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REVIEW ARTICLE

Robot-Assisted Radical Prostatectomy vs. Open Retropubic Radical Prostatectomy for Prostate Cancer: A Systematic Review and Meta-analysis

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Abstract Open retropubic radical prostatectomy (ORP) remains the "gold standard" for surgical treatment of clinically localized prostate cancer (PCa). Robot-assisted radical prostatectomy (RARP) is a robotic surgery used worldwide. The aim of this study is to collect the data available in the literature on RARP and ORP, and further evaluate the overall safety and efficacy of RARP vs. ORP for the treatment of clinically localized PCa. A literature search was performed using electronic databases between January 2009 and October 2013. Clinical data such as operation duration, transfusion rate, positive surgical margins (PSM), nerve sparing, 3- and 12-month urinary continence, and potency were pooled to carry out meta-analysis. Six studies were enrolled for this meta-analysis. The operation duration of RARP group was longer than that of ORP group (weighted mean difference=64.84). There was no statistically significant difference in the transfusion rate, PSM rate, and between RARP and ORP (transfusion rate, OR=0.30; PSM rate, OR=0.94). No significant difference was seen in 3- and 12-month urinary continence recovery (3 months, OR=1.32; 12 months, OR=1.30). There was a statistically significant difference in potency between the 3- and 12-month groups (3 months, OR=2.80; 12 months, OR=1.70). RARP is a safe and feasible surgical technique for the treatment of clinically localized PCa owing to the advantages of fewer perioperative complications and quicker patency recovery.

Keywords Robot-assisted radical prostatectomy · Open retropubic radical prostatectomy · Prostate cancer

Abbreviations

PCa	Prostate cancer
RP	Radical prostatectomy
ORP	Open retropubic radical prostatectomy
RRP	Retropubic radical prostatectomy
RARP	Robot-assisted radical prostatectomy
RALP	Robot-assisted laparoscopic prostatectomy
PSA	Prostate-specific antigen
NOS	Newcastle–Ottawa Scale

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PSM	Positive surgical margins
OR	Odds ratio
WMD	Weighted mean difference
BNC	Bladder neck contracture
IH	Inguinal hernia
LC	Learning curve

Introduction

Prostate cancer (PCa) is the most commonly diagnosed male carcinoma, accounting for 28 % (238,590) of incident cases in all male cancers in 2013, and the second leading cause of cancer-related death among men in the USA [1]. With dietary and lifestyle changes in the recent years, the incidence of PCa in China has increased substantially and has become one of the common malignancies in the male urinary system. Prostate-specific antigen (PSA) has routinely been used as a marker for the diagnosis of PCa. According to the American Urological Association (AUA) Guidelines (2013), the Panel strongly recommends that men aged 55–69 years consider PSA routine screening at 2-year intervals [2]. Since the prevalence of PSA screening, clinically localized PCa has been detected increasingly earlier.

Radical prostatectomy (RP) has been shown to be the most efficient treatment for PCa patients [3], and open retropubic radical prostatectomy (ORP) remains the "gold standard" procedure among all surgical treatments [4]. Nonetheless, ORP is associated with more blood loss and transfusion, longer hospital stay, more intraoperative and postoperative complications, and higher in-hospital mortalities as compared with other analogous surgical procedures [5]. These unfavorable factors urge researchers to develop safer and more effective alternative surgical procedures to replace ORP.

Owing to the wide use of minimally invasive radical prostatectomy techniques, robot-assisted radical prostatectomy (RARP) has drawn the attention of the world. Pasticier et al. [6] performed the first robot-assisted laparoscopic prostatectomy (RALP) with the Da Vinci robot (Intuitive Inc., Mountain View, CA, USA) in 2000. In the USA, 52.7 % of the current procedures are robotic assisted laparoscopic surgeries compared to 44.4 % open surgeries in 2008, and now RARP is more prevalent than open surgery in urban hospitals among white patients in high volume [7]. The reasons for the hot trend is that the robotic surgical system has numerous unprecedented advantages in radical prostatectomy, such as 3D vision, precise movements without physical limitations, enhanced magnification, and tremor filtering [8].

Therefore, several studies have been carried out to evaluate the superiority of RARP over ORP. RARP is associated with improving quality of life and intra- and postoperative outcomes as compared with ORP [9, 10]. However, the data in the current literature do not provide convincing evidence to assess the real superiority of this robotic surgical technique over traditional surgery due to the lack of randomized controlled trials. Our main aim is to collect the existing literature on RARP and ORP and further evaluate the overall safety and efficacy of RARP vs. ORP for clinically localized PCa.

Methods

A literature search was performed using PubMed (US National Library of Medicine National, Institutes of Health Search database), Google Scholar, Embase, and Web of Science. We limited our search to English-language articles and time span between January 2009 and October 2013. The following keywords were used: open retropubic radical prostatectomy or ORP, robot-assisted radical prostatectomy or RARP. We included all latest relevant studies comparing RARP and ORP and all included patients of clinically localized PCa, and excluded studies on laparoscopic prostatectomy without comparing robot-assisted, non-comparative studies, patients treated with preoperative radiotherapy or neoadjuvant androgen deprivation therapy, and patients with high-risk PCa.

The Newcastle–Ottawa Scale (NOS) was performed to estimate the methodological quality of these studies. The NOS is known as a "star system" including three broad perspectives: study group selection (four items, four stars), group comparability (two items, two stars), and outcome ascertainment (three items, three stars) [11] .

Two reviewers independently carried out data extraction by searching the full texts of included studies. The extracted data were authors, publication year, treatments, number of patients, operation duration, transfusion rate, positive surgical margins (PSM), nerve sparing, urinary continence, and potency.

A meta-analysis was performed to compare the efficacy and safety of RARP and ORP. Tests for homogeneity were performed by the Cochrane Inconsistency (I2). A value of $P > 0.10$ shows homogeneity of included studies, and I2 <50 % shows acceptable heterogeneity. Dichotomous variables and continuous variables were pooled by odds ratio (OR) and weighted mean difference (WMD), respectively. The fixed-effect model (Mantel–Haenszel method) [12] was applied to calculate pooled estimates for homogeneous studies, and the random-effect model (DerSimonian–Laird method) [13] was used for heterogeneous studies. The pooled effects were measured by means of Z test, and $P \leq 0.05$ was considered statistically significant. Data analysis was carried out with Review Manager (RevMan 5.1, Cochrane Collaboration, Oxford, UK).

Results

A total of 243 related studies were identified for further evaluation by searching PubMed, Google Scholar, Embase,

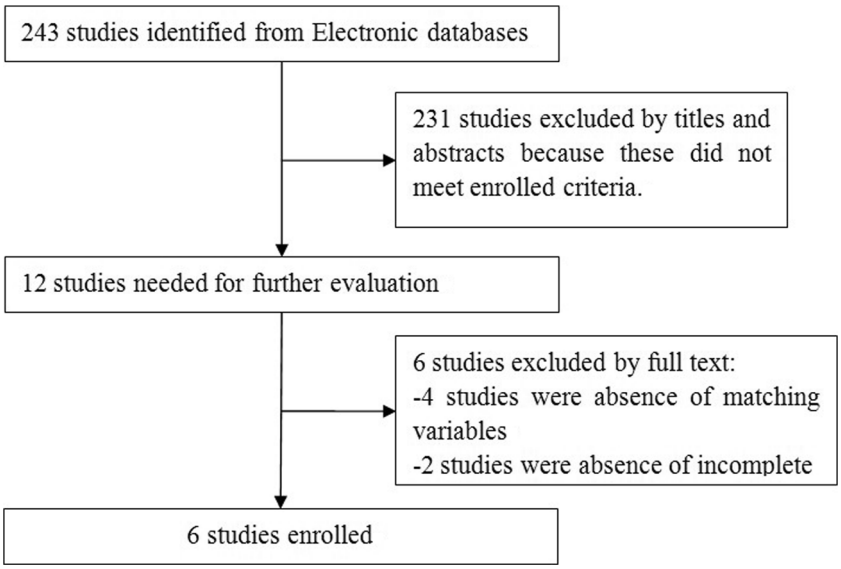

Fig. 1 Flowchart showing filtering studies for the meta-analysis

and Web of Science. Finally, six studies [14–19] were enrolled for this meta-analysis (Fig. 1). Table 1 shows the characteristics of included studies.

The results of NOS quality assessment for the enrolled studies are indicated in Table 2. Two high-quality studies won a score of 9. The remaining four studies were scored 8 because of the lack of adequate follow-up data or missing follow-up data.

The operation duration of RARP group was longer than that of ORP group [weighted mean difference (WMD)= 64.84, 95 % confidential interval (95 % CI)=44.12–85.55, $P<0.00001$] (Fig. 2). There was no statistically significant difference in the transfusion and PSM rate between RARP and ORP groups (transfusion rate, OR=0.30, 95 % CI=0.05–1.77, $P=0.18$; PSM rate, OR=0.94, 95 % CI=0.76–1.16, $P=0.55$) (Fig. 3). There were no statistically significant differences in urinary continence recovery at 3- and 12-month postoperative follow-up between RARP and ORP groups (3 months, OR=1.32, 95 % CI=0.58–3.03, $P=0.51$; 12 months, OR=1.30, 95 % CI=0.55–3.09, $P=0.55$) (Fig. 4).

All patients included to assess the potency had satisfactory potency before surgery (defined according to the International Index of Erectile Function–5). Despite similar nerve sparing (bilateral or unilateral) between the 3- and 12-month groups (OR=1.17, 95% CI=0.36–3.74, $P=0.80$) (Fig. 5), the potency

Table 1 Characteristics of included studies

Authors	Year	Treatments	Number of patients	Operation duration (min)	Transfusion (%)	PSM (%)	Urinary continence (%)		Potency (%)		Publication type
							3 months	12 months	3 months	12 months	
Choo et al. [14]	2013	RALP	77	220	17	40	71	94	17	54	Non RCT
		ORP	176	151	18	40	80	96	6	40	
Di Pierro et al. [15]	2011	RALP	75	330	–	12	95	89	55	71	Non RCT
		RRP	75	253	–	24	83	80	26	65	
Lo et al. [16]	2010	RARP	20	306	5	20	–	–	–	–	Non RCT
		ORP	20	289	65	25	–	–	–	–	
Doumerc et al. [17]	2010	RALP	212	192	0.9	21.2	–	–	–	–	Non RCT
		RRP	502	147	2	84	–	–	–	–	
Rocco et al. [18]	2009	RARP	120	–	–	22	70	97	31	61	Non RCT
		RRP	240	–	–	25	63	88	18	41	
Krambeck et al. [19]	2009	RARP	294	–	–	15.6	–	91.8	–	70	Non RCT
		RRP	558	–	–	17	–	93.7	–	62.8	

Data are shown as mean or rate

RALP robot-assisted laparoscopic prostatectomy, *RARP* robot-assisted radical prostatectomy, *ORP* open retropubic radical prostatectomy, *RRP* retropubic radical prostatectomy, *PSM* positive surgical margins, *RCT* randomized controlled trials

Table 2 The Newcastle–Ottawa scale for quality assessment of included studies

Studies	Selection				Comparability	Outcomes			Total score
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Outcome of interest was not present at start of study	Based on the design or analysis	Assessment of outcome	Follow-up long enough for outcomes to occur	Adequacy of follow-up of cohorts	
Choo et al. [14]	1	1	1	1	2	1	1	1	9
Di Pierro et al. [15]	1	1	1	1	2	1	1	0	8
Lo et al. [16]	1	1	1	1	2	1	1	0	8
Doumerc et al. [17]	1	1	1	1	2	1	1	0	8
Rocco et al. [18]	1	1	1	1	2	1	1	1	9
Krambeck et al. [19]	1	1	1	1	2	1	1	0	8

recovery for RARP group was significantly quicker than for ORP group (3 months, OR=2.80, 95% CI=1.83–4.27, $P<0.00001$; 12 months, OR=1.70, 95% CI=1.30–2.23, $P=0.0001$) (Fig. 6).

Discussion

Robotic surgery represents a revolutionary progress in the history of urology and has become a hot area among many researchers. A growing body of literature has reported the superiority of robotic surgery as compared with traditional surgery [20–23]. On this foundation, our study would further explain the advantages of RARP for treating clinically localized PCa vs. ORP.

According to a nationwide inpatient sample, blood loss and transfusions of patients treated with RARP were less than ORP [24]. Kordan et al. [25] reported that estimated blood loss of patients undergoing RALP ranged 50–200 ml vs. 300–600 ml in patients undergoing ORP. However, many factors can affect intraoperative blood loss. With the current prevalence of cardiovascular diseases, more PCa patients administer antithrombotic drugs daily, which increases the risk of surgical procedures. A recent study [26] reported that the mean blood loss of patients who administered aspirin 750 ml for ORP and 700 ml for RARP, and the transfusion rate in patients undergoing RARP was significantly lower than that in patients undergoing ORP (8 % vs. 21 %). Another study [27] found that Hct% reduction was more significant in patients who used statins than that in patients without using statins (20.7 % vs. 18.6 %) when they underwent ORP; however, there was no significant change in Hct% in patients undergoing RARP.

Prostate-specific membrane antigen (PSM) is a risk factor contributing to postoperative tumor recurrence. Our meta-analysis showed no statistically significant difference between RARP and ORP. However, a most recent non-randomized observational study reported that RARP had a lower PSM rate than the open approach, and postoperative adjuvant therapies including radiotherapy, chemotherapy, or androgen deprivation therapy seemed less likely to be accepted by patients who received RARP as compared with those who received ORP (OR=0.59, 95% CI=0.39–0.88, $P=0.010$) [28]. On the contrary, Williams et al. [29] reported that the PSM rate in

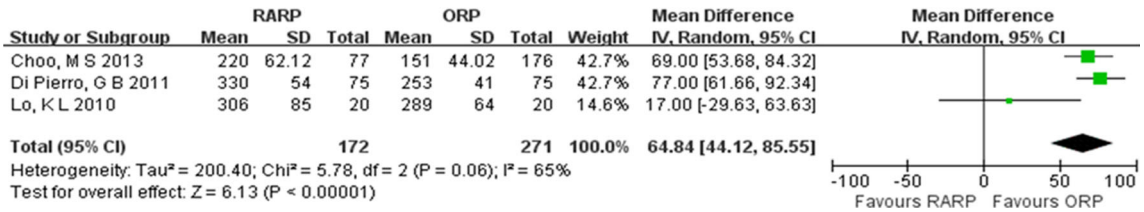

Fig. 2 Pooled estimates of operation duration

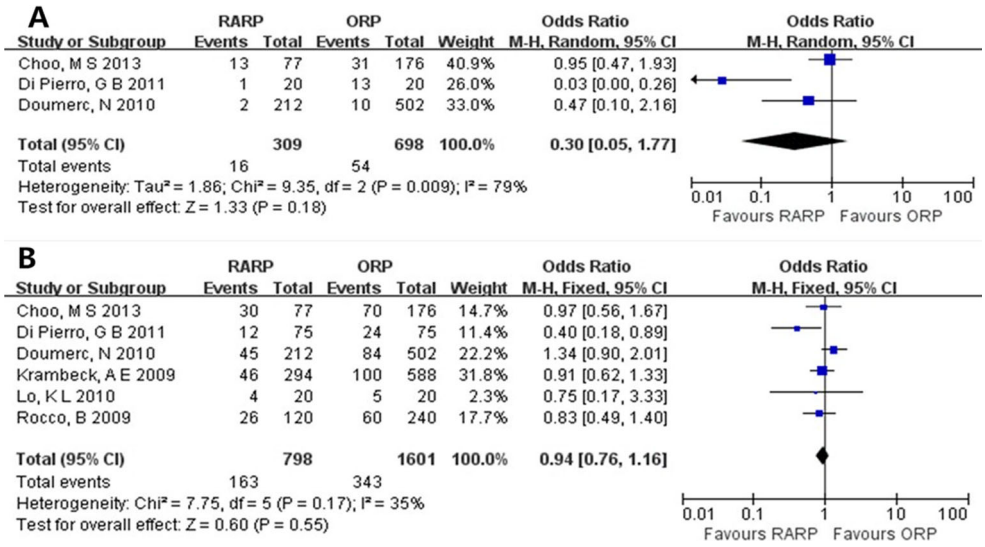

Fig. 3 Pooled estimates of transfusion rate (**a**) and PSM rate (**b**)

patients undergoing nerve-sparing RALP and nerve-sparing ORP was 13.5 % and 7.6 %, respectively. For high-risk PCa patients, a recent retrospective study showed no significant difference in oncological outcomes between the two groups [30]. Similarly, Punnen et al. [31] reported no statistically significant difference in the PSM rate in patients with high-risk PCa between RARP and ORP groups.

Urinary incontinence is a common postoperative long-term complication after radical prostatectomy [32]. Therefore, postoperative urinary continence recovery is defined as 0–1 pad per day, which is also a measure of the quality of life for patients treated with RP. In our meta-analysis, the outcome of 3- and 12-month urinary continence recovery in RARP group was similar to that in ORP group. Likewise, Froehner et al. [33] reported no detectable difference in continence recovery between the two groups. However, a study [34] reported that patients undergoing RALP might have a better functional outcome and earlier recovery of urinary incontinence than patients undergoing RP. In a recent single surgeon experience report [35], the 12-month recovery of continence favored RALP as compared with ORP, and factors contributing to this difference were associated with the operation method, patient age, and the membranous urethral length.

Potency after RP is an important indicator for assessing the quality of life. Brandina et al. [10] showed that the potency rate was 79.2–80.4 % during the 1-year follow-up period. Our meta-analysis showed that the 3- and 12-month postoperative potency in RARP group was significantly better than that in ORP group. However, Rocco et al. [14] reported that functional erection of patients undergoing RARP was significantly higher than that of patients undergoing ORP. Additionally, Krambeck et al. [19] reported no statistical difference between the two groups.

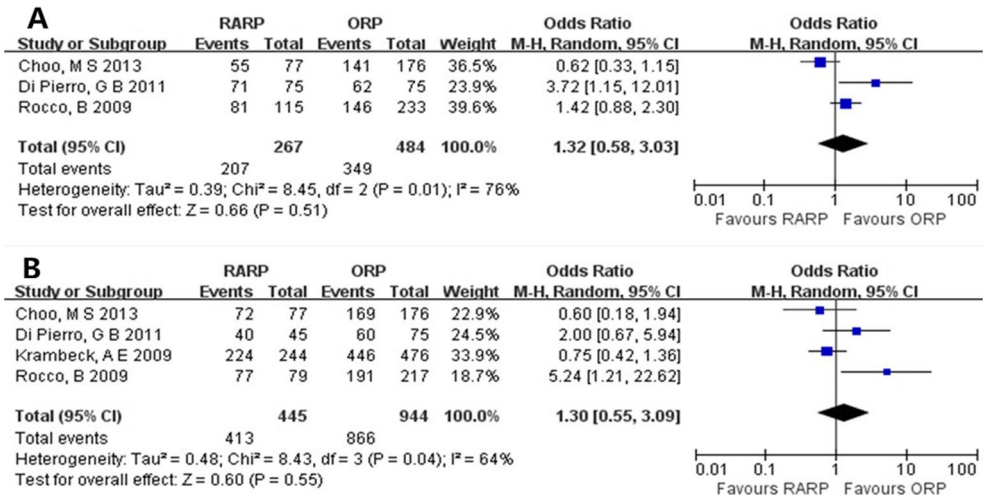

Fig. 4 Pooled estimates of urinary continence recovery at 3 months (**a**) and 12 months (**b**) of follow-up

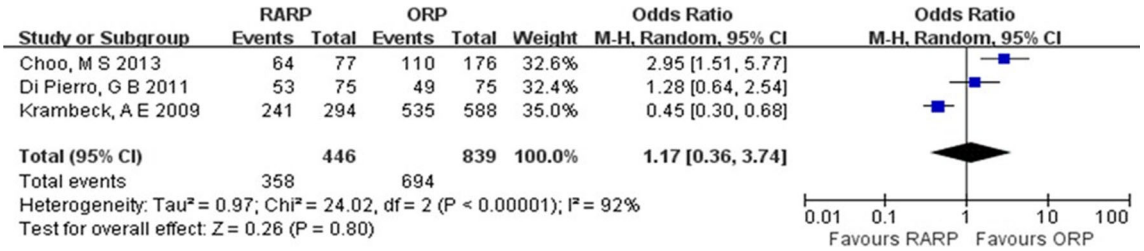

Fig. 5 Pooled estimates of nerve sparing

Compared with ORP, RARP also showed spectacular advantages in other related complications. Bladder neck contracture (BNC) is a known complication of RP. Breyer et al. [36] reported that the BNC rate was 1.4 % for RALP and 2.6 % for ORP. Webb et al. [37] also reported that RALP was superior to ORP in the incidence of BNC. The incidence rate of inguinal hernia (IH) as a postoperative complication may have a difference due to surgical methods. Stranne et al. [38] reported that the cumulative incidence rate of IH at 48 months was 12.2 % for patients undergoing ORP and 5.8 % for patients undergoing RALP, the difference being statistically significant.

During the past decade, RARP has become the dominant surgical approach in the treatment of PCa due to enormous advantages over ORP. RARP is easily accepted for young surgeons because of the shorter learning curve as compared with other radical prostatectomy procedures. A systematic review [39] recently reported that the learning curve for RALP was 40 procedures as a minimum number compared with the learning curve for ORP ranging from 250 to 1,000 cases. Nonetheless, many factors need to be considered. The cost of treatment for PCa is a concern that most patients have to consider before surgery. The total actual costs associated with RARP were significantly greater than those for ORP [40, 41]. According to the statistics [42], the 1-, 2-, 5-, and 10-year cumulative cost of RARP was $17,824, $18,308, $20,117, and $22,762, respectively, vs. $9,732, $10,360, $12,209, and $15,084 for ORP. The high cost of RARP is attributable to robot purchase, maintenance, and supplies, which was the main factor for limiting its widespread adoption. Another factor is that the Da Vinci robotic surgical system also has inevitable malfunction, although this situation is uncommon. An international survey [43] showed that robotic malfunction could occur at any time during surgery. Therefore, well-trained and experienced surgeons are required to handle these mechanical failures to complete the prostatectomy.

There were some limitations in our study. First, due to the lack of randomized controlled trials in this area, all studies included for meta-analysis were non-randomized controlled studies. Second, several data were unavailable in some studies due to the lack of complete data. For example, blood loss, catheterization, hospital stay, and pelvic lymph node dissection PLND were provided only with median, range, and 25th percentile and 75th percentile in some studies. Third, some included studies lacked adequate follow-up data. Two studies did not show follow-up data and one study did not show early follow-up data.

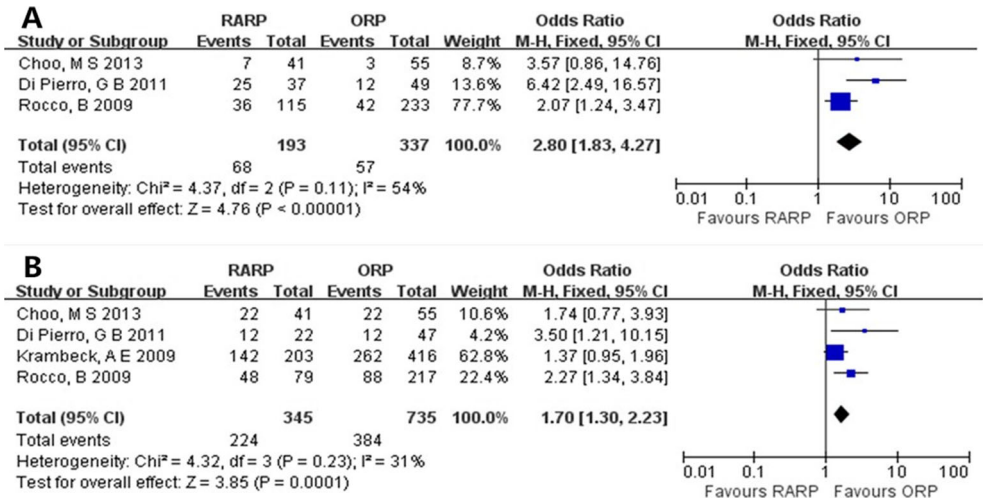

Fig. 6 Pooled estimates of potency recovery at 3 months (**a**) and 12 months (**b**) of follow-up

Conclusions

Despite the absence of randomized controlled trials to provide high-quality evidence, our results demonstrated that RARP has the advantages of fewer perioperative complications and quicker potency recovery as compared with ORP, and therefore it is a safe and feasible surgical technique for the treatment of clinically localized PCa. However, prospective randomized studies are required to further evaluate the role of RARP in the treatment of localized PCa.

Disclosure Statement No competing financial interests exist.

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