Original Article

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What Changed in Partial Nephrectomy in the Last Decade? A Comparison of Surgical Management and Outcomes

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Abstract

Objective: Surgical management of renal tumors has shifted toward partial nephrectomy (PN), even in larger or more complex cases. This study aimed to evaluate how clinical practice patterns, surgical approaches, and outcomes of PN evolved over the last decade.
Materials and Methods: Using the Turkish Urooncology Association REDCap database, we retrospectively reviewed 3,482 patients who underwent PN for renal cell carcinoma between 1997 and 2024. Patients were stratified into earlier (before 2014) and later (after 2014) groups. Demographic, surgical, perioperative, and oncologic parameters were compared. Subgroup analyses assessed open, laparoscopic, and robot-assisted PN. Statistical analyses were performed using t-tests and chi-square tests with significance set at $p<0.05$.
Results: Patients in the last decade were older (56.9 vs. 54.9 years; $p<0.001$). Hospital stay, blood loss, and ischemia time were significantly reduced (all $p<0.001$). The use of minimally invasive PN increased significantly, with robotic procedures comprising 12.2% of cases after 2014 ($p<0.001$). Intraoperative complications declined from 3.5% to 1.5% ($p=0.001$), and postoperative complications declined from 14.1% to 6.5% ($p<0.001$). Recurrence decreased from 8.7% to 3.5% ($p<0.001$), while positive margin rates remained stable at 9.1% in both groups. Subgroup analyses confirmed reductions in complications and in recurrence for both open and laparoscopic PN.
Conclusion: PN has evolved toward wider use in older patients and with minimally invasive techniques. Despite comparable tumor sizes, perioperative complications and recurrence rates declined significantly over time, supporting PN as a safe and effective treatment for complex renal tumors.
Keywords: Nephrectomy, renal cell carcinoma, surgical oncology

Introduction

Recently, surgical management of renal tumors has increasingly shifted toward partial rather than radical nephrectomy (RN), even for larger and more complex cases when feasible (1,2). Earlier detection through imaging and growing experience with partial nephrectomy (PN) have influenced this shift (3,4). PN is widely accepted as the preferred option for T1a renal masses and is increasingly used in selected T1b and even T2 cases when technically possible (5,6). Although RN was more common in the past, its use in T1 and selected T2 tumors has gradually decreased (7,8). PN offers similar cancer control especially for T1 tumors and may help preserve long term kidney function more effectively (9). However particularly in larger tumors, some studies have reported mixed results regarding overall survival, keeping the discussion open (9,10). With advances in surgical techniques and increased use of minimally invasive methods, open, laparoscopic and robot assisted PN have become more common and safer in many centers (11,12). Studies support the use of PN for larger renal tumors, showing advantages in kidney function outcomes, though with a slightly higher rate of complications (13,14). Also, the oncologic impact of positive surgical margins (PSM), a concerning outcome of PN, remains

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controversial (15). For small renal tumors, management may include PN as previously discussed, as well as ablative techniques or active surveillance in selected patients (16,17). This diversity in the management of renal tumors maintains the topic's relevance.

Our study aims to assess how the clinical approach to PN has changed over time by comparing patients treated in the last decade with those from earlier years. We investigated shifts in patient selection, surgical techniques, tumor complexity, and perioperative and oncological outcomes.

Materials and Methods

In our study, data from the Turkish Urooncology Association REDCap database were retrospectively reviewed (18,19). A total of 3,482 patients who underwent PN for renal cell carcinoma between 1997 and 2024 were included. As this was a multicenter, retrospective study, variability in surgical expertise, available technology, and institutional protocols was inevitable. However, all participating centers are high-volume tertiary institutions experienced in renal surgery, and data entry followed standardized definitions within the national database. While some heterogeneity may exist, the large sample size and consistent data collection likely reduce its overall impact. Variables assessed included patient age at the time of surgery, tumor size, operation type and duration, preoperative nephrometry scores, length of hospital stay, ischemia duration, and complications. Injuries involving the bowel, major vascular structures, diaphragm, or liver were collectively categorized as intraoperative complications and recorded as present or absent. Postoperative complications were similarly recorded as binary variables and included bleeding or the need for selective embolization, urinary fistula or the associated need for ureteral stenting, postoperative renal failure, reoperation, and development of deep vein thrombosis or pulmonary embolism. During postoperative follow-up, surgical margin status and tumor recurrence were also documented.

All statistical analyses were performed to compare clinical, surgical, and oncologic parameters between patients treated before 2014 and patients treated after 2014. That year was chosen as the cut-off point to provide a balanced comparison between earlier and more recent cases and to represent the most recent decade of data. It was not linked to any specific guideline change or technological milestone, but aimed instead to reflect temporal improvements in surgical practice and institutional experience. Continuous variables were expressed as mean ± standard deviation and compared using independent samples t-tests. Categorical variables were summarized as frequencies and percentages, and comparisons were performed using Pearson's chi-square test. Subgroup analyses were conducted for patients who underwent open, laparoscopic, or robot-assisted PN to assess changes over time in complication rates, recurrence, and surgical margin status.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). A p-value of less than 0.05 was considered statistically significant. Figures were generated using Python version 3.14.0 (Python Software Foundation, Wilmington, DE, USA).

Ethical approval for this multicenter database study was obtained from the Institutional Ethics Committee of Manisa Celal Bayar University (decision no: 20.478.486/3395, date: 04.09.2025). All participating centers have the necessary approvals to enter patient data into the database, and all data are stored anonymously.

Results

Significant differences between the earlier patients (before 2014) and patients from the last decade (after 2014) were observed using independent-samples t-tests. The last-decade patients were significantly older compared to earlier patients (56.92±14.12 vs. 54.92±13.03; p<0.001). Length of hospital stay (4.24±7.99 vs. 5.47±7.77; p<0.001), estimated blood loss (195.35±250.43 vs. 237.34±279.85; p < 0.001), and ischemia time (17.06±0.7 vs. 19.38±0.8; p<0.001) were all significantly lower in the last-decade patients. No statistically significant differences were found between the groups in terms of tumor size (3.65±2.01 vs. 3.82±2.38; p=0.78) and operative time (2.23±1.44 vs. 2.35±0.91; p=0.14) (Table 1). The narrow standard deviation, especially for ischemia time, is likely due to standardized reporting across centers and to the fact that extreme values were both infrequent and excluded.

Preoperative nephrometry scores were assessed using the RENAL, PADUA, C-index, and DAP systems in 670, 319, 116, and 117 patients, respectively. The limited number of patients with available nephrometry scores was due to the retrospective design the long study period, and the multicenter nature of the study. Nevertheless, extensive data screening was performed to include the maximum number of eligible cases, and the final analyses were based on these data. While mean RENAL (6.97 vs.

Table 1. Comparison of patient, tumor and perioperative characteristics

Variable	Before 2014	After 2014	p-value
Age (years)	54.92±13.03	56.92±14.12	**<0.001**
Hospital stays (days)	5.47±7.77	4.24±7.99	**<0.001**
Estimated blood loss (mL)	237.34±279.85	195.35±250.43	**<0.001**
Ischemia time (minutes)	19.38±0.8	17.06±0.7	**<0.001**
Tumor size (cm)	3.82±2.38	3.65±2.01	0.780
Operative time (hours)	2.35±0.91	2.23±1.44	0.140

6.54) and PADUA (8.66 vs. 8.35) scores were slightly higher in patients in the last decade, these differences were not statistically significant (p=0.123 and 0.147, respectively). The C-index was marginally higher in earlier patients (2.09 vs. 1.94), whereas DAP scores were slightly higher in the last-decade group (6.15 vs. 5.91); neither difference reached statistical significance (p=0.777 and 0.374, respectively) (Table 2).

A significant shift in the type of surgical approach was observed between the two groups. Among earlier patients, 618 (71.2%) underwent open surgery and 250 (28.8%) laparoscopic surgery. In the last decade, 1,280 patients (49%) underwent open surgery, 1,016 (38.8%) underwent laparoscopic surgery, and 318 (12.2%) underwent robot-assisted surgery. This change was statistically significant according to Pearson's chi-square test (p<0.001) (Figure 1). Significant differences were observed in intraoperative and postoperative complications and in recurrence rates. Intraoperative complications were recorded in 29 patients (3.5%) in the earlier cohort and in 37 patients (1.5%) in the last-decade cohort (p=0.001). Postoperative complications were also more frequent in the earlier group, affecting 116 patients (14.1%) compared with 165 patients (6.5%) in the last-decade group (p<0.001). There was no statistically significant difference in PSM; both groups had identical rates of 9.1% (p=1.000). Recurrence rates significantly declined from 8.7% (77 cases) in the earlier group to 3.5% (92 cases) in the last-decade group (p<0.001) (Table 3).

A subgroup analysis was conducted focusing only on patients who underwent open PN. Significant differences were identified in intraoperative and postoperative complications, as well as in recurrence. Intraoperative complications were recorded in 3.1% (18/578) of patients in the earlier period and 1.4% (17/1227) of patients in the last decade (p=0.001). Postoperative complications occurred in 10.9% (63/576) of earlier patients and in 5.5% (67/1224) of patients from the last decade (p<0.001). No statistically significant difference in surgical margin status was found: positive margins were reported in 8.0% (47/591) of patients in the earlier period and 9.4% (22/234) of patients in the last decade (p=0.300). Recurrence was detected in 8.1% (50/618) of earlier patients and in 3.5% (45/1280) of patients from the last decade (p<0.001), indicating a significant reduction over time (Table 3).

A secondary subgroup analysis was then performed, focusing on patients who underwent laparoscopic PN. Significant differences were observed between the two groups in intraoperative and postoperative complications and recurrence rates. Intraoperative complications occurred in 3.9% (9/233) of patients from an earlier period and 1.5% (19/1275) of patients from the last decade (p<0.05). Postoperative complications were noted in 19.4% (45/232) of patients from an earlier period and in 7.3% (94/1288) of patients from the last decade (p<0.001). No statistically significant difference in surgical margin status was found: positive margins were observed in 12.7% (21/165) of patients from the earlier period and 8.9% (102/1140) of patients from the last decade (p=0.130). Recurrence was reported in 10.0% (25/250) of earlier patients and 3.4% (45/1334) of patients in the last decade, representing a statistically significant decrease (p<0.001). Over the last decade, 318 patients who underwent robot-assisted laparoscopic surgery were included in the laparoscopic group because no robotic surgeries were performed in the earlier group (Table 3).

A subgroup analysis evaluated the relationships among PSM, recurrence, and tumor size by time period. Before 2014, recurrence occurred in 7/54 (13.0%) patients with PSM vs. 70/832 (8.4%) patients with negative surgical margins (p=0.19). After 2014, recurrence was 3/21 (14.3%) vs. 87/2,575 (3.4%) (p=0.07). Mean tumor size was slightly higher in PSM cases both before (4.25±2.34 cm vs. 3.79±2.29 cm; p=0.11) and after 2014 (4.05±1.92 cm vs. 3.63±1.97 cm; p=0.12). Although PSM patients showed higher recurrence rates and larger tumors in both periods, none of these differences were statistically significant.

Discussion

In this study, we observed notable shifts in the surgical management and clinical characteristics of patients undergoing PN over time. The last-decade group was significantly older than earlier patients (p<0.001), and showed significant reductions in length of hospital stay (p<0.001), estimated blood loss (p<0.001), and ischemia time (p<0.001). Despite these factors, perioperative outcomes improved markedly: intraoperative complications declined from 3.5% to 1.5% (p=0.001), postoperative complications declined from 14.1% to 6.5% (p<0.001), and recurrence rates declined from 8.7% to 3.5% (p<0.001). Use of laparoscopic PN rose significantly, from 28.8% to 38.8%, with an additional 12.2% undergoing robot-assisted surgery (p<0.001). Over time, surgical practice shifted from open PN to laparoscopic and robotic PN. Advances in minimally invasive surgery, together with greater surgical expertise, improved hospital protocols, and multidisciplinary care, have led to shorter ischemia times, less blood loss, and fewer complications. These combined factors likely contributed to better perioperative and oncologic outcomes observed over the last decade without increasing PSM.

Support for the oncologic safety of PN in larger tumors is further provided by Janssen et al. (5), who found significantly lower recurrence with PN than with RN for T2 tumors (9.0% vs. 41.6%, p=0.046), along with significantly better cancer specific survival

Table 2. Comparison of nephrometry scores

Score	Total (n)	Before 2014 (mean)	After 2014 (mean)	p-value
RENAL	670	6.54±2.05	6.97±2.01	0.123
PADUA	319	8.35±1.73	8.66±1.89	0.147
C-Index	116	2.09±3.31	1.94±1.14	0.777
DAP	117	5.91±1.46	6.15±1.39	0.374

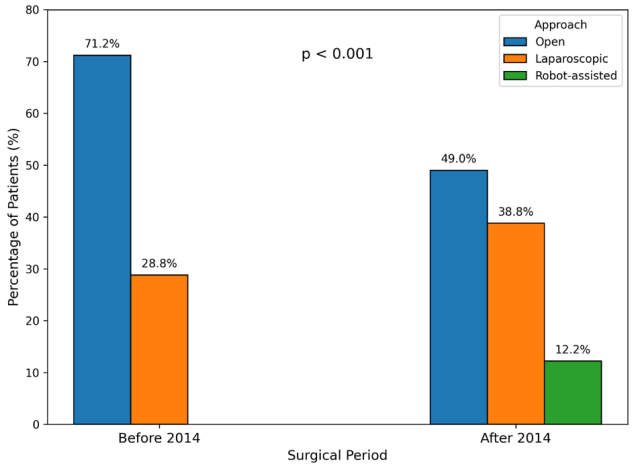

Figure 1. Change in surgical approach over time

in the PN group (p=0.015). However, this difference likely reflects selection bias, as PN was offered electively to carefully selected patients with more favorable tumor characteristics, whereas larger and more aggressive tumors were preferentially treated with RN. In our series, recurrence rates were also lower over the last decade despite comparable tumor sizes, supporting the notion that, with growing surgical expertise, PN can be safely expanded to selected patients without compromising oncologic outcomes.

The systematic review and meta-analysis conducted by Mir et al. (13), which included 21 comparative studies covering patients treated between 1970 and 2012, primarily reflects earlier surgical practice and thus temporally aligns with the first half of our cohort. In their analysis of T1b and ≥T2 tumors, patients selected for PN were on average 2.3 years younger (p<0.001) and had tumors that were 0.65 cm smaller (p<0.001) than those undergoing RN. They also reported a significantly higher overall complication risk in the PN group (odds ratio: 1.74; p<0.001). In contrast, our more recent data show that PN has increasingly been applied to older patients with tumors of similar size, and, importantly, this shift has been accompanied by a marked decline in complication rates, whereas positive margin rates have remained stable. These evolving trends likely reflect improvements in surgical expertise, patient selection, and institutional practices.

Hjelle et al. (20) similarly observed a significant increase in the utilization of PN across Norway between 2008 and 2013. This trend was particularly evident for tumors up to 7 cm and was associated with a corresponding improvement in relative survival rates. PN rates rose from 43% to 66% for tumors ≤4 cm and from 10% to 18% for tumors measuring 4.1-7 cm. The 5-year relative survival for T1b tumors was 98.8% following PN versus 90.0% following RN (p<0.05). Our data reflect this trend, showing a clear rise in minimally invasive and robotic PN over the last decade, while open surgery rates have declined. Importantly, perioperative and oncologic outcomes improved in parallel, with fewer complications and lower recurrence rates, despite the tumors treated being of similar size. These findings suggest that broader implementation of PN can lead to improved outcomes, particularly when performed at experienced centers.

Our findings are further supported by the comprehensive analysis of Touijer et al. (21), who reviewed outcomes of PN across multiple institutions and concluded that PN is both feasible and oncologically safe for tumors >4 cm. In their multicenter cohort, local recurrence rates after PN for T1b tumors were 3.6%, comparable to the 2.3% recurrence observed after RN; disease-specific survival did not differ significantly between the two groups (p=0.800). Moreover, they reported a higher, but acceptable, complication rate in PN for larger tumors, with urinary fistula rates of 4.4% and perioperative bleeding rates of 3.1%. Consistent with these findings, our series demonstrated a decline in recurrence and complication rates over time, reflecting that growing surgical experience and minimally invasive techniques can effectively mitigate the technical challenges of modern PN.

Table 3. Comparison of complications, surgical margins and recurrence by period and surgical technique

Parameter	Surgical type	Before 2014	After 2014	p-value
Intraoperative complications	Overall	29/824 (3.5%)	37/2538 (1.5%)	**0.001**
	Open PN	18/578 (3.1%)	17/1227 (1.4%)	**0.001**
	Laparoscopic PN	9/233 (3.9%)	19/1275 (1.5%)	**<0.05**
Postoperative complications	Overall	116/822 (14.1%)	165/2549 (6.5%)	**<0.001**
	Open PN	63/576 (10.9%)	67/1224 (5.5%)	**<0.001**
	Laparoscopic PN	45/232 (19.4%)	94/1288 (7.3%)	**<0.001**
Surgical margin	Overall	54/591 (9.1%)	21/234 (9.1%)	1.000
	Open PN	47/591 (8.0%)	22/234 (9.4%)	0.300
	Laparoscopic PN	21/165 (12.7%)	102/1140 (8.9%)	0.130
Recurrence	Overall	77/886 (8.7%)	92/2664 (3.5%)	**<0.001**
	Open PN	50/618 (8.1%)	45/1280 (3.5%)	**<0.001**
	Laparoscopic PN	25/250 (10.0%)	45/1334 (3.4%)	**<0.001**

PN: Partial nephrectomy

Study Limitations

This study has several limitations. As a retrospective multicenter study, it was inevitable that there would be variability in surgeon experience, technology availability, and institutional practices. Potential confounders such as comorbidities, tumor location, and incomplete nephrometry data were not adjusted for in the analysis and may have influenced some results. Some long-term renal function outcomes, such as estimated glomerular filtration rate trends, could not be analyzed. Moreover, missing data bias may exist, as nephrometry scores were available only for a subset of patients. Multivariate regression could not be performed due to insufficient variable completeness, which limited our ability to adjust for potential confounders. Despite these limitations, the large sample size and standardized data collection across high-volume tertiary centers enhance the reliability and generalizability of the findings.

Conclusion

Our findings demonstrate significantly lower complication and recurrence rates among patients undergoing PN over the last decade, despite increasing tumor complexity and broader use of minimally invasive techniques. These results suggest that PN remains a safe and effective option even for more complex renal tumors. Ongoing advances in surgical techniques and patient selection remain important for maintaining favorable outcomes.

Ethics

Ethics Committee Approval: Ethical approval for this multicenter database study was obtained from the Institutional Ethics Committee of Manisa Celal Bayar University (decision no: 20.478.486/3395, date: 04.09.2025).

Informed Consent: All participating centers have the necessary approvals to enter patient data into the database, and all data are stored anonymously.

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Contribution: There is not any contributors who may not be listed as authors.

Footnotes

Authorship Contributions

Surgical and Medical Practices: O.Ü., T.M., M.G., Ç.A., S.Y., S.Ç., V.İ., Concept: T.M., M.G., S.Y., Design: T.M., M.G., V.İ., Data Collection or Processing: O.Ü., S.Y., O.E., Analysis or Interpretation: O.Ü., Ç.A., Literature Search: M.G., S.Y., S.Ç., O.E., Writing: O.Ü., O.E.

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