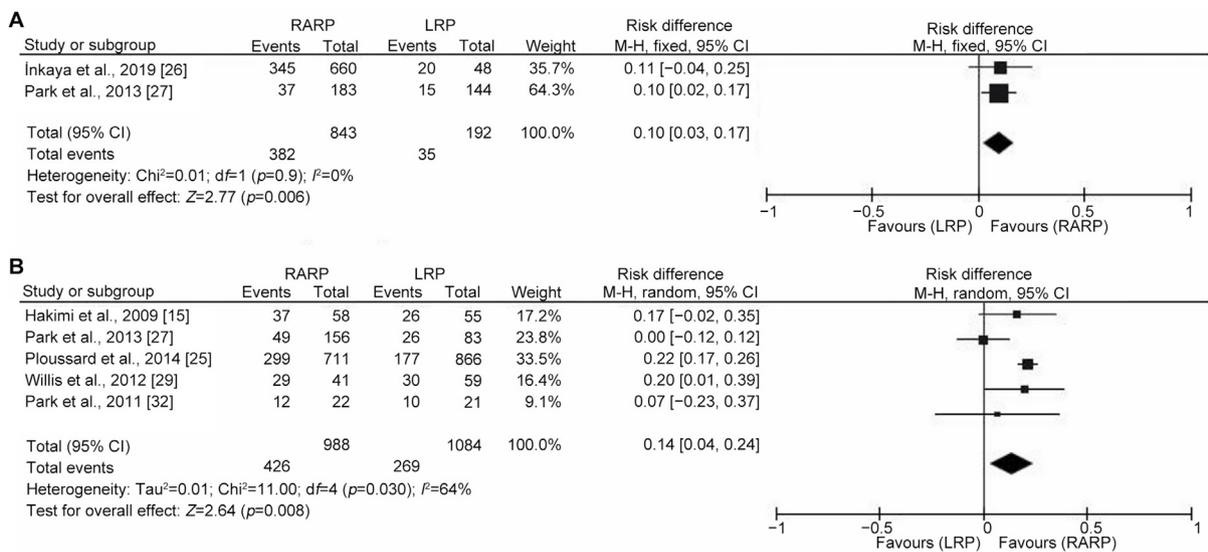
Our findings indicate that patients undergoing RARP showed greater preservation of erectile function than those undergoing LRP, during all analyzed periods, mainly 6 months after surgery. In addition to the quantitative analysis of the number of patients with erectile function, another study is consistent with the results obtained in our study by providing an assessment of the simplified International Index of Erectile Function 5 (IIEF-5), showing that the mean of this index is higher in patients undergoing RARP 6 months after surgery [18]. This difference arises from three-dimensional visualization, tremor minimization, and more harmonic movements. In this sense, dissection of the lateral pedicle of the prostate through the enlargement of the field of view during RARP allows for nerve preservation with greater precision in this surgical modality compared to LRP [19].

The meta-analysis of RCTs did not show any significant differences when evaluated at 3 months postoperatively, which differs from a similar meta-analysis published previously [6]. According to Ma et al. [6], the recovery of potency in RCTs during the same period was significant (RD 4.25, 95% CI 1.67–10.82;  $p=0.002$ ); however, considering the most recent study by Porpiglia et al. [11], the results were divergent. Thus, the importance of developing more RCTs to conduct meta-analyses with greater methodological evidence is observed, since the meta-analysis of non-randomized studies considering the entire cohort in the same period showed the superiority of robotic-assisted surgery over laparoscopic surgery ( $p=0.040$ ).

At 6 months postoperatively, both meta-analyses of non-randomized studies showed superiority regarding RARP, which evidenced that even with nerve preservation, the robotic approach had more patients who maintained erectile function after radical prostatectomy. Another recent review also presented similar results after the same period (RD 3.52, 95% CI 1.31–9.44;  $p=0.010$ ) [6]. However, this is the first systematic review to show the superiority of RARP when analyzing only



**Figure 2** Meta-analysis of erectile function preservation at 3 months postoperatively. (A) Randomized clinical trials; (B) Non-randomized studies with the entire cohort; (C) Non-randomized studies with patients undergoing nerve preservation. RARP, robotic-assisted radical prostatectomy; LRP, laparoscopic radical prostatectomy; CI, confidence interval; M-H, Mantel-Haenszel method.

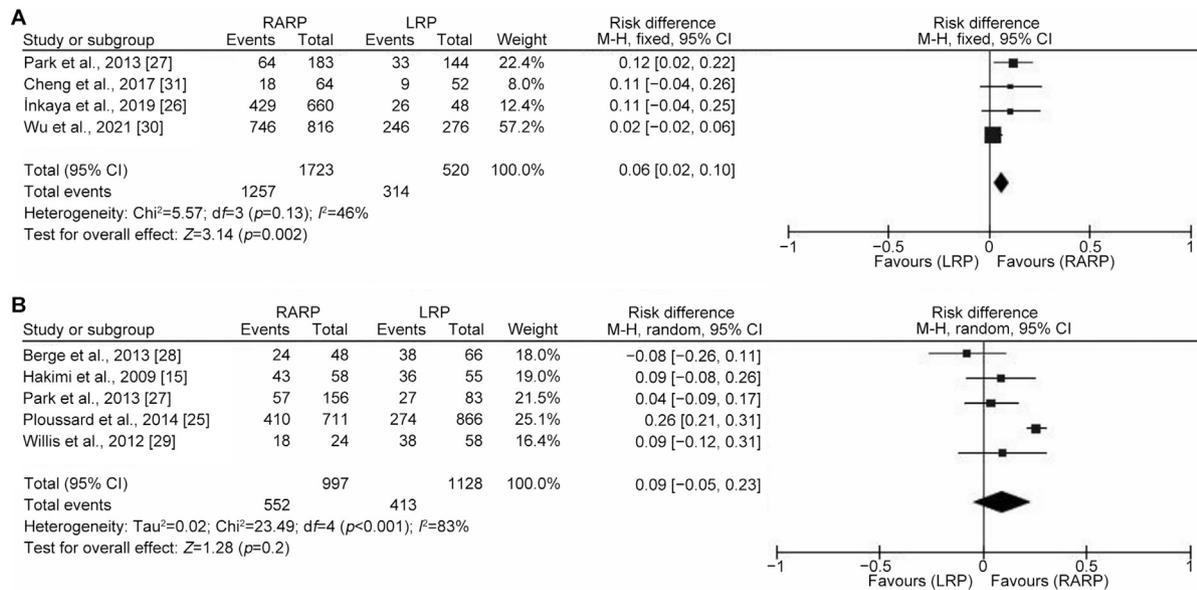


**Figure 3** Meta-analysis of non-randomized studies at 6 months postoperatively. (A) Considering the entire cohort; (B) Restricted to patients undergoing nerve preservation. RARP, robotic-assisted radical prostatectomy; LRP, laparoscopic radical prostatectomy; CI, confidence interval; M-H, Mantel-Haenszel method.

patients undergoing nerve-sparing surgery at 6 months postoperatively.

Regarding the meta-analysis of non-randomized studies at 12 months postoperatively, significant results in favor of

RARP were also observed in the analysis of the entire cohort ( $p=0.002$ ). However, the same cannot be observed in the restricted analysis of patients undergoing nerve preservation surgery, as this procedure is fundamental for



**Figure 4** Meta-analysis of non-randomized studies at 12 months postoperatively. (A) Evaluating the entire cohort; (B) Analyzing only patients undergoing nerve-sparing surgery. RARP, robotic-assisted radical prostatectomy; LRP, laparoscopic radical prostatectomy; CI, confidence interval; M-H, Mantel-Haenszel method.

the evaluation of sexual potency, making the difference between RARP and LRP less significant. Therefore, it is important to emphasize that robotic technology, by presenting a structure with suspended arms, improved vision, thinner arms, and longer instruments, allows anatomical access in virtually any position, which can significantly improve nerve procedure results [20,21]. An interesting finding was considered by the study by Asimakopoulos et al. [22] when considering the mean IIEF-6 score at 12 months postoperatively, which reinforced the superiority of robotic-assisted surgery over laparoscopic surgery (17.77 [SD 6.52] vs. 21 [SD 6.34];  $p=0.005$ ). Additionally, evaluating potency after other periods up to 60 months, Porpiglia et al. [11] obtained significant results in favor of robotic-assisted surgery.

This systematic review has limitations and the main one is the limited number of articles analyzed. Besides that, the articles presented an intermediate risk of bias. Furthermore, the meta-analysis conducted with studies of higher levels of evidence was evaluated for a single time interval of 3 months due to limitations regarding the number of RCTs available in the current literature. The studies also presented different definitions of potency: some studies used validated questionnaires like the IIEF score, while others only defined potency as the presence of sufficient sexual erection for sexual intercourse with or without the use of a phosphodiesterase-5 inhibitor. In this sense, some important studies were not included in the meta-analysis due to difficulties in inserting them when reporting the analysis from sexual domains. Thus, the lack of standardization regarding the analysis of erectile function can be considered a major limitation for the results of this review.

Moreover, some included studies, especially retrospective comparative studies, do not have preoperative erectile function data, which can generate biases in the comparison between the groups that underwent robotic-assisted and

laparoscopic surgery. It is also important to note that the age intervals of the included patients among the studies are different, which influences the analysis of sexual potency. Finally, a last limitation of the meta-analysis is the results showing considerable heterogeneity.

From this perspective, the evaluation of sexual function recovery after radical prostatectomy presents a difficult comparative analysis, as already depicted in other systematic reviews [23], since it is influenced by various factors and different surgical techniques, besides the definition of potency presenting distinct definitions. In this sense, more long-term studies with high levels of evidence and methodological standardization are necessary to evaluate erectile function.

## 5. Conclusion

The meta-analysis showed that robotic-assisted surgery demonstrated better clinical outcomes in erectile function 3 months, 6 months, and 12 months after radical prostatectomy. However, more studies with greater methodological rigor should be conducted to further elucidate the topic.

## Author contributions

*Study concept and design:* Ana J. Pina, Vitor C. Melo, Aguinaldo C. Nardi, Wanderley M. Bernardo.

*Data acquisition:* Ana J. Pina, Vinícius W. Carlos, Vitor C. Melo.

*Data analysis:* Ana J. Pina, Luca S. Tristão, Clara L. Santos. *Drafting of manuscript:* Luca S. Tristão, Ana J. Pina, Vitor C. Melo.

*Critical revision of the manuscript:* Wanderley M. Bernardo, Aguinaldo C. Nardi, Luca S. Tristão.

## Conflicts of interest

The authors declare no conflict of interest.

## Acknowledgements

The authors thank Carlos Antonio Negrato, PhD, and also the student Livia Domingos de Moraes Pimentel Porto, both from Bauru School of Medicine, University of São Paulo, Bauru, Brazil, for their support regarding the preparation of this manuscript.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ajur.2024.10.002>.

## References

- [1] Potosky AL, Miller BA, Albertsen PC, Kramer BS. The role of increasing detection in the rising incidence of prostate cancer. *JAMA* 1995;273:548–52.
- [2] Huang J, Chan EO, Liu X, Lok V, Ngai CH, Zhang L, et al. Global trends of prostate cancer by age, and their associations with gross domestic product (GDP), Human Development Index (HDI), smoking, and alcohol drinking. *Clin Genitourin Cancer* 2023;21:e261–70.e50. <https://doi.org/10.1016/j.clgc.2023.02.003>.
- [3] Siegel RL, Miller KD, Wagle NS, Jemal A. Cancer statistics, 2023. *CA Cancer J Clin* 2023;73:17–48.
- [4] Finkelstein J, Eckersberger E, Sadri H, Taneja SS, Lepor H, Djavan B. Open versus laparoscopic versus robot-assisted laparoscopic prostatectomy: the European and US experience. *Rev Urol* 2010;12:35–43.
- [5] Hilger C, Schostak M, Neubauer S, Magheli A, Fydrich T, Burkert S, et al. The importance of sexuality, changes in erectile functioning and its association with self-esteem in men with localized prostate cancer: data from an observational study. *BMC Urol* 2019;19:9. <https://doi.org/10.1186/s12894-019-0436-x>.
- [6] Ma J, Xu W, Chen R, Zhu Y, Wang Y, Cao W, et al. Robotic-assisted versus laparoscopic radical prostatectomy for prostate cancer: the first separate systematic review and meta-analysis of randomised controlled trials and non-randomised studies. *Int J Surg* 2023;109:1350–9.
- [7] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. <https://doi.org/10.1136/bmj.n71>.
- [8] University of York, Centre for Reviews and Dissemination. PROSPERO: International prospective register of systematic reviews [Internet]. <https://crd.york.ac.uk/prospero/>. [Accessed January 25, 2024].
- [9] Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019;366:l4898. <https://doi.org/10.1136/bmj.l4898>.
- [10] Wells G, Shea B, O'Connell D, Peterson J, Welch V, Losos M, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analysis. [http://www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp). [Accessed 2 January 2024].
- [11] Porpiglia F, Fiori C, Bertolo R, Manfredi M, Mele F, Checcucci E, et al. Five-year outcomes for a prospective randomised controlled trial comparing laparoscopic and robot-assisted radical prostatectomy. *Eur Urol Focus* 2018;4:80–6.
- [12] Porpiglia F, Morra I, Lucci Chiarissi M, Manfredi M, Mele F, Grande S, et al. Randomised controlled trial comparing laparoscopic and robot-assisted radical prostatectomy. *Eur Urol* 2013;63:606–14.
- [13] Eckhard C. [Untersuchungen über die Erektion des Penis beim Hunde]. *Anat Physiol* 1863;3:123–66. [Article in German].
- [14] Kyriazis I, Spinos T, Tsaturyan A, Kallidonis P, Stolzenburg JU, Liatsikos E. Different nerve-sparing techniques during radical prostatectomy and their impact on functional outcomes. *Cancers* 2022;14:1601. <https://doi.org/10.3390/cancers14071601>.
- [15] Hakimi AA, Blitstein J, Feder M, Shapiro E, Ghavamian R. Direct comparison of surgical and functional outcomes of robotic-assisted versus pure laparoscopic radical prostatectomy: single-surgeon experience. *Urology* 2009;73:119–23.
- [16] Liu Y, Deng X, Qin J, Wen Z, Jiang Y, Huang J, et al. Erectile function, urinary continence and oncologic outcomes of neurovascular bundle sparing robot-assisted radical prostatectomy for high-risk prostate cancer: a systematic review and meta-analysis. *Front Oncol* 2023;13:1161544. <https://doi.org/10.3389/fonc.2023.1161544>.
- [17] Haney CM, Kowalewski KF, Westhoff N, Holze S, Checcuci E, Neuberger M, et al. Robot-assisted versus conventional laparoscopic radical prostatectomy: a systematic review and meta-analysis of randomised controlled trials. *Eur Urol Focus* 2023;9:930–7.
- [18] Deng W, Chen R, Zhu K, Cheng X, Xiong Y, Liu W, et al. Functional preservation and oncologic control following robot-assisted versus laparoscopic radical prostatectomy for intermediate- and high-risk localized prostate cancer: a propensity score matched analysis. *JAMA Oncol* 2021;2021:4375722. <https://doi.org/10.1155/2021/4375722>.
- [19] Ku JY, Lee CH, Lee JZ, Ha HK. Comparison of functional outcomes between laparoscopic radical prostatectomy and robot-assisted laparoscopic radical prostatectomy: a propensity score-matched comparison study. *Asia Pac J Clin Oncol* 2017;13:212–8.
- [20] Ficarra V, Novara G, Ahlering TE, Costello A, Eastham JA, Graefen M, et al. Systematic review and meta-analysis of studies reporting potency rates after robot-assisted radical prostatectomy. *Eur Urol* 2012;62:418–30.
- [21] Sivaraman A, Sanchez-Salas R, Prapotnich D, Barret E, Mombet A, Cathala N, et al. Robotics in urological surgery: evolution, current status and future perspectives. *Actas Urol Esp* 2015;39:435–41. [Article in English, Spanish].
- [22] Asimakopoulos AD, Pereira Fraga CT, Annino F, Pasqualetti P, Calado AA, Mugnier C. Randomized comparison between laparoscopic and robot-assisted nerve-sparing radical prostatectomy. *J Sex Med* 2011;8:1503–12.
- [23] Carbonara U, Srinath M, Crocero F, Ferro M, Cantiello F, Lucarelli G, et al. Robot-assisted radical prostatectomy versus standard laparoscopic radical prostatectomy: an evidence-based analysis of comparative outcomes. *World J Urol* 2021;39:3721–32.
- [24] Stolzenburg JU, Holze S, Neuhaus P, Kyriazis I, Do HM, Dietel A, et al. Robotic-assisted versus laparoscopic surgery: outcomes from the first multicentre, randomised, patient-blinded controlled trial in radical prostatectomy (LAP-01). *Eur Urol* 2021;79:750–9.
- [25] Ploussard G, de la Taille A, Moulin M, Vordos D, Hoznek A, Abbou CC, et al. Comparisons of the perioperative, functional, and oncologic outcomes after robot-assisted versus

- pure extraperitoneal laparoscopic radical prostatectomy. *Eur Urol* 2014;65:610–9.
- [26] İnkaya A, Tahra A, Sobay R, Kumcu A, Küçük EV, Boylu U. Comparison of surgical, oncological, and functional outcomes of robot-assisted and laparoscopic radical prostatectomy in patients with prostate cancer. *Turk J Urol* 2019;45:410–7.
- [27] Park B, Kim W, Jeong BC, Jeon SS, Lee HM, Choi HY, et al. Comparison of oncological and functional outcomes of pure versus robotic-assisted laparoscopic radical prostatectomy performed by a single surgeon. *Scand J Urol* 2013;47:10–8.
- [28] Berge V, Berg RE, Hoff JR, Wessel N, Diep LM, Karlsen SJ, et al. A prospective study of transition from laparoscopic to robot-assisted radical prostatectomy: quality of life outcomes after 36-month follow-up. *Urology* 2013;81:781–6.
- [29] Willis DL, Gonzalgo ML, Brotzman M, Feng Z, Trock B, Su LM. Comparison of outcomes between pure laparoscopic vs. robot-assisted laparoscopic radical prostatectomy: a study of comparative effectiveness based upon validated quality of life outcomes. *BJU Int* 2012;109:898–905.
- [30] Wu SY, Chang CL, Chen CI, Huang CC. Comparison of acute and chronic surgical complications following robot-assisted, laparoscopic, and traditional open radical prostatectomy among men in Taiwan. *JAMA Netw Open* 2021;4:e2120156. <https://doi.org/10.1001/jamanetworkopen.2021.20156>.
- [31] Cheng KC, Chan YS, Chau H, Lam KM, So SH. Comparative study of laparoscopic radical prostatectomy and robot-assisted radical prostatectomy on perioperative, oncological and functional outcomes. *Surg Pract* 2017;21:141–8.
- [32] Park JW, Won Lee H, Kim W, Jeong BC, Jeon SS, Lee HM, et al. Comparative assessment of a single surgeon's series of laparoscopic radical prostatectomy: conventional versus robot-assisted. *J Endourol* 2011;25:597–602.