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# Magnetic resonance imaging characteristics and changes in hemostatic agents after partial nephrectomy

Erdem Kisa[1] · Hilal Sahin[2] · Ozgür Cakmak[1] · Cem Yucel[1] · Gokhan Koc[1] · Zafer Kozacioglu[1] · Yusuf Ozlem Ilbey[1]

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## Abstract

**Purpose** To evaluate the characteristics of images generated by magnetic resonance imaging (MRI) and changes in the mass-like lesion (MLL) during the follow-up of patients who underwent partial nephrectomy (PN) with the intra-operative use of hemostatic agents (HAs).

**Methods** The records of patients who had undergone PN in our clinic due to renal mass between January 2013 and August 2018 were retrospectively reviewed. Our study included 47 patients who were administered one or more HAs during the PN and who received diffusion and dynamic MRI at the post-operative 2nd/4th Queryand 12th month.

**Results** MLL is defined as T2 heterogeneous, intermediate-signal intensity bolster-related mass with a pseudocapsule in the renal parenchymal defect. When we looked at the morphological changes of MLL, the mean largest axial dimensions of masses were 27.3 (range 12.2–44.7) mm in the first follow-up period (2nd/4th months) and 21.2 (range 11–44.7) mm in the 12th month follow-up period. The average change in size of MLL was −0.66 mm/month. We did not see any significant relationship between observation of MLL in the post-operative follow-up MRI images and the use of HAs such as Surgicel®, Spongostan®, and autologous fatty tissue as well as the amount of the agents used in PN operations ($p=0.405$, $p=0.159$, respectively).

**Conclusions** The distinction of MLL causing bolster-related mass and granulomatosis tissue from relapse/recurrence can be made based on the change in mass size observed in the MR images and image characteristics.

**Keywords** Partial nephrectomy · Renal tumors · Hemostatic agents · Magnetic resonance imaging

## Introduction

Partial nephrectomy (PN) surgery is favored for the management of T1 renal masses when technically feasible [1]. Bleeding is a major concern after PN and has an incidence between 0 and 4.3% [2]. Therefore, hemostasis is a key factor during PN. Various methods such as surgical suturing, electrocautery, hemostatic agents (HA), and tissue sealants can be used during hemostasis [3–5]. In recent years, HAs and tissue sealants are used more commonly as an adjuvant to suturing during PN [4, 5]. They act by imitating, promoting or bypassing specific steps of the coagulation cascade [6]. Some of these agents help during hemostasis and can

✉ Erdem Kisa
drerdemkisa@hotmail.com

Hilal Sahin
hilalcimen@gmail.com

Ozgür Cakmak
drozgurcakmak577@yahoo.com

Cem Yucel
meclecuy@hotmail.com

Gokhan Koc
gokfekoc@gmail.com

Zafer Kozacioglu
zaferkozacioglu@gmail.com

Yusuf Ozlem Ilbey
ozlemyusufilbey@hotmail.com

[1] Department of Urology, Tepecik Training and Research Hospital, Güney Mahallesi, 1140/1. Sk. No:1, Yenişehir, Konak, 35180 Izmir, Turkey

[2] Department of Radiology, Tepecik Training and Research Hospital, Güney Mahallesi, 1140/1. Sk. No:1, Yenişehir, Konak, 35180 Izmir, Turkey

also contribute to renography by filling the parenchymal defect that occurs after tumor excision [6–9].

Computed tomography (CT) or magnetic resonance imaging (MRI) can be used as the imaging option during the follow-up after the PN [10]. In the literature, there are studies that show and describe HA-related changes in kidneys and perirenal area using CT images [11–15]. The post-operative follow-up images may suggest mass-like lesion (MLL) and post-surgical fluid collection (PSFC), and may be confused with residual tumor, tumor recurrence or abscess during follow-up [11–15]. The different compositions of those HAs cause variable radiological appearances, which may confound the interpretation of findings in the follow-up after PN. In our study, we describe the characteristics of images generated by MRI and changes in the MLLs during the follow-up of patients who underwent PN with the intraoperative use of HAs.

## Material and methods

The records of 86 patients who had undergone OPN or LPN operation in our clinic due to renal mass between January 2013 and August 2018 were retrospectively reviewed. Approval of the institutional ethics committee was obtained (2019/3-27, 13.02.2019). Patients who had not been administered HA during PN, patients with contraindications for MRI or intravenous contrast during the follow-up period (gadolinium allergy, glomerular filtration rate < 30), and patients that could not tolerate MRI examinations were excluded from the study. Patients' demographic characteristics and operative data were recorded.

### OPN or LPN surgical techniques and the use of HAs

The decision for choosing open partial nephrectomy (OPN) or laparoscopic partial nephrectomy (LPN) was determined according to the R.E.N.A.L Nephrometry Score and surgeon's experience. During the PN, both the renal artery and the renal vein were dissected and prepared. Only the renal artery was clamped during the warm ischemia. The tumor was excised with a cold scissor, and the block was removed. After removal of the mass, excision bed hemostasis was achieved with absorbable sutures (2.0 vicryl). The collecting system was checked for leaks and if present, the leaks were closed with absorbable sutures (3.0 vicryl). The tumor cavity was then filled with either cellulose-based agent (Surgicel®; Ethicon, Somerville, NJ, USA), gelatin-based sponge (Spongostan® (Ferrosan, Copenhagen, Denmark), fibrin sealant (Tachosil®; Nycomed, Zurich, Switzerland) or autologous perirenal fat, based on the surgeon's choice and the size of the cavity. The polytetrafluoroethylene (PTFE) Pledgets (Syneture®; Covidien, Mansfield, MA) was used during the renal parenchymal approximation to prevent sutures from tearing the parenchyma and then the renography was completed. In addition, Weck Hem-O-lock clips (Weck Closure Systems Research, Triangle Park, NC) were used during the suturing and parenchymal approximation in the LPN. Then, in case of need and based on the surgeon's choice, either hemostatic powder (Bloodcare powder®; Life Line, Brno, Czech Republic) or adhesives (Bioglue®; CryoLife, Kennesaw, GA, USA) alone or in combination were used on the renography area. After the reconstruction was completed, the arterial clamp was removed and after the bleeding control, the procedure was completed. The types and distribution of HAs used during PN are summarized in Table 1.

### Radiologic evaluation methods

Our stage-based surveillance protocol is an abdominal MRI protocol including diffusion-weighted imaging and dynamic contrast-enhanced imaging at second/fourth months post-operatively to evaluate the residual renal parenchymal change in all patients treated with PN. For patients whose pathology results were benign, the next MRI examination was performed in the post-operative 12th month. For patients whose pathology results indicated renal cell carcinoma (RCC) and the MRI images suggested no MLL or no complications, the second MRI was performed in the post-operative 12th month. Last, the patients whose pathology results suggested RCC and the MRI images indicated MLL or PSFC (suspicious findings with residual or recurrent tumor granulation tissue or abscess that cannot be differentiated) were reexamined with MRI at the post-operative sixth month.

### MRI protocol

MRI examinations with standard protocol were performed by 1.5 T MRI systems (Siemens Avanto, Siemens Aera, GE Optima360) using a six-channel body coil. The protocol

**Table 1** The distribution of HAs used in the study

| HAs | Number of patients (%) |
|---|---|
| Fibrin sealant (Tachosil®) | 2 (4.2) |
| Cellulose-based agents (Surgicel®) | 13 (27.6) |
| Gelatin-based sponge (Spongostan®) | 5 (10.6) |
| Adhesives (Bioglue®) | 6 (12.7) |
| Hemostatic powder (Bloodcare powder®) | 11 (23.4) |
| Autologous perirenal fat | 9 (19.1) |
| Hemoclips | 7 (14.8) |
| PTFE pledgets (PLEDGETS®) | 13 (27.6) |

included axial and coronal T2-weighted images without fat saturation, axial T2-weighted fat-saturated images, diffusion-weighted imaging with *b* values of 50, 400 and 800, and axial T1-weighted fat-saturated gradient-echo images before and after intravenous contrast administration (Gadoteric acid, Dotarem®, Guerbet, Paris, 0.1 mmol/kg).

### Data analysis

Images were re-evaluated by a consultant radiologist, HS, who has 7 years of experience in the field of abdominal MRI. The reader was blinded to the clinical data, results of surgical staging, and pathology reports. Images were re-evaluated for MLL, presence of definable HAs, tumor recurrence, and post-operative complications such as hematomas or serous fluid collections. The MLL was defined as areas of intermediate, heterogeneous signal intensity at the site of PN on T2-weighted images, which were different than normal adjacent low-signal intensity renal parenchyma. Contrast-enhanced T1-weighted images were used as a supplementary sequence to exclude hypervascular residual or recurrent tumor. Diameters of MLL or PSCF were measured in three orthogonal planes and maximum diameter was recorded as the largest size.

### Statistical analyses

The median (min–max) was used as descriptive statistics for numerical data, while frequency (percentage) was used for categorical data. Non-parametric Spearman's correlation coefficient was calculated for all correlations and their statistical significance was evaluated. The chi-square analysis was used for the evaluation of categorical variables. In all analyzes, the probability of Type I error was set to 0.05. All analyses were made in IBM SPSS V22.

## Results

Our study included 47 patients who were administered one or more HAs during the PN operation and who received diffusion and dynamic MRI at the post-operative 2nd/4th and 12th months. The demographic characteristics and operative data of the patients are summarized in Table 2.

### Appearance on MRI scans performed within post-operative second/fourth months

The characteristics of MRI images taken at post-operative second/fourth months and distribution of patients are summarized in Table 3. Perinephric stranding is the common image observed in the follow-up MRI of all patients after PN. MLL is defined as T2 heterogeneous, intermediate-signal

**Table 2** Patient characteristics

| | |
|---|---|
| Number of patients | 47 |
| Median age, year (min–max) | 63 (38–79) |
| Mean ± SD | 61.6 ± 10.6 |
| Sex (%) | |
| Male | 29 (61.7%) |
| Female | 18 (38.2%) |
| Operation side | |
| Right | 24 (51%) |
| Left | 23 (48.9%) |
| Renal tumor location | |
| Upper pole | 10 (21.1%) |
| Midpole | 18 (38.2%) |
| Lower pole | 19 (40.4%) |
| Median pre-operative renal tumor size, cm (min–max) | 3.5 (1–11) |
| Mean ± SD | 3.7 ± 1.7 |
| Operation type | |
| Open | 40 (85.1%) |
| Laparoscopic | 7 (14.8%) |
| Median operative time, min (min–max) | 165 (105–350) |
| Mean ± SD | 170.8 ± 49.5 |
| Median ischemia time, min (min–max) | 11 (0–35) |
| Mean ± SD | 11.5 ± 11.1 |
| Median HAs used, min (min–max) | 2 (1–4) |
| Mean ± SD | 2 ± 1 |
| Median hospitalization time, day (min–max) | 3 (2–14) |
| Mean ± SD | 4 ± 1.9 |
| Pathology | |
| Benign | 10 (21.2%) |
| Oncocytoma | 6 (12.7%) |
| Angiomyolipoma | 2 (4.2%) |
| Simple cyst | 1 (2.1%) |
| Chronic pyelonephritis | 1 (2.1%) |
| Malignant | 37 (78.7%) |
| Clear cell type | 21 (44.6%) |
| Papillary type 1 | 5 (10.6%) |
| Papillary type 2 | 3 (6.3%) |
| Chromophobe type | 7 (14.8%) |
| Multilocular cyst type | 1 (2.1%) |

**Table 3** Appearance on MRI scans performed at second/fourth months post-operatively

| Post-operative second/fourth months MRI findings | *N* (%) |
|---|---|
| Perinephric stranding | 47 (100) |
| Parenchymal defect | 41 (87.2) |
| MLL | 27 (57.4) |
| Post-surgical fluid collection (PSFC) | 7 (14.8) |
| Fat at excision site | 9 (19.1) |
| Local recurrence | 1 (2.1) |

intensity bolster-related mass with a pseudocapsule in the renal parenchymal defect (Figs. 1, 2, 3). When we looked at the morphological changes of MLL, the median largest axial dimensions of masses were 27.3 (range 12.2–44.7) mm in the first follow-up period (2nd/4th months) and 21.2 (range 11–44.7) mm in the 12th month follow-up period. The average change in size of MLL was − 0.66 mm/month (Table 4). The MRI image of the PSFC formed at the post-PN follow-up is shown in Fig. 3. A suspected tumor recurrence on the surgical field was observed in follow-up MR images of one of the patients and an increase in the size of the mass was detected during further follow-up. A biopsy sample obtained from the patient was compatible with RCC (Fig. 4).

## The association of HAs with MLL

Based on the follow-up MR images, there was no statistically significant relationship between the use of three HAs (Surgicel®, Spongostan®, and autologous fatty tissue) alone or in combination and development of MLL ($p = 0.405$). Furthermore, there was no statistically significant relationship between the amount of three HA agents used and the presence of MLL in the post-operative MRI follow-ups of the patients ($rs = 0.214$, $p = 0.159$).

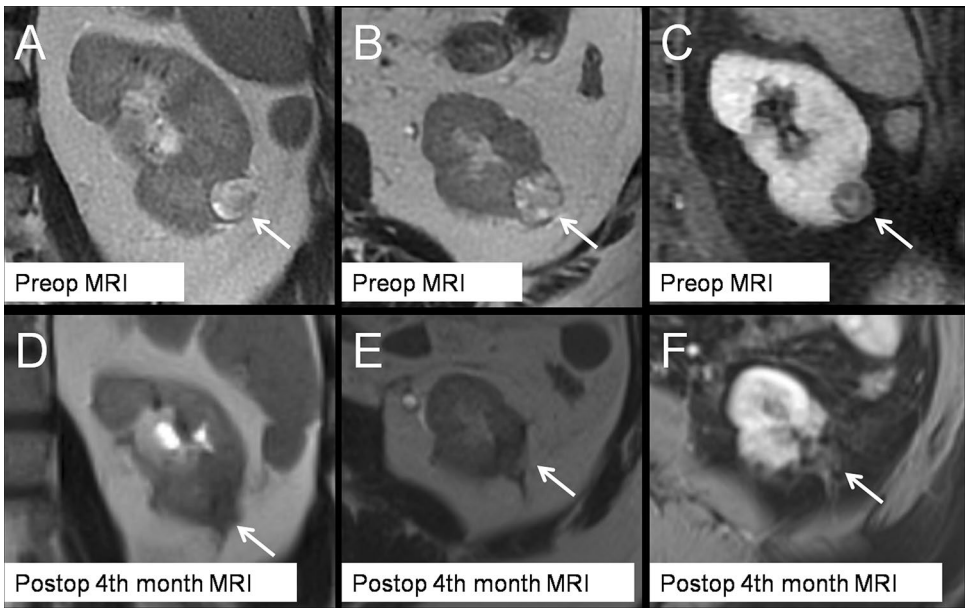


**Fig. 1** A 64-year-old man with solid renal mass in lower renal pole, whose pathology results indicated clear cell-type RCC (arrows) (**a**–**c**). A cellulose-based agent (Surgicel®) was used in the PN. In the fourth month follow-up MRI, there is low signal intensity at the operation site and perinephric stranding in T2-weighted images (arrows) (**d**, **e**). A parenchymal defect, which shows a mild enhancement (arrow), is seen in the axial post-contrast T1-weighted image (**f**)

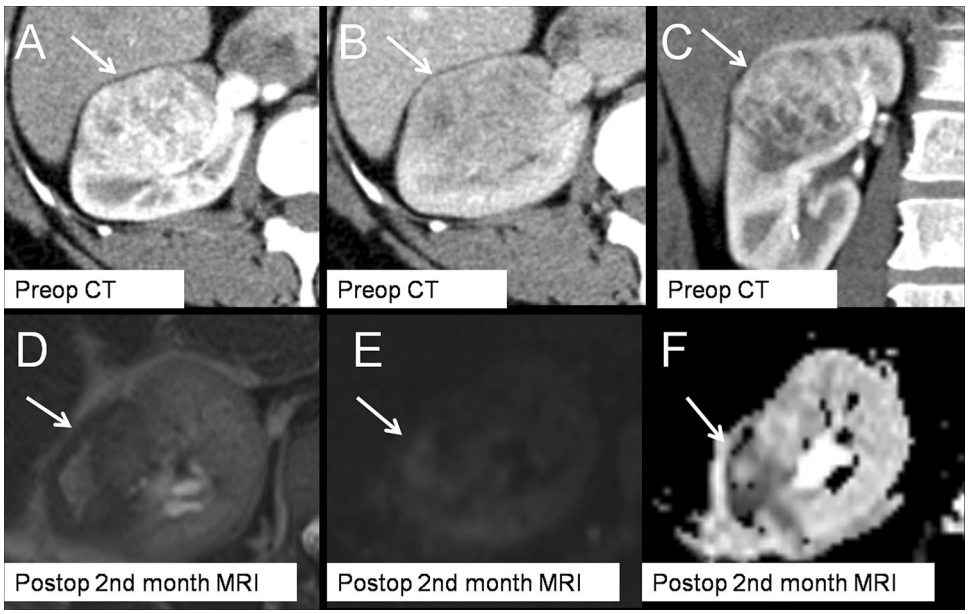


**Fig. 2** A 38-year-old woman with a large solid renal mass in CT, whose pathology results indicated clear cell-type RCC (arrows) (**a**–**c**). A gelatin-based agent (Spongostan®) was used in the PN. In the second month follow-up MRI, there is a MLL (a bolster-related mass) at the operation site, which has a T2 hypointense rim (arrow) (**d**). High-*b* value diffusion-weighted image (**e**) and ADC map (**f**) shows linear diffusion restriction areas in that mass (arrows)

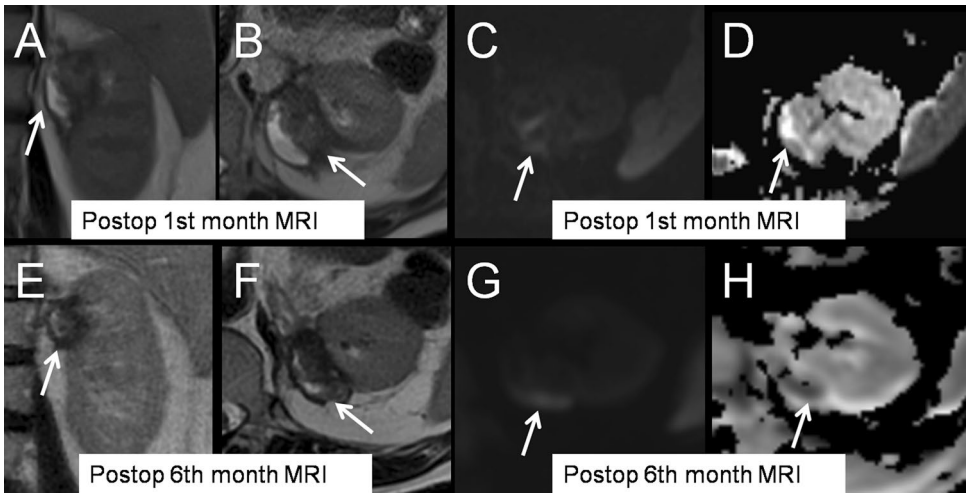


**Fig. 3** A 53-year-old man with partial nephrectomy due to clear cell-type RCC. A cellulose-based agent (Surgicel®) was used in the operation. In the first month follow-up MRI, there is a large MLL (bolster-related mass) at the operation site (upper pole) and PSFC (arrows) (**a**–**d**). The mass has a T2 hypointense rim (**a**, **b**) and shows a linear restricted diffusion areas in the diffusion-weighted image (**c**) and ADC map (**d**) (arrows). In sixth month follow-up, the mass seems smaller and only small fluid shows diffusion restriction (arrow) (**e**–**h**)

**Table 4** Changes in the morphology of MLL at 2nd/4th month and 12th month post-operative follow-up

| Morphology and size | 2nd/4th month follow-up | 12th month follow-up |
|---|---|---|
| Median largest dimension, mm (range) | 27.3 (12.2–44.7) | 21.2 (11–44.7) |

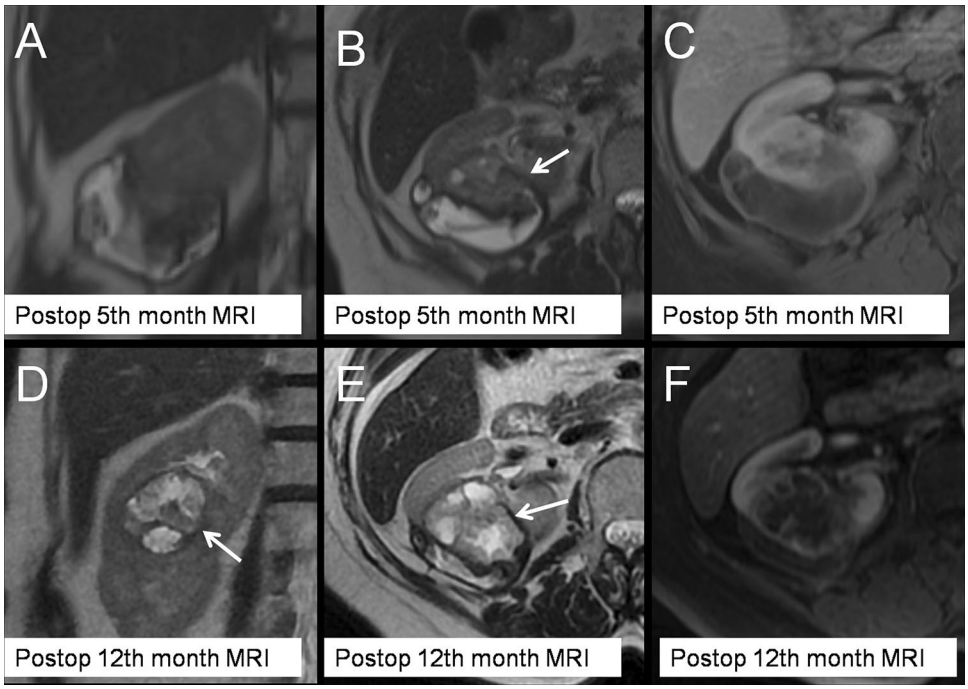


**Fig. 4** A 65-year-old woman with partial nephrectomy due to clear cell-type RCC. A cellulose-based agent (Surgicel®) was used in the operation. In the fifth month follow-up MRI, there is a large MLL (bolster-related mass) (arrow in **b**) at the operation site (interpolar region) and PSFC in T2-weighted images (**a**, **b**). Contrast enhancement is seen in MLL (**c**). In 1-year follow-up, the PSFC seems smaller. However, MLL increased in size with solid and cystic areas in it (arrow) indicating a recurrent tumor (**d**, **e**). The mass shows heterogeneous contrast enhancement (**f**)

## MRI features associated with HAs and tissue sealants

The post-operative MR images of the patients treated with HAs during PN are summarized below:

1. Fibrin sealant

Product: *Tachosil*®: these agents are absorbable and do not form a mass; therefore, they are not clearly seen on the MRI after PN. However, a linear area at the operation site may sometimes be observed without contrast enhancement (Fig. 5).

2. Cellulose-based agents

Product: *Surgicel*®: it is usually circumscribed with a T2 hypointense thick line resembling a fibrous capsule. The clue to differentiate it from tumor recurrence is decrease in size in sequential imaging methods and the awareness of the placement of the hemostatic agent. The bolster-related mass regresses gradually in months (Fig. 1).

3. Gelatin-based sponge

Product: *Spongostan*®: it is usually circumscribed with a T2 hypointense thick line resembling a fibrous capsule (Fig. 2).

4. Albumin glutaraldehyde tissue adhesive adhesives

Product: *Bioglue*®: it may be used in conjunction with other hemostatic agents. It is not readily seen in control MRIs of the patients since they do not form a mass.

5. Hemostatic powder

Product: *Bloodcare powder*®: groups of these particles may be seen as hypointense dots in T1-weighted images, particularly in T1-weighted in-phase gradient-echo sequence in which susceptibility is clearly seen.

## Other materials that have roles in hemostasis

1. *Autologous perirenal fat* Autologous fat package is easily recognized at the defect site after PN due to classical fat signal. A fibrous capsule surrounding fat package or peripheral contrast enhancement may be seen. While this tissue may still be visible in the follow-up images of some patients producing an angiomyolipoma-like image, in most patients, the fat tissue degrades and disappears (Fig. 6).
2. *Hemo clips* These clips remain stable over time; however, they are not readily seen or differentiated from granulation tissues in MR images.

## Other materials that have a role in suture support

1. PTFE pledgets

Product: *PLEDGETS*®: they are non-absorbable pledgets composed of polytetrafluoroethylene (PTFE)/Teflon. They cause a minimal inflammatory reaction, followed by gradual encapsulation by fibrous connective tissue. In imaging, they are not seen or differentiated from granulation tissues.

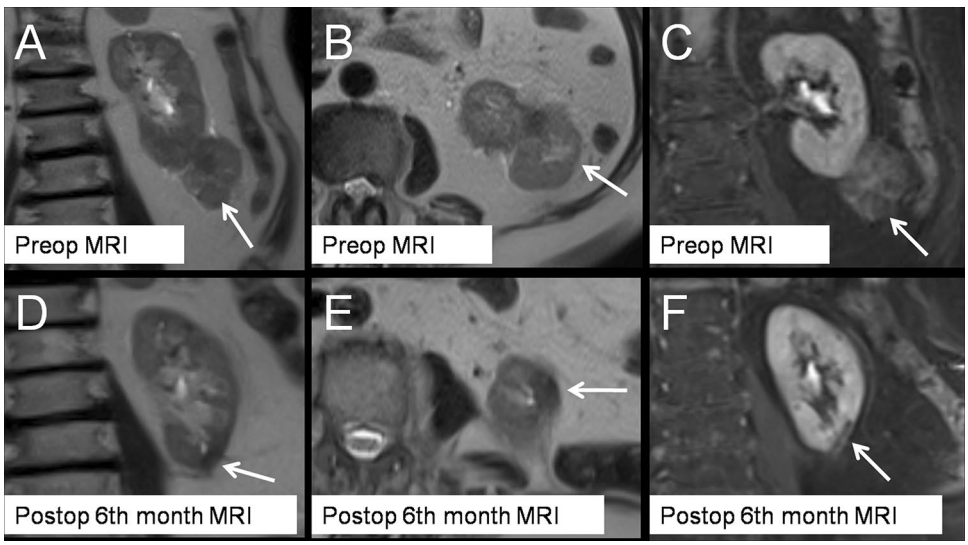


**Fig. 5** A 77-year-old woman with solid renal mass in left lower pole, whose pathology results indicated chromophobe-type RCC (arrows) (**a**–**c**). Fibrin sealant (Tachosil®) was used in the PN. In the sixth month follow-up MRI, there is low signal intensity at the operation site and perinephric stranding in T2-weighted images (arrows) (**d**, **e**). In coronal post-contrast T1-weighted image, a non-enhancing linear area is seen near the cortex which is possibly related to hemostatic agent (arrow) (**f**)

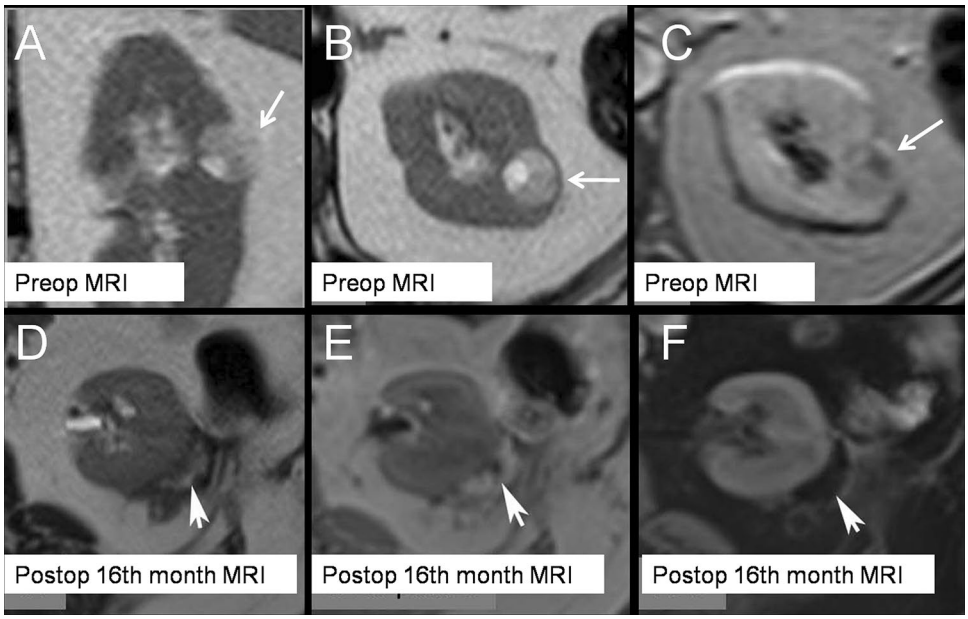


**Fig. 6** A 62-year-old woman with solid renal mass, whose pathology results indicated clear cell-type RCC. Pre-operative MRI shows a small cortical renal mass (arrows) (**a**, **b**). Tumor shows moderate enhancement (arrow) (**c**). Autologous fat was packed in the defect site during partial nephrectomy. In the 16th month follow-up MRI, in axial T2-weighted (**d**), T1-weighted (**e**) and fat-saturated T1-weighted images (**f**), crescent-shaped fat signal is seen at the operation site (arrow heads). A T2 hypointense fibrous capsule is seen around that fat package

## Discussion

The increased per-operative use of HAs in recent years has caused some unique MR or CT images during the post-operative follow-up. These agents may cause MLL and PSFC images in CT or MR imaging and may be confused with residual tumor, tumor recurrence or abscesses during the post-operative follow-ups [11–15]. This confusion may result in unnecessary biopsies and overtreatment of patients. To resolve this issue, both radiologists and urologists must be well aware of the features that occur in the post-operative MR or CT images due to these agents, changes in the parenchyma caused by them, and their morphological and dimensional changes over time. Several studies have reported that HAs have caused a number of changes observed in the CT images taken during the follow-up of patients that underwent PN [11–15]. However, there are no detailed studies of MR images taken during the follow-up of patients after the PN. In this study, we aimed to show the MRI characteristics of HAs used during the PN operations and how they were morphologically modified during the post-operative follow-ups. Moreover, we aimed to increase the awareness of both radiologists and urologists in the distinction of these changes from MLL, PSFC and recurrence.

It has been shown that in renal mass treatment, when compared to the radical nephrectomy, the PN results in better protection of the renal reserve and decreases the risk of metabolic and cardiovascular disorders [16]. During this operation, after the tumor is excised, the important step is to quickly control the bleeding by providing a good hemostasis to see surgical margins clearly and to achieve reconstruction of renal parenchyma in a shorter time. Various HAs are frequently used worldwide to facilitate this stage and minimize bleeding complications [3–9]. The most common HAs used in minimally invasive urologic surgeries are oxidized regenerated methylcellulose, gelatin-based sealant, albumin glutaraldehyde-based adhesives, human fibrinogen and thrombin fleece, absorbable hemostatic gelatin sponge, and hemostatic fibrin sealant powder [7]. In addition, autologous perirenal fat, Hem-O-lock clips, and adhesives are also used to achieve hemostasis [7–9]. During the OPN or LPN, HAs help to achieve hemostasis after tumor excision, to fill the cavity after tumor excision, and to prevent sutures from tearing the parenchyma during the approximation of the parenchyma. Recent studies have reported that the use of HA during PN did not statistically affect the bleeding complications [17, 18]. These studies also believe that hemostasis suture thrown into the excision base at the hemostasis stage is the most important step in terms of bleeding control and that HAs play more of a supportive role [17, 18].

Post-operative MR images of patients that underwent PN can indicate MLL in the surgical field. These lesions may occur due to tissue damage during PN, per-operative bleeding or urine leakage. Some studies have suggested that MLL might be caused by Surgicel® and Spongostan®, used during the PN [11–15]. In our study, there was no statistically significant relationship between the use of the aforementioned three HAs alone or combination and the development of MLL. The fact that we did not see any relationship between the presence of MLL and the use of HAs suggests that these agents might not always cause MLLs. This may be due to the fact that in some patients these HAs disappear after a certain period of time, while in some patients the macrophages do not work well at the cellular level at the microenvironment of the PN surgical field, thus HAs-related artifacts can be observed on the MRI [19, 20]. However, due to the limited

number of studies in this field we do not know exactly why it occurs in some patients and not in others. In our study, we showed that the decrease in dimension of bolster-related and granulomatous MLLs (− 0.66 mm/month) in follow-up MR images is a key differentiator of relapse/recurrence. Kim et al. have reached the similar conclusion but using CT imaging in the post-PN follow-ups [12].

We also did not detect any statistical relationship between the number of HAs used during PN and the presence of PSFC. We think that PSFC is not always associated with HA, and that bleedings in a shape of a small leakage or urine leakages in the vicinity of surgical area can suggest a collection on the MR images. In patients that underwent PN, the differentiation between PSFC and abscess seen in the post-operative MR images should be made by evaluating the MR images as well as the clinical examination of the patient and infiltrating laboratory markers.

The most powerful aspects of our study are detailed observation of the MLLs' morphological changes seen in the MR images and the evaluation of relationship of MLLs with HAs. The limitations of our study include relatively short follow-up time, small number of patients, absence of the control group, such as a conventional PN with no use of HAs, so it is not clear whether the results are related to the technique or hemostatic effects, and use of more than one HAs during PN in some patients, which may have led to heterogeneity.

## Conclusion

PN is a standardized method in the treatment of small renal masses. In post-operative follow-up of patients that underwent PN with the use of HAs, it is important to know the characteristics of lesions such as MLL, which may occur in MR images. This knowledge can help in distinguishing between the MLL and tumor recurrence/relapse during follow-up. Bolster-related mass, which causes MLL, can be distinguished from granulomatous tissue and recurrence/relapse based on the mass size and the rate of shrinkage. We believe that knowing characteristics of post-PN MR images will be beneficial for both urologists and radiologists.

### Compliance with ethical standards

**Conflict of interest** There is no conflict of interest. Author Erdem KISA declares that he has no conflict of interest. Author Hilal Sahin declares that he has no conflict of interest. Author Ozgür CAKMAK declares that he has no conflict of interest. Author Cem YÜCEL declares that he has no conflict of interest. Author Gokhan KOC declares that he has no conflict of interest. Author Zafer KOZACIOGLU declares that he has no conflict of interest. Author Yusuf Ozlem ILBEY declares that he has no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Local ethic committee; Date 13/02/2019 No: 24.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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