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ORIGINAL ARTICLE

Sutureless robotic-assisted partial nephrectomy: a propensity score-matched analysis (UroCCR N.158)

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ABSTRACT

BACKGROUND: Sutureless (SL) techniques have emerged as an alternative to standard renorrhaphy (RR) in robot-assisted partial nephrectomy (RAPN), aiming to reduce the potential adverse effects of parenchymal suturing on renal function, especially in off-clamp procedures. The aim of this article is to compare perioperative, functional, and oncological outcomes of sutureless *versus* renorrhaphy-based off-clamp RAPN in a matched cohort.

METHODS: Between June 2020 and March 2024, 410 off-clamp RAPN were included in the UroCCR database. A 2:1 propensity score matching was performed based on the R.E.N.A.L. nephrometry score for comparison of SL and RR groups. The primary endpoint was trifecta achievement (negative surgical margins, no major complications (Clavien–Dindo ≥III), and preservation of ≥90% of preoperative eGFR at first follow-up).

RESULTS: Of 410 off-clamp RAPN, 112 were sutureless and 298 with renorrhaphy. After matching, 112 SL and 224 RR cases were included. Trifecta achievement was superior in the SL group (66.1% *vs*. 43.3%, P<0.001), mainly due to early renal function recovery. SL patients had reduced blood loss (103 *vs*. 344 mL, P<0.001), shorter operative time (145 *vs*. 176 min, P=0.001), and fewer intraoperative complications (0.9% *vs*. 5.4%, P=0.04). Postoperative morbidity, long-term renal function, and oncological outcomes, including margin status, recurrence and survival, were comparable between groups.

CONCLUSIONS: In selected off-clamp RAPN cases, the omission of parenchymal and capsular renorrhaphy appears to be a safe and effective strategy that may enhance early functional outcomes and reduce operative time, without increasing perioperative morbidity or compromising oncological safety.

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KEY WORDS: Nephrectomy; Robotic surgical procedures; Hemostasis; Kidney neoplasms; Glomerular filtration rate.

Kidney cancer is of increasing incidence worldwide with the majority of cases diagnosed at a localized stage.[1] Partial nephrectomy (PN) is the standard of care for clinical T1 renal tumors, aiming to achieve oncological control while preserving renal function. In cases requiring vascular clamping, current guidelines recommend limiting warm ischemia time (WIT) to under 25 minutes to minimize ischemic injury to the renal parenchyma.[2]

In recent years, the widespread adoption of robot-assisted partial nephrectomy (RAPN) has enabled increasingly complex nephron-sparing procedures even in anatomically challenging tumors.[3, 4] To further optimize renal functional outcomes, several ischemia-reduction strategies,

such as selective clamping, early unclamping, and off-clamp approaches, have been developed.[5-7] Among these, off-clamp RAPN is particularly attractive as it avoids renal pedicle occlusion altogether, thereby eliminating ischemic injury. However, this technique requires meticulous hemostasis of the tumor bed in the absence of vascular control.

Traditionally, hemostasis is achieved through renorrhaphy, often involving multi-layered parenchymal and capsular sutures. However, emerging evidence suggests that renorrhaphy may contribute to renal function deterioration due to parenchymal compression, vascular ligation, or induced inflammatory response.[8-10] These concerns have sparked a growing interest in sutureless techniques[11] that rely on meticulous excision and targeted coagulation without routine parenchymal reconstruction, particularly in the off-clamp setting.[12-14] In this context, the true necessity of parenchymal suturing in off-clamp RAPN is being questioned. Sutureless techniques may offer a less traumatic alternative, with the potential to enhance early postoperative renal function without compromising perioperative safety or oncological efficacy.

This study aimed to evaluate the perioperative, functional, and oncological outcomes of sutureless off-clamp RAPN compared to conventional renorrhaphy, using a propensity score-matched analysis in a high-volume academic center.

Materials and methods

Study design and population

All consecutive patients who underwent off-clamp RAPN for a localized kidney tumor at our institution between June 2020 and March 2024 were prospectively included, and their data were recorded in the French Research Network on Kidney Cancer database, UroC-CR (NCT03293563). All patients provided informed consent, and the study protocol received institutional review board approval (CNIL N. DR-2022-091) and ethical clearance from the Sud-Ouest et Outre-Mer III Ethics Committee (DC 2012/108).

Exclusions included metastatic disease, age under 18 years, and hereditary renal cancer syndromes (*e.g.*, Von Hippel–Lindau disease), to avoid bias related to multifocal or iterative tumor resections.

Surgical technique

All procedures were performed using an off-clamp technique. The kidney was mobilized and defatted, and tumor margins were delineated with or without intraoperative ultrasound. Tumor excision was performed following the enucleation plane to minimize bleeding and parenchymal trauma. Hemostasis was achieved through progressive monopolar coagulation. When required, Hem-o-lok® clips were used to control bleeding vessels exceeding the limits of thermal coagulation. Adjunctive hemostatic agents were applied as necessary. In cases involving entry into the collecting system, a selective suture was placed to close the defect. No parenchymal or capsular sutures were performed in sutureless cases.

In the renorrhaphy group, parenchymal reconstruction was performed based on surgeon preference and intraoperative findings, using capsular, parenchymal, or combined suturing techniques.

Data collection

The following variables were collected:

• demographics and clinical data: sex, age at surgery, American Society of Anesthesiologists (ASA) score, body mass index (BMI), indication for nephron-sparing surgery, and presence of multiple tumorectomies;

• tumor characteristics: tumor size, TNM classification (according to the 2017 UICC version), R.E.N.A.L. nephrometry score, malignancy status, and histological subtype were also collected;

• renal function metrics: serum creatinine and estimated glomerular filtration rate (eGFR - CKD-EPI 2021), were measured preoperatively, on postoperative at day 1, and at follow-up visits. Postoperative renal function was reassessed at the first follow-up visit, at 1-3 months.

Outcomes

The primary endpoint was the achievement of the trifecta,[15] defined as the combination of negative surgical margins, absence of major complications (Clavien-Dindo grade ≥III), and preser-

vation of at least 90% of preoperative eGFR at first follow-up.

Secondary outcomes included operative time, intra and postoperative complications (assessed using the Clavien-Dindo Classification), estimated blood loss, length of hospital stay, occurrence of acute kidney injury (AKI), variation in eGFR, CKD stage progression, and oncologic endpoints (positive surgical margin, local recurrence and disease progression rates, recurrence free and overall survival). Pathological characteristics (pTNM stage and histological subtype) were also analyzed.

Postoperative follow-up was conducted according to national guidelines of the French Association of Urology(17).

Statistical analysis

Descriptive statistics were used to summarize baseline patients and tumors characteristics. Continuous variables were expressed as means and standard deviation or medians with interquartile range (IQR) and compared using the Student's *t*-test or Mann-Whitney U Test, depending on distribution (assessed via the Shapiro-Wilk Test). Categorical variables were compared using χ^2 or Fisher's Exact Tests, as appropriate.

To minimize selection bias, a 2:1 propensity score matching was performed on the R.E.N.A.L. nephrometry score. Logistic regression was used for categorical outcomes and linear regression for continuous outcomes. Kaplan-Meier curves were generated for recurrence-free survival (RFS) and overall survival (OS), and differences between groups were assessed using the log-rank test. All analyses were conducted using R software version 4.4.1 (2024-06-14 ucrt) with statistical significance set at $P \leq 0.05$.

Results

Study population

Between June 2020 and March 2024, 410 consecutive patients underwent off-clamp RAPN at our center. Among them, 112 patients were treated with a sutureless (SL) technique and 298 with conventional renorrhaphy (RR). After 2:1 propensity score matching based on the R.E.N.A.L. nephrometry score, 112 SL patients were compared to 224 RR patients. The study flow chart is presented in Figure 1.

Baseline demographic and clinical characteristics were well balanced between groups following matching (Table I). There was no significant difference regarding age (60.3±13.2 *vs.* 61.3±13.9 years, P=0.5), sex distribution (67.9%

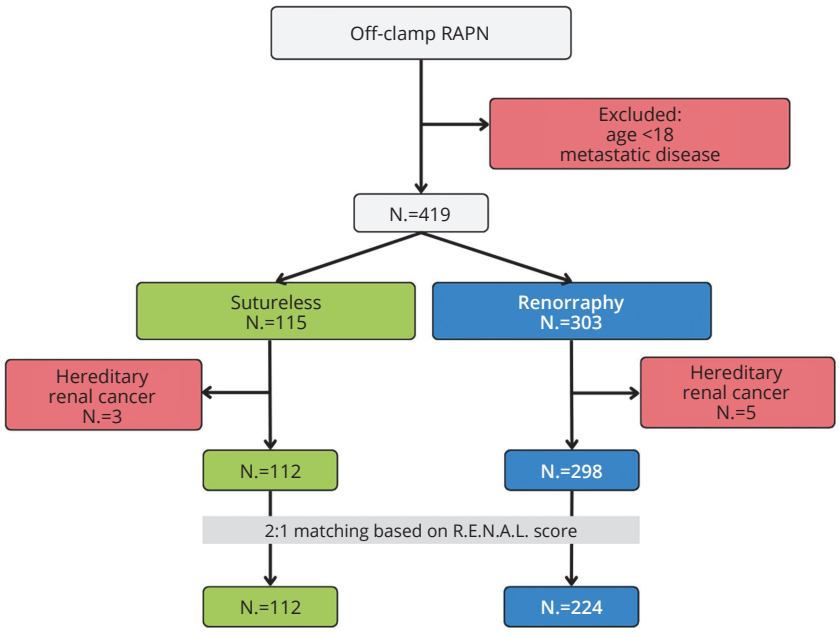

Figure 1.—Study flow chart. Flow diagram illustrating patient selection for inclusion in the sutureless (SL) and renorrhaphy (RR) groups. Exclusions included metastatic disease, age under 18 years, and hereditary renal cancer. A 2:1 propensity score matching based on the R.E.N.A.L. nephrometry score was then performed to obtain the final cohorts.

TABLE I.—*Baseline characteristics before and after propensity score matching.*

Parameter	Before matching			After matching		
	SL (N.=112)	RR (N.=298)	P value	SL (N.=112)	RR (N.=224)	P value
Age (years)	60.3±13.2	60.7±14.4	0.8	60.3±13.2	61.3±13.9	0.5
Sex						
Male	76 (67.9%)	201 (67.4%)	1	76 (67.9%)	152 (67.9%)	1
Female	36 (32.1%)	97 (32.6%)		36 (32.1%)	72 (32.1%)	
BMI (kg.m^2)	27.3±5.6	27.8±5.5	0.4	27.3±5.5	27.9±5.5	0.4
ASA score						
1	19 (17.0%)	51 (17.1%)	0.9	19 (17.0%)	36 (16.1%)	0.9
2	64 (57.1%)	168 (56.4%)		64 (57.1%)	129 (57.6%)	
≥3	29 (25.9%)	79 (26.5%)		29 (25.9%)	59 (26.3%)	
Tumor size (cm)	3.7±1.7	4.1±1.9	0.04*	3.7±1.7	3.7±1.6	0.8
cTNM						
T1a	68 (60.7%)	156 (52.3%)	0.5	68 (60.7%)	136 (60.7%)	0.9
T1b	36 (32.1%)	105 (35.2%)		36 (32.1%)	75 (33.5%)	
T2a	4 (3.6%)	19 (6.4%)		4 (3.6%)	6 (2.7%)	
T2b	2 (1.8%)	10 (3.4%)		2 (1.8%)	3 (1.3%)	
T3a	2 (1.8%)	8 (2.7%)		2 (1.8%)	4 (1.8%)	
Indication for NSS			0.7			0.5
Elective	86 (76.8%)	238 (79.9%)		86 (76.8%)	181 (80.8%)	
Imperative	15 (13.4%)	33 (11.1%)		15 (13.4%)	21 (9.4%)	
Relative	11 (9.8%)	27 (9.1%)		11 (9.8%)	22 (9.8%)	
Solitary kidney	6 (5.4%)	17 (5.7%)	1	6 (5.4%)	11 (5.4%)	0.8
Multiple tumorectomies	6 (5.4%)	24 (8.1%)	0.5	6 (5.4%)	17 (7.6%)	0.6
RENAL score	7.1±1.8	7.8±1.9	0.001*	7.1±1.8	7.3±1.8	0.3
Low complexity	43 (38.4%)	78 (26.3%)		43 (38.4%)	75 (33.5%)	
Intermediate complexity	58 (51.8%)	142 (47.9%)		58 (51.8%)	122 (54.5%)	
High complexity	11 (9.8%)	73 (24.6%)		11 (9.8%)	27 (12.1%)	
Preoperative eGFR (mL/min)	84.6±19.7	84.6±23.5	0.9	84.6±19.7	84.6±22.9	0.9
Preoperative CKD stage						
1-2	100 (90.1%)	252 (86.3%)	0.6	100 (90.1%)	190 (87.2%)	0.8
3	10 (9.0%)	36 (12.3%)		10 (9.0%)	25 (11.5%)	
4	1 (0.9%)	2 (0.7%)		1 (0.9%)	2 (0.9%)	
5	0 (0.0%)	2 (0.7%)		0 (0.0%)	1 (0.5%)	

SL: sutureless; RR: renorrhaphy, BMI: Body Mass Index; eGFR: estimated glomerular filtration rate; CKD: chronic kidney disease
*Statistically significant difference.

male in both groups), BMI (27.3±5.5 *vs*. 27.9±5.5 kg/m^2, P=0.4), ASA score, tumor size (3.7±1.6 cm in both groups, P=0.8), clinical stage (T1a in 60.7% of patients), or R.E.N.A.L score (7.1±1.8 *vs*. 7.3±1.8, P=0.3). Preoperative renal function was comparable with a mean eGFR of 84.6 mL/min in both groups.

Trifecta achievement

The trifecta was achieved in 66.1% of patients in the SL group *versus* 43.3% in the RR group (P<0.001) (Table II). This difference was primarily driven by better preservation of renal function, with 68.8% of SL patients maintain-

TABLE II.—*Trifecta achievement and component criteria in SL and RR groups.*

Parameter	SL (N.=112)	RR (N.=224)	P value
Trifecta achievement	74 (66.1%)	97 (43.3%)	<0.001*
Individual criteria failure			
Positive margins	2 (1.8%)	11 (4.9%)	0.1
Severe complications (Clavien–Dindo grade III-IV) within 30 days	1 (0.9%)	3 (1.3%)	0.7*
Patients with <90% preservation of preoperative eGFR at first follow-up [a]	35 (31.2%)	116 (51.8%)	<0.001*

SL: sutureless; RR: renorrhaphy; eGFR: estimated glomerular filtration rate; CKD: chronic kidney disease.
[a] Mean±SD in months: SL: 2.28±1.00; RR: 2.13±1.01; *statistically significant difference.

ing ≥90% of their preoperative eGFR at first follow-up, compared to 48.2% in the RR group (P<0.001). Rates of positive surgical margins (1.8% *vs*. 4.9%, P=0.1) and severe complications (0.9% *vs*. 1.3%, P=0.7) were low and not significantly different between groups. In both groups, no patient failed all three trifecta criteria. Patient flow and corresponding trifecta status in both groups after matching are displayed in Figure 2.

Perioperative outcomes

Sutureless RAPN was associated with significantly reduced blood loss (103.2±135.2 *vs*. 343.9±407.9 mL, P<0.001) and shorter operative time (144.6±54.6 *vs*. 175.8±60.9 minutes, P=0.001) (Table III). Hemostasis was achieved using electrocoagulation alone in 35.6% of SL cases. Hemostatic agents were used in 64.4% of SL procedures *vs*. 31.3% in the RR group (P<0.001). Intraoperative complications were less frequent in the SL group (0.9% *vs*. 5.4%, P=0.04).

There was no significant difference in postoperative surgical complication rates between both groups (1.8% *vs*. 2.7%, P=0.4). Medical complications occurred in 11.6% of SL patients *versus* 17.4% in the RR group (P=0.15), with no significant difference in severe complications (0.9% *vs*. 1.3%, P=0.7). Mean hospital stay was comparable between groups (1.2±1.8 *vs*. 1.3±1.3 days, P=0.5).

Functional outcomes

At postoperative day 1, mean eGFR was higher in the SL group (67.8±23.7 *vs*. 64.0±24.9 mL/min, P=0.1) and the decline from baseline was significantly lower (-16.4±12.6 *vs*. -20.8±14.6 mL/min, P=0.004). Results are summarized in Table IV.

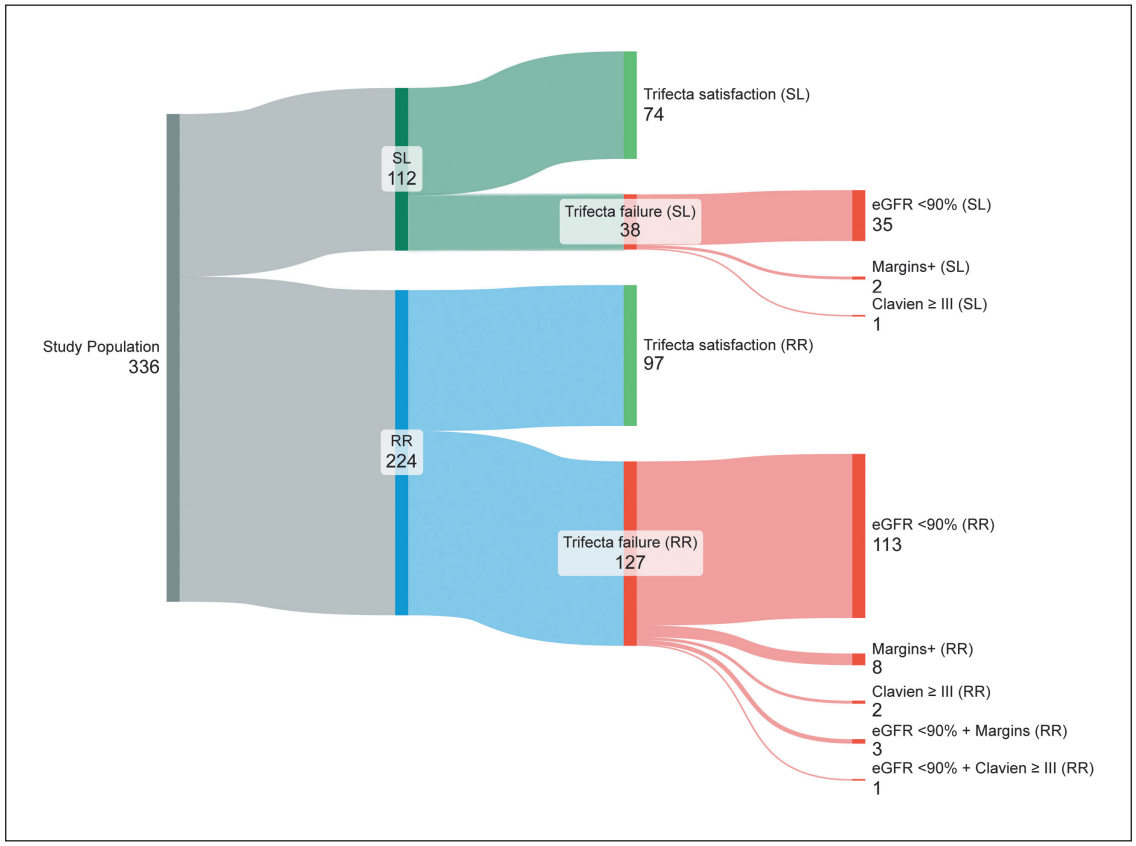

Figure 2.—Sankey diagram showing patient flow and trifecta outcomes in SL *vs.* RR groups after matching. Margins +: positive surgical margins; Clavien ≥III: major postoperative complications (Clavien-Dindo grade ≥III); eGFR <90%: failure to preserve ≥90% of preoperative estimated glomerular filtration rate at first follow-up.

TABLE III.—*Perioperative and postoperative morbidity outcomes.*

Parameter	SL (N.=112)	RR (N.=224)	P value
Blood loss (mL)	103.2±135.2	343.9±407.9	<0.001*
Operative duration (min)	144.6±54.6	175.8±60.9	0.001*
Intraoperative complications	1 (0.9%)	12 (5.4%)	0.04*
Intraoperative surgical complications type			
Hemorrhagic	0 (0%)	6 (2.7%)	
Vascular injury	0 (0%)	2 (0.9%)	
Digestive tract injury	1 (0.9%)	3 (1.3%)	
Ureteral injury	0 (0%)	1 (0.4%)	
Postop surgical complications	2 (1.8%)	6 (2.7%)	0.4
Postop medical complications	13 (11.6%)	39 (17.4%)	0.15
30-day postop event complications (Clavien Dindo)			
Mild-moderate (Grade I-II)	12 (10.7%)	34 (15.2%)	0.2*
Severe (Grade III-IV)	1 (0.9%)	3 (1.3%)	0.7*
Length of hospital stay (days)	1.2±1.8	1.3±1.3	0.5

SL: sutureless; RR: renorrhaphy.
*Statistically significant difference.

TABLE IV.—*Functional outcomes over time.*

Parameters	SL (N.=112)	RR (N.=224)	P value
eGFR according to CKD-EPI formula (mL/min)			
Day 1	67.8±23.7	64.0±24.9	0.1
First follow-up [b]	83.5±22.3	79.5±23.5	0.1
Last follow-up [c]	79.7±20.8	78.0±23.1	0.07
Postoperative AKI	0 (0.0%)	3 (1.3%)	0.9
Change in eGFR compared to preop (mL/min)			
Day 1	-16.4±12.6	-20.8±14.6	0.004*
First follow-up [b]	-0.4±8.1	-5.2±9.8	<0.001*
Last follow-up [c]	-5.0±11.7	-6.9±11.2	0.07
CKD upstaging compared to preop [a]			
Day 1	60 (55.6%)	136 (61.5%)	0.21
First follow-up [b]	11 (11.8%)	33 (19.5%)	0.20
Last follow-up [c]	17 (21.8%)	30 (22.4%)	0.65

SL: sutureless; RR: renorrhaphy; eGFR: estimated glomerular filtration rate; CKD: chronic kidney disease; SD: standard deviation.
[a] The percentage of CKD upstaging at each follow-up time point is calculated based on the number of patients still being followed at that time; [b] mean in months SL: 2.28±1.00; RR: 2.13±1.01; [c] mean in months SL: 15.2±10.5; RR: 18.1±11.8.

At first follow-up, mean eGFR remained significantly higher in SL patients (83.5±22.3 *vs*. 79.5±23.5 mL/min, P<0.001). At last follow-up (15.2±10.5 *vs*. 18.1±11.8 months), this difference was no longer statistically significant (79.7±20.8 *vs*. 78.0±23.1, P=0.07).

CKD upstaging rates were similar at last follow-up (33.0% *vs*. 39.7%, P=0.2), and no acute kidney injury occurred in the SL group, compared to 1.3% in the RR group.

Oncological outcomes

Positive surgical margins were observed in 1.8% of SL patients and 4.9% of RR patients (P=0.1). Local recurrence occurred in three patients (2.7%) in the SL group *vs*. 11 (4.9%) in the RR group (P=0.3). Metastatic progression was reported in one patient (0.9%) in the SL group and in nine patients (4.0%) in the RR group (P=0.2).

When considering both local recurrence and metastatic progression as a composite disease recurrence endpoint, the median time to recurrence was comparable between groups: 10.4 months (IQR 4.6–19.7) in the SL group *vs*. 9.8 months (IQR 3.1-20.6) in the RR group (P=0.8). The Kaplan-Meier curve for disease-free survival, based on this combined recurrence endpoint, showed no significant difference between groups (P=0.85) (Figure 3).

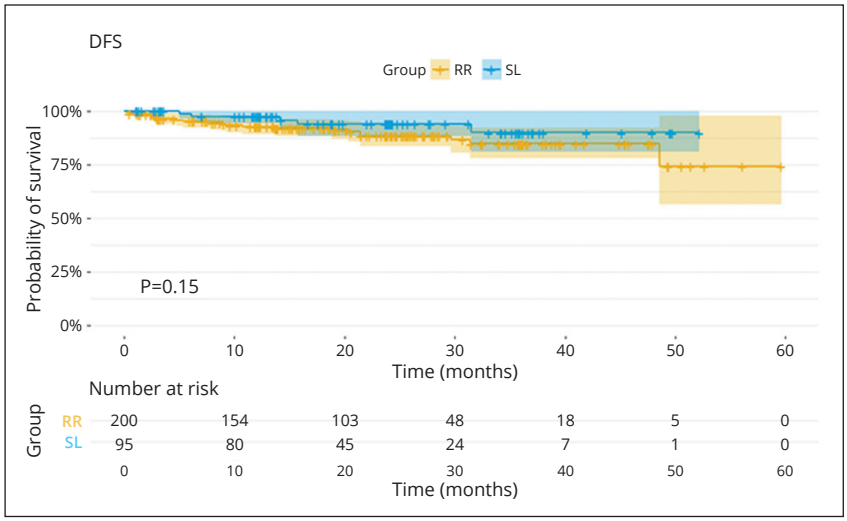

Figure 3.—Kaplan–Meier curve for disease-free survival in the SL and RR groups. Disease-free survival was defined as the time from surgery to either local recurrence or metastatic progression.

Pathological characteristics

Histological malignancy was confirmed in 84.8% of SL patients and 91.5% of RR patients (P=0.09).

Clear cell renal cell carcinoma (ccRCC) was the most common histological type in both groups, with 52.7% in SL and 64.7% in RR (P=0.10).

No statistically significant difference was observed regarding pTNM stage distribution (P=0.11).

Discussion

In this propensity score-matched cohort of patients undergoing off-clamp RAPN, the sutureless technique was associated with a significantly higher trifecta achievement rate compared to standard renorrhaphy. This difference was primarily driven by greater preservation of renal function at first follow-up, with more patients in the sutureless group maintaining ≥90% of their baseline eGFR. These findings are aligned with growing evidence suggesting that the renorrhaphy step, historically considered essential for hemostasis and parenchymal reconstruction, may in fact contribute to functional deterioration. Proposed mechanisms include parenchymal compression, inadvertent vessel ligation, and inflammatory activation induced by mechanical stress.[8-10, 16] This concept is supported by the systematic review by Bertolo *et al.*,[17] which demonstrated better renal function preservation with single-layer compared to double-layer renorrhaphy, reinforcing the notion that "less is more" in parenchymal reconstruction. Our study further supports this concept, showing that complete omission of parenchymal suturing can be safely achieved in selected cases when hemostasis is adequate. The omission of renorrhaphy did not result in increased intra or post-operative bleeding complications underscoring the safety and reproducibility of this approach in selected patients.

The functional benefit observed with the sutureless technique was most pronounced at early time points and appeared to attenuate over time. At final follow-up, eGFR levels and CKD stage upstaging rates were comparable between the groups. These findings are consistent with previous studies, including that of Brassetti *et al.*, which highlighted a short-term functional advantage without long-term divergence in CKD trajectories.[14] Notably, our study includes a longer follow-up period (mean 15.2±10.5 months in the sutureless group and 18.1±11.8 months), which further supports that early preservation does not necessarily translate into durable functional superiority.

However, this early preservation may still carry clinical relevance, particularly in patients with borderline baseline renal function or a solitary kidney, where short-term protection could

prevent acute decompensation or facilitate subsequent treatments.

Our findings align with those of Bertolo *et al.*,[16, 18] who reported comparable perioperative outcomes and renal function preservation between single- and double-layer renorrhaphy during robot-assisted partial nephrectomy.

In line with this, the EAU YAU pooled analysis[19] found that tumor enucleation reduced complications, renal function loss, and the need for clamping, supporting the feasibility of precise off-clamp enucleation procedures and potentially sutureless approaches. All procedures in our cohort were performed using an off-clamp strategy, eliminating warm ischemia as a confounding factor and allowing for an isolated assessment of the impact of renorrhaphy. In this context, sutureless hemostasis — achieved through monopolar coagulation and hemostatic agents — appeared sufficient to control bleeding in the vast majority of cases. These results are consistent with preclinical findings demonstrating that soft coagulation induces limited, superficial thermal damage to the renal cortex,[20] and with clinical reports supporting the safety of this approach.[21, 22]

The role of robotic technology in enabling such precision should also be highlighted,[23] as it has been associated with better functional outcomes and hemostatic accuracy in off-clamp procedures, indirectly supporting the feasibility of sutureless approaches.

The lower intraoperative complication rate observed in the sutureless group may reflect both the atraumatic nature of the technique and a potential selection bias. Indeed, the decision to omit parenchymal suturing was made intraoperatively based on the adequacy of hemostasis, potentially excluding more hemorrhagic or complex resections. While this pragmatic decision-making reflects real-world surgical practice, it also introduces a bias that must be acknowledged. Prospective protocols with predefined criteria for sutureless eligibility may help standardize patient selection in future studies.

This technique was developed and applied in a high-volume center by experienced robotic surgeons, which likely contributed to its reproducibility and safety across a range of tumor complexities. Nevertheless, sutureless partial nephrectomy may represent a feasible option for surgeons willing to adopt this approach, particularly in cases with favorable anatomy or low-complexity tumors. Current EAU Guidelines report comparable safety and functional outcomes between off- and on-clamp approaches, while recommending off-clamp techniques mainly for selected patients such as those with pre-existing renal impairment or a solitary kidney.

Another relevant consideration is the inflammatory response triggered by renorrhaphy. Experimental data suggest that suturing may induce localized ischemia and chronic inflammation, which could impair microvascular integrity and nephron function over time.[24, 25] The absence of this mechanical injury in sutureless RAPN may partially explain the observed functional benefit. Future studies integrating inflammatory biomarkers such as platelet-to-lymphocyte ratio, neutrophil-to-lymphocyte ratio, and C-reactive protein may help elucidate this mechanism further.

Our evaluation of functional outcomes was based on global eGFR, which reflects overall renal performance but does not isolate the contribution of the operated kidney. This represents a methodological limitation, as contralateral compensatory hyperfiltration may mask subtle unilateral loss. Future studies should integrate imaging-based functional assessments such as renal scintigraphy[26] or pre/postoperative volumetric CT analysis[27] to more accurately quantify parenchymal preservation.

Our findings align with those of Liu *et al.*, whose meta-analysis demonstrated that sutureless partial nephrectomy offers improved renal function preservation, shorter operative times, and comparable complication rates when compared to standard renorrhaphy.[28] Taken together, these results support the selective use of sutureless techniques in appropriately chosen patients.

Importantly, our data reinforce the notion that in off-clamp RAPN, the absence of parenchymal suturing, when hemostasis is adequately secured, does not compromise perioperative safety. Electrosurgical hemostasis, complemented when necessary by topical hemostatic agents, appears sufficient to manage the tumor bed in most cases. These results challenge the traditional assump-

tion that parenchymal reconstruction is always necessary and support the emergence of a new paradigm in nephron-sparing surgery: sutureless resection as a viable and potentially preferable option once hemostasis has been achieved at the end of the tumorectomy phase.

Another avenue for enhancing functional preservation in nephron-sparing surgery lies in the integration of three-dimensional (3D) preoperative planning and image guidance. Recent studies have shown that 3D modeling can significantly improve the surgeon's ability to anticipate tumor depth, vascular anatomy, and proximity to the collecting system, thereby facilitating parenchymal sparing and tailored reconstruction. In particular, 3D-assisted approaches may prove especially valuable in the context of sutureless techniques, where precise excision and selective hemostasis are critical. A multicenter propensity score–matched analysis by Michiels *et al.*[29] demonstrated that 3D image-guided RAPN was associated with improved functional outcomes and greater accuracy in planning elective urinary tract reconstruction. These tools may help better identify cases in which renorrhaphy can be safely omitted, and conversely, when collecting system involvement warrants selective closure. As such, the use of 3D planning could serve as a valuable adjunct to intraoperative decision-making in future sutureless surgery protocols.

Beyond clinical outcomes, this approach also carries procedural and logistical advantages. The technique is reproducible and does not require advanced suturing skills, making it accessible to centers beyond high-volume referral institutions, provided the surgical team is experienced with off-clamp nephrectomy. The absence of renorrhaphy simplifies the operative workflow and may enhance efficiency. Indeed, in our cohort, operative time was reduced by approximately 30 minutes in the sutureless group compared to standard renorrhaphy. While this difference may seem modest, it represents a 17% decrease in operative time and becomes substantial when extrapolated across high-volume programs or resource-limited settings. As emphasized by Martins *et al.*, operating room time remains a major driver of robotic surgery costs, alongside equipment and personnel.[30] Streamlined approaches such as sutureless RAPN may thus contribute meaningfully to cost containment and procedural optimization.

Oncologic follow-up in our study, while adequate to detect early events, remains limited in duration. Although local recurrence and progression rates did not significantly differ between groups, longer-term prospective data are needed to fully assess oncological durability and validate these findings.

Conclusions

In this propensity score–matched study of off-clamp RAPN, the sutureless technique was associated with higher trifecta achievement, mainly due to improved early renal function preservation. Perioperative and oncological outcomes were comparable to those of standard renorrhaphy.

These results support the selective use of sutureless approaches in cases where hemostasis is adequately achieved. This technique appears to be safe, and potentially beneficial for functional outcomes and operative efficiency. Further studies are needed to validate its long-term impact and optimize patient selection.

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Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions
All authors read and approved the final version of the manuscript.

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