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Comparison of 3-dimensional laparoscopy and conventional laparoscopy in the treatment of complex renal tumor with partial nephrectomy

A propensity score–matching analysis

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Abstract

To compare the efficacies of 3-dimensional laparoscopic partial nephrectomy and conventional laparoscopic partial nephrectomy for complex renal tumors. The complex renal tumors was defined as Preoperative Aspects and Dimensions Used for an anatomical (PADAU) ≥10, including some cT1b tumors.

This was a retrospective analysis of patients with local complex renal tumors who presented to our hospital from January 2014 to January 2018. All patients were managed with laparoscopic partial nephrectomy (LPN) or 3-dimensional partial nephrectomy (3DLPN).

There were 48 patients in the LPN group and 60 in the 3DLPN group. In the matched groups, demographic and tumor characteristics including Charlson Comorbidity Index, PADUA, based on the preoperative images, were similar. By contrast, 3DLPN achieved better results in terms of warm ischemia time (19 vs 27 minutes), operation time (105 vs 128 minutes), postoperative complications (14.9% vs 23.4%), and marginal width (0.6 cm vs 0.4 cm). We found statistically significant differences in terms of length of stay, estimated blood loss (EBL), positive surgical margin (PSM), and conversion to open or radical nephrectomy (RN). Median follow-up time was 17 and 18.5 months for the LPN and 3DLPN groups, respectively. The recovery of renal function (% change eGFR, 0 vs −8.7) was significantly different between the 3DLPN and LPN groups, whereas 12-month recurrence-free survival did not differ.

Both 3-dimensional laparoscopic nephron-sparing nephrectomy and conventional laparoscopic partial nephrectomy are safe, effective, and acceptable approaches to treating complex renal tumors, while the former may facilitate tumor resection and renorrhaphy for challenging cases, offering a minimally invasive surgical option for patients who may otherwise require open surgery.

Abbreviations: 3DLPN = 3-dimensional laparoscopic partial nephrectomy, AML = Angiomyolipoma, BMI = body mass index, CCI = Charlson comorbidity index, CKD = chronic kidney disease, EBL = estimated blood loss, eGFR = estimated glomerular filtration rate, IQR = interquartile range, LPN = laparoscopic partial nephrectomy, MDRD = Modification of Diet in Renal Disease, NSS = nephron sparing surgery, PADUA = preoperative aspects and dimensions used for an anatomical, PSM = positive surgical margins, RFS = recurrence-free survival, RN = radical nephrectomy, WIT = warm ischemia time.

Keywords: 3-dimensional laparoscopy, complex renal tumor, partial nephrectomy

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1. Introduction

Renal tumors are common, and the incidence in China is dramatically increasing coincident with the widespread use of abdominal computational tomography and B-type ultrasound.[1] Tumor resection is the most effective treatment; nevertheless, radical nephrectomy (RN) carries the significant risk of chronic kidney disease (CKD), possibly increasing the risk for cardiocerebrovascular events.[2] Various lines of evidence[3] suggest that partial nephrectomy (PN) achieves equivalent oncological outcomes with those of RN. Current guidelines recommend that PN be the standard treatment for small renal cancers (cT1 stage).[4,5] As the applications of PN continues to expand, the clear majority of patients presenting with a renal mass may eventually be offered some form of nephron-sparing surgery (NSS). In fact, the indications for NSS are gradually expanding with the advancement of minimal invasive techniques. Nevertheless, there remain great challenges in performing laparoscopic partial nephrectomy (LPN) for complex renal tumors. Despite the fact that the definition of surgical complexity of renal tumor has not been clearly standardized, objective anatomical classification systems do exist. Here, we defined complex renal tumors as Preoperative

Aspects and Dimensions Used for an anatomical (PADAU) ≥10,[6] including some cT1b tumors.

Of the currently available PN techniques, robot-assisted laparoscopy has had difficulty expanding in China mainland because of policy and high costs. Nevertheless, conventional laparoscopy possesses some inherent disadvantages. Compared to conventional laparoscopy, 3-dimensional laparoscopy provides hyper accurate vision, and 3-dimensional reconstruction effect, both of which greatly assist judgment of distance and visualization of anatomical layers and microstructures; the technique facilitates *en bloc* removal of tumors and rapid suturing. A few studies[7–10] have demonstrated the safety and efficacy of PN in removal of complex renal tumors, although these reports focus on open or robot-assisted laparoscopic approaches. Therefore, more investigations are needed to determine the safety and efficacy of 3DLPN for treatment of complex renal tumors. Therefore, we retrospectively reviewed data of patients with complex renal tumors in our center from January 2014 to January 2018, and compared the perioperative and follow-up characteristics of LPN and 3DLPN in terms of oncologic control, renal function recovery and complications.

2. Patients and methods

2.1. Data acquisition

The data were obtained from a retrospectively maintained database approved by the institutional review board and ethics committee. From January 2014 to January 2018, all patients who underwent LPN or 3DLPN for complex renal tumors were identified and classified as LPN or 3DLPN group according to the surgical approach. The patients with multiple or bilateral tumors, metastatic disease was excluded. All patients had first-time newly-diagnosed renal tumors. The demographic details were recorded. All CT scans were viewed by an urologist and a radiologist. The PADAU nephrometry scoring system was used to account for tumor complexity using a retrospective review of imaging[6]: evaluation including anterior or posterior face, longitudinal, and rim tumor location; tumor relationships with renal sinus or urinary collecting system; and the percentage of tumor extending into the kidney. The complex renal tumor was defined in our study as the PADAU ≥10. The procedures were performed by 1 surgeon.

Operative characteristics were noted, including warm ischemia time (WIT), estimated blood loss (EBL), operation time (OT), postoperative complications in Clavien-Dindo format,[11] length of hospital stay (LOS), and percent change in estimated glomerular filtration rate (eGFR) evaluated by using the Modification of Diet in Renal Disease (MDRD) equation.[12] This change in creatinine and eGFR was calculated at the immediate postoperative period and at the last available follow-up of the patient. Histopathology was reviewed for type of renal tumor, margin status, marginal width. These patients were follow-up regularly and examined the eGFR at discharge, 3 months, and 12 months postoperatively.

Oncological outcomes were evaluated through routine post-operative follow-up imaging studies, e.g. chest X-ray, CT of the chest, abdominal CT, and/or MRI. Imaging was carried out at 6, 12 months, then yearly and when clinically indicated. Events of local recurrence, distant metastasis, death from cancer, and all causes of death were reviewed and analyzed. Local recurrence was defined as detection of a new enhancing lesion, specifically in the surgical bed or in the same region (e.g. lower pole or renal fossa). Distant metastasis was defined as disease recurrence in the contralateral kidney or other body organs. Events of death from RCC and events of death from any other cause were collected from the medical records of the hospitals.

2.2. Short description of surgical techniques

After induction of general anesthesia, a urinary catheter is placed. The patient is positioned in the standard full-flank position with the kidney rest elevated and the operative table is flexed. Three ports along with the superior border of the iliac crest, subcostal incision, and the tip of 12th rib are placed. Pneumoperitoneum of 13 to 15 mm Hg is created using open access. Laparoscopic bulldog clamps are applied to block the renal artery. If the collecting system had been entered, or if large vessels remained patent, a repair with absorbable barbed wire is made before proceeding with renorrhaphy. The ureteric stenting are not performed.

2.3. Statistical analysis

To minimize selection bias, 7 perioperative variables representative of patient features (age, gender, BMI, CCI, and baseline CKD) and tumor characteristics (location and PADAU score) were selected and matched 1:1 using propensity score matching, because these variables are thought have significant impact on patient survival. Values are expressed as medians (interquartile ranges) except where indicated. Categorical variables were compared using pairwise Chi-Squared test of independence or Fisher exact test. Continuous variables were compared using the pairwise Mann–Whitney *U* test. Kaplan–Meier survival curves were used to compare the local recurrence-free survival between 2 groups. All reported *P* values were two-sided, and statistical significance was set at $P<.05$. Statistical analyses were performed using the Statistical Package for Social Sciences, version 23.0, for Windows (IBM Corp., Armonk, NY, USA)

3. Results

3.1. Preoperative characteristics

Overall, 108 patients underwent LPN (48), or 3DLPN (60) between January 2014 and January 2018 at the Department of Urology. Patient demographics and preoperative characteristics are reported in Table 1. We performed a propensity score-matching adjustment for potential confounding factors. Firstly, the propensity score for every patient was calculated by logistic regression method and the covariables including age, gender, body mass index and Charlson comorbidity index, baseline renal function, tumor laterality, and PADAU score categories. Then the patients in the LPN and 3DLPN groups were matched by nearest neighbor matching method. The final sample size was 47 patients in each group. Age, gender, body mass index, Charlson comorbidity index, baseline renal function, tumor laterality, and PADAU score categories were similar between 2 groups after matching. Interestingly, the patients in our cohort were relatively fat slender: median BMI was 23.3 and 23.5 for the LPN and 3DLPN groups, respectively. Median age in both groups were 58 years, and the gender ratio was close to 1:1. Of the 47 patients in the LPN group, 6 had more than 3 stages CKD. Similarly, there were 6 in the 3DLPN group. The clear majority of PADAU score

Table 1

Patient and tumor characteristics.

	Before matching			After matching		
Variables	**LPN**	**3DLPN**	***P***	**LPN**	**3DLPN**	***P***
Patients, no	48	60		47	47	
Age (y), median (IQR)	58 (50,71)	58 (48,73)	.82	58 (51, 71)	58 (50,73)	.88
Gender, no (%)			.76			.68
Male	24 (50.0)	29 (48.3)		23 (48.9)	22 (46.8)	
Female	24 (50.0)	31 (51.7)		24 (51.1)	25 (53.2)	
BMI (kg/m^2), median (IQR)	23.5 (21.5,27.2)	23.8 (21.5, 28.7)	.78	23.3 (21.5, 27.2)	23.5 (20.6, 27.5)	.86
CCI (age adjusted), no (%)			.79			.46
0–1	31 (64.6)	39 (65.0)		30 (63.8)	28 (59.6)	
2–3	10 (20.8)	12 (20.0)		10 (21.3)	11 (23.4)	
4–5	4 (8.3)	5 (8.3)		4 (8.5)	5 (10.6)	
≥6	3 (6.3)	4 (6.7)		3 (6.4)	3 (6.4)	
Baseline ≥CKD 3 stage, no (%)	6 (12.5)	7 (11.7)	.15	6 (12.8)	6 (12.8)	1.0
Tumor laterality, no (%)			.37			.06
Right	23 (48.0)	31 (51.7)		23 (48.9)	24 (51.1)	
Left	25 (52.0)	29 (48.3)		24 (51.1)	23 (48.9)	
Clinical stage, no (%)			.74			.46
T1a	18 (37.5)	23 (38.3)		18 (38.3)	17 (36.2)	
T1b	30 (62.5)	37 (61.7)		29 (61.7)	30 (63.8)	
PADUA score categories, no (%)			.18			.07
10	29 (60.4)	36 (60.0)		28 (59.6)	27 (57.5)	
11	16 (33.3)	19 (31.7)		16 (34.0)	16 (34.0)	
12	2 (4.2)	3 (5.0)		2 (4.3)	3 (6.4)	
13	1 (2.1)	2 (3.3)		1 (2.1)	1 (2.1)	

BMI = body mass index, CCI = Charlson Comorbidity Index, CKD = chronic kidney disease, IQR = interquartile range, PADUA = preoperative aspects and dimensions used for an anatomical.

for tumors were 10 or 11 in 2 groups, and the percentages of PADAU score 10 were 59.6% and 57.5% in the LPN and 3DLPN groups, respectively. The percentage of PADAU score 11 was 34% for both the LPN and 3DLPN groups.

3.2. Operative and perioperative characteristics

Operative and perioperative data are shown in Table 2. Median operative time was significantly shorter in the 3D-LPN group than in the LPN group (105 and 128 minutes, respectively). Median WIT was significantly shorter in the 3DLPN than in the LPN group (19 and 27 minutes, respectively). Before matching, median EBL was significantly lower in the 3DLPN than in the LPN group (90 and 100 ml, respectively); however, the difference between 2 groups was not statistically significant (98 vs 105 ml, $P = .06$) after matching. Marginal width was significantly thinner in the 3DLPN group than in the LPN group (0.4 vs 0.6 cm). One of the patients in the LPN group had positive surgical margins because the tumor located in the renal hilum and was adjacent to the renal pedicle. The conversion rate was the same (4.3%) for the 3DLPN and LPN groups. Lengths of stay were 6 and 7 days in the 3DLPN and LPN groups, respectively. The total complication

Table 2

Operation characteristics.

	Before matching			After matching		
Variables	**LPN**	**3D-LPN**	***P***	**LPN**	**3D-LPN**	***P***
WIT, median (IQR), min	25 (20, 40)	17 (14, 27)	<.001	27 (22,40)	19 (15, 28)	<.001
>20 min, no (%)	30 (62.5)	11 (18.3)	<.001	30 (63.8)	11 (23.4)	<.001
≥30 min, no (%)	6 (12.5)	2 (3.3)	<.001	6 (12.8)	2 (4.3)	<.001
Operative time, median (IQR), min	125 (80, 180)	100 (70, 170)	<.001	128 (81, 180)	105 (76, 175)	.034
EBL, median (IQR), mL	100 (70, 150)	90 (65,140)	.043	105 (72,150)	98 (68, 145)	.06
Conversion to open or RN, no (%)	2 (4.2)	2 (3.3)	.064	2 (4.3)	2 (4.3)	1.0
Marginal width, median (IQR), cm	0.6 (0.5, 0.8)	0.3 (0.2, 0.5)	<.001	0.6 (0.5, 0.8)	0.4 (0.3, 0.6)	.04
Post-op complication (%)	11 (22.9)	8 (13.3)	<.001	11 (23.4)	7 (14.9)	<.001
Clavien grade 1	8 (16.7)	6 (10.0)		8 (17.0)	5 (10.6)	
Clavien grade 2	2 (4.2)	2 (3.3)		2 (4.3)	2 (4.3)	
Clavien grade 3	1 (2.1)*	0		1 (2.1)*	0	
Positive surgical margin, no (%)	1 (2.1)	0	.39	1 (2.1)	0	.15
Length of stay, median (IQR), days	7 (4, 12)	6 (3, 12)	.47	7 (4, 12)	6 (4,12)	.69

* Clavien Grade 3 complication involved post-op bleeding requiring radiological embolization.

CCI = Charlson Comorbidity Index, CKD = chronic kidney disease, EBL = estimated blood loss, IQR = interquartile range, PADUA = preoperative aspects and dimensions used for an anatomical, RN = radical nephrectomy, WIT = warm ischemia time.

Table 3

Oncological outcome characteristics.

Variables	Before matching LPN	Before matching 3DLPN	Before matching P	After matching LPN	After matching 3DLPN	After matching P
Histology, no (%)			.74			.69
AML	9 (18.7)	12 (20)		8 (17.0)	7 (14.9)	
Clear-cell	27 (56.3)	34 (56.7)		27 (57.4)	25 (53.2)	
Papillary	6 (12.5)	7 (11.7)		6 (12.8)	7 (14.9)	
Chromophobe	2 (4.2)	3 (5.0)		2 (4.3)	3 (6.4)	
Other	4 (8.3)	4 (6.6)		4 (8.5)	4 (8.5)	
12-month RFS, no (%)*	38 (97.4)	48 (100)		38 (97.4)	40 (100)	.32†
Follow-up, median (IQR), months	19 (14, 45)	18 (13, 47)	.65	18.5 (15,45)	17 (14, 44)	

* Only for malignant.
† Log-rank *P* value.
AML = Angiomyolipoma, IQR = interquartile range, RFS = recurrence free survival.

rate was significantly lower in the 3DLPN group than in the LPN group (14.9% and 24.3%, respectively), and almost all were minor complications, except 1 patient with a 4 cm size hilar tumor in the LPN group who had 2 days post-operative bleeding requiring radiological embolization.

Pathological features are shown in Table 3. In the matched LPN group, there were 8 patients with AML, and 39 patients with malignant tumors, including clear cell cancer, papillary cancer, chromophobe cancer, and others. Similarly, in the matched 3DLPN group, there were 9 patients with AML and 40 patients with malignant tumor. After median 18.5- and 1- month follow-up, there was 1 local recurrence case in the LPN group while all patients in the 3DLPN group achieved recurrence-free survival (RFS). Kaplan–Meier survival curve showed no differences between them (data not shown, Log-rank $P = .32$).

3.3. Preservation of renal function

The changes in renal function pre- and post-operatively are summarized in Table 4. The median eGFR was 84.5 ml/minute and 84 ml/minute in the matched LPN group and the matched 3DLPN group, respectively. The changes of eGFR were statistically smaller in the 3DLPN than in the LPN after surgery. The values were −9.0% vs −13.5% at discharge, −4.3% vs −10.2% at 3 months post-operatively, 0 vs −8.7% at 12 months post-operatively, respectively.

4. Discussion

The optimal treatment of renal tumors should provide acceptable functional and oncologic outcomes with minimal morbidity. Partial nephrectomy preserves working nephrons, diminishes the risk of postoperative chronic kidney disease, and dramatically improves the overall survival and survival quality compared to the effects of radical nephrectomy.[3] Currently, there are 3 approaches partial nephrectomy, including open surgery, laparoscopy, and robot-assisted laparoscopy. Several lines of evidence[13–15] suggest that LPN is alternative to open PN for resection of T1 renal tumors, associated with shorter hospital stay and yielding equivalent oncologic outcomes to those of the open approach. Nevertheless, LPN is technically demanding and can be particularly challenging for more complex tumors, including some T1b tumors and hilar or endophytic masses.

Generally, more complex tumors are associated with longer operative times, longer WIT, and greater blood loss, as well as higher complication rates. Although robot-assisted PN has been proved to be a safe and effective treatment for selected patients with complex tumors,[7,9,16–19] robot-assisted laparoscopy is not yet available for most hospitals in the Chinese mainland because of regulations from the Chinese government and the high costs of the instruments. Laparoscopy remains the most popular minimal invasive technique; it is associated with 2-dimensional views and longer learning curves than robot-assisted laparoscopy. The advent of 3-dimensional laparoscopy may fill a gap between these approaches. The 3D laparoscopy provides 3-dimensional and high-definition view, allowing further expansion of the indications of minimally invasive NSS, allowing safer and more precise excision of larger tumors. The cost of each procedure with 3-dimensional laparoscopy is comparable to that with conventional laparoscopy.

In the present study, we assessed the complexity of renal tumors using the PADAU nephrometry score and compared

Table 4

Pre- and post-op renal function characteristics.

eGFR, median (IQR), ml/minutes/1.73 m^2	Before matching LPN	Before matching 3D-LPN	Before matching P	After matching LPN	After matching 3DLPN	After matching P
Pre-op	85 (60, 95)	83 (58, 93)	.46	84.5 (62, 93)	84 (60, 95)	.68
at discharge	70 (52, 85)	75 (54, 87)		71 (51, 86)	76 (56, 86)	
% Change eGFR, median (IQR)	−14.3 (−18.3, 10.5)	−9.3 (−12.7, −6.9)	.04	−13.5 (−17.5, −10.5)	−9.0 (−11.5, −7.3)	.01
3 months post-op	75 (55,84)	81 (60,95)		75 (55,84)	82 (60, 95)	
% Change eGFR, median (IQR)	−9.5 (−12, −6.8)	−4.5 (−6.5, −1.5)	.02	−10.2 (−12.5, −6.8)	−4.3 (−6.8, −2.0)	<.001
12 months post-op	78 (59,90)	83 (59,95)		77 (58,90)	84 (61, 95)	
% Change eGFR, median (IQR)	−8.3 (−9.0, −5.8)	0.5 (−1,3)	<.001	−8.7 (−9.5, −5.8)	0 (−2.0, 3)	<.001

% change eGFR is the result of comparing with baseline eGFR, eGFR = estimated glomerular filtration rate, IQR = interquartile range.

3DLPN and LPN with respect to perioperative, long-term functional and oncological outcomes. To the best of our knowledge, this is the first study in the literature to provide a long-term comparative analysis between the 2 surgical approaches.

Patients in the 3DLPN group had shorter operation time (105 vs 128 minutes, $P=.04$) and WIT (19 vs 27 minutes, $P<.001$), thinner marginal width (0.4 vs 0.6 cm, $P=.04$), and lower complication rate (14.9% vs 23.4%, $P<.001$) than patients in the LPN groups. There appeared to be lower EBL (98 vs 105 ml); however, the difference was not statistically significant ($P=.06$). This may reflect the technical advantages offered by 3D laparoscopy that employs magnified 3-dimensional views to help the surgeon assess and maintain the proper plane of tumor resection. Magnification of the renal resection bed can also aid in the identification of open vessels or cracks in the collecting system needing closure; the results of the LPN group were not inferior to those published before.[9,14] Interestingly, because the national medical insurance system in China is quite different from those of western countries, median lengths of hospital stay were 6 and 7 days for 3DLPN and LPN, respectively; this is longer than values reported in previous studies from western countries (3–5 days).[7–9,16,18]

In terms of safety, the incidence of postoperative complications in our study for 3DLPN and LPN were 14.9% and 23.4%, respectively ($P<.001$). One patient in the matched LPN group suffered postoperative bleeding (Clavien grade 3) requiring radiological embolization. More importantly, most of the postoperative complications were minor and classified as Clavien grade 1 or 2, and were managed using conservative therapy, pharmacotherapy or embolization.[11] Those rates are comparable to the rates reported for major series of RPN.[7,9,16,20] Conversion for 3DLPN and LPN was not common (4.3% vs 4.3%). Therefore, both techniques were safe for the management of complex tumors.

The difference of conversion rate between 2 groups were not significant, possibly because of unmanageable bleeding during surgery, which was difficult to suture quickly and accurately using laparoscopic instruments. In this respect, the 3D laparoscopy has no advantage over conventional laparoscopy.

One of the main goals of PN is to preserve renal function. In our study, we found that changes of eGFR were dramatically smaller in the 3DLPN group than in the LPN group after surgery: −9.0% vs −13.5% at discharge, −4.3% vs −10.2% 3 months postoperatively, and 0 vs −8.7% 12 months postoperatively, respectively. Many factors influence renal function recovery after PN, including effective nephron number preoperatively, WIT, the residual effective nephron number postoperatively, comorbidities and medication. WIT is thought to be most important for preserving renal function.[21,22] In another study WIT did not affect the preservation of renal function if it was less than 20 minutes; otherwise, it produced a significant impact.[23] According to this rationale, WIT has little effect on renal function postoperatively for patients with small renal masses, because the WIT of both approaches is less than 20 minutes, regardless of any significant difference between groups. Nevertheless, for complex renal tumors, the WIT reported by some investigators was between 20 and 30 minutes.[7–9,16,19,20] Our results showed that time saved during surgery in the 3DLPN with respect to the LPN group may play an important role in the recovery of renal function. The follow-up results in our series confirmed this conclusion. Although we only followed these patients for 1 year, the present data were sufficient to lead us to conclude that 3D laparoscopy has significant advantages over conventional laparoscopy for management of complex renal tumors, especially for preserving renal function. We attribute this result to the fact that postoperative eGFR is significant affected by the longer WIT in the LPN group,[24] despite the fact that Lee et al[25] reported that prolonged WIT was not associated with increased incidence of CKD after PN.

A major concern regarding partial nephrectomy for complex tumors is adequate oncological control. There were no cancer-related deaths in these patients; however, our RFS rates were 97.4% in matched LPN group and 100% in matched 3DLPN group at 12-month follow-up. In other series evaluating robot-assisted PN or LPN for complex renal tumors, no local recurrence was noted during follow-up; however, the follow-up of the available series are too short to draw any conclusions regarding oncological outcomes of robot-assisted PN for complex tumors.[19] In our study, PSM rates for matched LPN and 3DLPN groups were 2.1% and 0%, respectively. In other published series, PSM rates ranged from 1.9%[7] to 3.2%[20] for patients who underwent RPN with similar complex tumors. Though every effort must be performed to obtain negative margins, PSM appears to have a marginal impact on recurrence and survival.[26] To optimize the management of renal tumors, a new prognostic marker at molecular and cellular levels probably should be developed.[27]

Our findings are subject to the limitations of a single institution, non-randomized design and mid-term follow-up. Furthermore, most of the 3DLPN cases were performed toward the latter half of the study period, and the end results may be affected by surgeon learning curves and LPN experience. Finally, the follow-up period for RFS and recovery of renal function was only 12 months. Longer observation data for these clinical parameters is required to further evaluate the benefit of nephron-sparing surgery on long-term renal function and oncological outcome in our series. Additionally, there was no split assessment for the diseased kidney (only global GFR).

5. Conclusion

Both 3-dimensional laparoscopic nephron-sparing nephrectomy and conventional laparoscopic partial nephrectomy are safe and effective approaches to treating complex renal tumors, while the former may facilitate tumor resection and renorrhaphy for challenging cases, offering a minimally invasive surgical option for patients who may otherwise require open surgery.

Author contributions

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