Preserved Renal Function After Percutaneous Radiofrequency Ablation for Renal Tumors: Experience of a Single Institution

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Abstract. *Background: Percutaneous radiofrequency ablation (RFA) for small renal tumors has been reported to be effective in patients with poor surgical status. We retrospectively analyzed clinical outcomes, including renal function, after RFA. Patients and Methods: We retrospectively analyzed data of 24 patients with small renal tumors treated by RFA in our institution from January 2007 to November 2012. Results: A total of 36 tumors (35 renal cell carcinomas and one colon cancer metastasis) with a mean diameter of 21.1 mm (10-45 mm) in 24 patients were treated. Complete ablation was achieved in 22 patients (91.7%). There were two recurrences in other sites of the kidney (8.3%) and two distant metastases (8.3%) during the mean follow-up period of 21 months (1-57 months). No severe perioperative complications were observed. No significant difference in serum creatinine levels before and after RFA procedures in the 22 evaluable patients, nor in seven patients with a solitary kidney. Conclusion: RFA for small renal tumors is a safe treatment with sufficient preservation of renal function, even in patients with a solitary kidney.*

The incidence of renal cell carcinoma (RCC) has been increasing partially due to more accurate diagnosis with advances in imaging procedures (1). Although radical nephrectomy was the standard treatment for RCC, partial nephrectomy (PN), including laparoscopic or robotic surgery, is regarded as the standard treatment for small RCCs, in order to preserve renal function (2, 3). However, it remains unclear how to best treat ineligible surgical candidates with renal tumors.

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Key Words: Renal tumor, percutaneous radiofrequency ablation, renal function.

Recently, percutaneous radiofrequency ablation (RFA) has been reported to be a relatively minimally-invasive curative treatment procedure that is equally effective for small RCC to PN with regard to intermediate- and long-term outcome (4-12). RFA seems to be a favorable treatment option especially for patients with RCCs who have surgical risks, such as solitary kidney, advanced age, heart disease, and multiple renal tumors (5, 6, 11-14).

Several studies have indicated good preservation of renal function after RFA (6, 7, 11-14). In this study, we retrospectively confirmed on clinical oncological outcomes and renal function after percutaneous RFA in our institution.

Patients and Methods

After the Institutional Review Board approved the application of RFA to patients with small renal tumors who seemed to be poor surgical candidates (Kanazawa University No. 790), RFA was performed in 24 patients from January 2007 to November 2012 in our institution. We retrospectively analyzed the clinical courses of these patients and confirmed the clinical outcome and safety of RFA for small renal tumors. All patients had one or more renal tumor diagnosed by preoperative computed tomography (CT) and magnetic resonance imaging (MRI). Following consultation with radiologists, we decided whether RFA should be performed. The tumors were evaluated by the R. E. N. A. L. nephrometry score (15).

RFA was performed by using a Cool-Tip™ RF ablation system (model 30; RITA Medical Systems, Mountain View, CA, USA), which had a single straight electrode 15 cm in length. The patient was placed in the prone position under epidural anesthesia or local anesthesia. The electrode was placed into the tumor under real-time CT guidance and the tumor was ablated. The initial output energy delivery was 40 W, which was gradually elevated until it reached 120 W. If necessary, saline solution or 5% glucose solution was injected into the perinephric space to avoid colon injury. For tumors over 30 mm in diameter, transarterial embolization (TAE) was performed one week before the RFA procedure. All patients were observed for several days in the hospital after the RFA procedure. We recorded patients' complaints and whether they required anti-emetics and analgesics.

The efficacy of RFA was evaluated by CT one week after RFA. Incomplete ablation was defined as an increase or enhancement in

Table I. *Characteristics of patients and tumors.*

Variable	Value
Patient, n	24
Age (year)	
Mean	70.9
Range	36-87
Gender, n (%)	
Male	14 (58.3)
Female	10 (27.8)
Disease, n (%)	
Primary RCC	13 (54.2)
Recurrent RCC	10 (41.7)
Metastatic tumor (colon cancer)	1 (4.2)
Side, n (%)	
Left	12 (50.0)
Right	10 (41.7)
Bilateral	2 (8.3)
Multiplicity, n (%)	
Solitary tumor	20 (83.3)
Multiple tumors	4 (16.7)
Status, n (%)	
Solitary kidney	8 (33.3)
Bilateral kidneys	16 (66.7)
Serum creatinine (mg/dl)	
0.0-0.79	11 (45.8)
0.80-1.19	10 (41.7)
≥1.20	3 (12.5)
Total number of tumors	36
Tumor diameter (mm)	
Mean	21.1
Range	10-45
Location, n (%)	
Central type	6 (16.7)
Non-central type	30 (83.3)
RENAL nephrometry score (15), n (%)	
4-6	15 (41.7)
7-9	20 (55.6)
10-12	1 (2.8)

RCC: Renal cell carcinoma.

Table II. *Clinical outcomes and complications.*

Variable	Value
Number of RFA procedures	29
RFA per patient (n)	1.2
Range (n)	1-2
Complications, n (%)	
Subcapsular hematoma	2 (6.9)
Pain	5 (17.2)
Nausea	3 (10.3)
Fever	2 (6.9)
Complete ablation, n (%)	22 (91.7%)
Follow-up period (months)	
Mean	21.0
Range	5-57
Recurrence, n (%)	
Ablation site of the kidney	0 (0.0)
Other site of the kidney	2 (8.3)
Distant metastasis	2 (8.3)

RFA: Radiofrequency ablation.

ablated sites, and repeat RFA was performed within two weeks after initial RFA in these cases. The patients were followed-up at our outpatient clinic after RFA, and enhanced CT was performed every three months. Recurrence was defined as an increase or enhancement in ablated sites or the onset of new lesions on follow-up CT findings.

We analyzed laboratory data of the preoperative and early postoperative periods (one week) and follow-up period (three months) for each patient. Statistical analyses were performed using commercially available software (Prism; GraphPad Software, San Diego, CA, USA). We used the Kruskal–Wallis test to compare changes in serum creatinine levels between before and after RFA. In all analyses, $p<0.05$ was taken to indicate statistical significance.

Results

A total of 36 tumors were treated in 24 patients. Reasons for choosing RFA as a treatment for renal tumors in patients were solitary kidney (n=8), advanced age (n=6), circulatory insufficiency (n=4), renal insufficiency, respiratory dysfunction, and hereditary condition (VHL) (n=2, respectively). TAE before the RFA procedure was performed in four patients with tumors with diameters over 30 mm. Clinical characteristics of the patients and tumors are shown in Table I.

A total of 29 RFA procedures were performed in 24 patients (Table II). The mean number of RFA procedures per patient was 1.2 (range 1-2). Complete ablation was achieved in 22 patients (91.7%). There were two patients in whom the RFA procedure could not be performed due to technical reasons; in one patient, there was strong adhesion of the peritumoral colon to the kidney and the RFA procedure was discontinued, while the procedure could not be performed to another patient due to an electrical discharge to his metallic artificial femoral bone head, at ablation (Figure 1). Early complications recorded in 29 procedures were subcapsular hematoma, pain, nausea, and fever (Table II). All complications were mild and were managed conservatively. Late complications, such as ureteral stricture, were not recorded during the follow-up period in any patient.

There were no cases of local recurrence; two recurrences at other sites of the kidney (8.3%), and two distant metastases (8.3%) occurred during the follow-up period in our study population (Table II). Metastatic sites were the lung and adrenal gland in one patient and the femur in the other patient. There were no cases of recurrence or metastasis in patients with primary cT1aN0M0 RCC.

The mean pre-RFA serum creatinine level in 22 evaluable patients was 0.91 (0.60-1.65) mg/dl. The mean post-RFA (one week) serum creatinine level was 0.98 (0.69-1.67) mg/dl, and the mean serum creatinine level in the follow-up

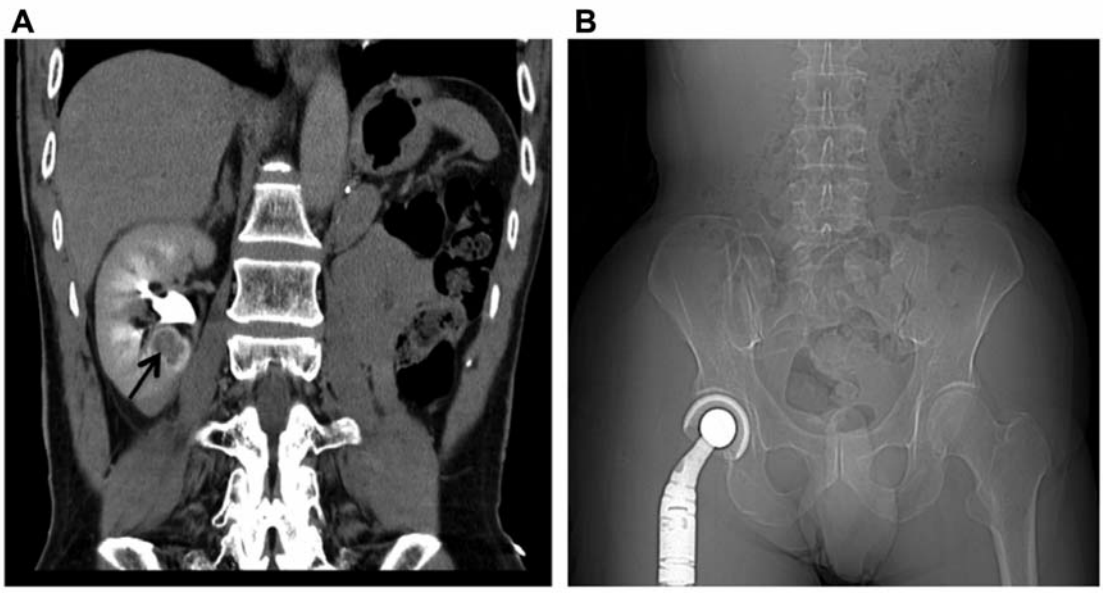

Figure 1. *A 59-year-old man with a right renal tumor (black arrow in A, diameter 20 mm) had undergone right femoral prosthetic replacement due to metastasis of renal cell carcinoma (RCC) one month before the RFA procedure. On RFA for a right renal tumor, he complained of right femoral pain because of electrical discharge to the metallic artificial bone head (B), and RFA could not be completely performed.*

period (three months) was 0.96 (0.70-1.88) mg/dl (Figure 2A). There was no significant difference in serum creatinine level before and after the RFA procedure. Comparison in seven patients with a solitary kidney indicated no significant differences in the serum creatinine level before and after the RFA procedure (Figure 2B).

Discussion

RFA for renal tumors is considered a useful alternative to PN. In the present study, complete ablation was achieved in 22 patients (91.7%) and no recurrence or metastasis was found in patients with primary T1aN0M0 RCC. We confirmed the efficacy of RFA for small renal tumors over intermediate-term follow-up. There have been several recent reports regarding the long-term clinical outcomes of RFA for RCC. Psutka *et al*. reported that 5-year recurrence-free, disease-free, and cancer-specific survival rates were 95.2, 88.6%, and 99.4%, respectively, for patients with cT1 RCC patients treated by RFA (10). These results are equivalent to the clinical outcomes of PN (2). Although RFA has limitations regarding tumor size, it is an effective treatment method even for marginally eligible surgical candidates with renal tumors, yielding good long-term clinical outcomes.

RFA is a treatment method that can preserve renal function in patients with renal tumors (7, 11-14). Levinson *et al*. reported that the mean serum creatinine level in 31 patients with a renal tumor increased from 1.05 mg/dl before the RFA procedure to 1.19 mg/dl at last follow-up (mean follow-up period 61.6 months) (11). As described, RFA for small renal tumors did not have a significant influence on renal function, even in patients with a solitary kidney. There have been several reports related to changes in renal function before and after RFA in patients with a solitary kidney, and the findings of these studies were equivalent to ours (12-14). Jacobsohn *et al*. reported that only 1 of 16 patients with a solitary kidney developed renal failure after the RFA procedure, and the mean serum creatinine did not differ before and after the RFA procedure (1.40 mg/dl before to 1.45 mg/dl at last follow-up of a mean 15.3 months) (13). Furthermore, Raman *et al*. analyzed the renal function of patients with a solitary kidney who had renal tumors that were treated with RFA or open PN (14). Compared to RFA, patients treated with open PN had a greater decline in glomerular filtration rate (GFR) immediately and both of 12 months after the procedure and at the last follow-up (15.8% *vs*. 7.1%, 24.5% *vs*. 10.4%, and 28.6% *vs*. 11.4%, respectively; $p<0.001$) (14). Thus, RFA is a useful method for preserving sufficient renal function even in patients with a solitary kidney. However, long-term large-scale studies are required to determine whether RFA is indicated for all patients with a solitary kidney.

In this retrospective study, the perioperative complications were subcapsular hematoma (6.9%), pain (17.2%), nausea (10.3%), and fever (6.9%). These results were similar to the incidence of complications reported previously (5-10%) (16).

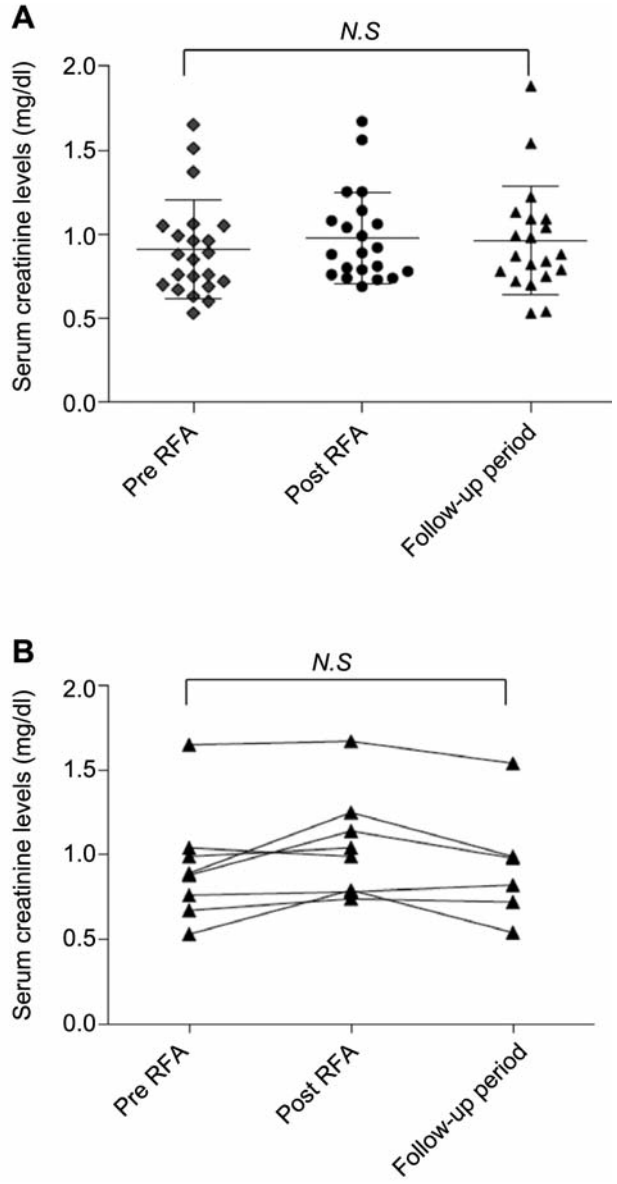

Figure 2. *Changes in serum creatinine levels before and after Radiofrequency Ablation (RFA). A: Evaluation of serum creatinine levels of 22 evaluable patients before and after RFA. B: Changes in serum creatinine levels in seven patients with a solitary kidney. Values are presented as means±standard deviation. There were no significant differences between each period for either group. The Kruskal–Wallis test was used to determine the significance of differences.*

Hemorrhage is the most common major complication of RFA, and can cause perinephric hematoma and macrohematuria, which may require surgical intervention. However, McDougal *et al*. reported that they transfused only two of 85 patients (2.4%) and did not have to use an open surgical procedure to control hemorrhage (17). In this study, two patients with subscapular hematoma did not require either transfusion or surgical intervention. The location of the tumor was thought to be one of the risk factors for injury of the collecting system (16); however, there were no urinary complications even in central types of tumors and in these with high R. E. N. A. L. scores in this study. Careful RFA procedures may avoid severe complications in cases of small renal tumor (17).

We encountered one case in which the procedure was incomplete due to a metallic artificial femoral bone head (Figure 1). At the time of the RFA procedure, the patient suffered right thigh pain due to an electric discharge of the ablation to the metallic artificial bone head. The patient had undergone right femoral prosthetic replacement due to metastasis of RCC one month before the RFA procedure. As RFA was successfully completed in other patients with a metallic artificial bone head, new tissue around the metallic artificial bone head may be necessary in order to be able to perform RFA successfully.

Conflicts of Interest

None declared.

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Received July 29, 2013
Revised September 11, 2013
Accepted September 12, 2013