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Apparent Diffusion Coefficient Distinguishes Malignancy in T1-Hyperintense Small Renal Masses

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Abstract

OBJECTIVE.—Small renal masses (< 4 cm) can be difficult to accurately classify as benign or malignant, particularly when they appear T1 hyperintense on MRI. This intrinsic signal, potentially related to intralesional hemorrhage, may limit evaluation of signal intensity on DWI. The purpose of this study was to test whether apparent diffusion coefficient (ADC) measurements may distinguish malignancy.

MATERIALS AND METHODS.—This single-center retrospective study identified patients with a T1-hyperintense renal mass less than 4 cm on MRI. Malignant lesions were pathologically proven; a benign mass was established by a predefined hierarchy of pathologic proof, follow-up ultrasound, or follow-up imaging showing more than 5 years of stability. T1 hyperintensity, defined as a signal intensity equivalent to or greater than the adjacent renal cortex, was confirmed by a senior abdominal radiologist. Two additional abdominal radiologists independently measured ADC of the lesion, which was normalized to the ADC of the background ipsilateral kidney and represented as ADC_{ratio}.

RESULTS.—The final cohort included 58 benign and 37 malignant renal lesions in 95 patients. Interrater agreement for ADC measurements was almost perfect ($\kappa = 0.836–0.934$). ADC_{ratio} was significantly lower in malignant compared with benign lesions (0.65 ± 0.29 vs 1.03 ± 0.32 ; $p < 0.001$). Malignant lesions were significantly larger than benign lesions (2.66 ± 0.86 cm vs 1.50 ± 0.65 cm; $p < 0.001$); however, after controlling for lesion size, ADC_{ratio} remained a significant predictor of malignancy ($p < 0.001$).

CONCLUSION.—ADC_{ratio} was highly reproducible for T1-hyperintense small renal masses and was significantly lower in malignant compared with benign renal masses.

Keywords

DWI; hemorrhagic cyst; MRI; proteinaceous cyst; renal cell carcinoma

Incidental renal masses are frequently encountered during routine imaging of the abdomen, and these most frequently represent benign cysts [1]. However, a small percentage of these masses are solid renal neoplasms. Although many renal masses can be confidently diagnosed on imaging as a benign cyst or angiomyolipoma, a substantial minority are

difficult to accurately classify [2, 3]. Specifically, the imaging appearance of hemorrhagic or proteinaceous renal cysts, because of their T1 hyperintensity on T1-weighted MRI and higher attenuation on CT, can mimic renal cell carcinoma [4–7]. In the setting of an indeterminate renal mass, 5 years of stability on imaging follow-up is often required to confidently establish benignity [8].

DWI, which characterizes the random motion of water molecules in tissues or lack thereof (i.e., diffusion restriction), has shown promise in the characterization of indeterminate renal masses [9–11]. Indeed, restricted diffusion correlates with increased cellularity, a common feature in malignant neoplasms, and may predict tumor grade [12, 13]. However, intralesional hemorrhage, which manifests as T1 hyperintensity, can impair the measurement of apparent diffusion coefficient (ADC) [14–16]. Whether DWI predicts malignancy in renal masses that are T1 hyperintense is unknown; the purpose of this study was to test whether ADC measurements may discriminate malignancy in small (< 4 cm) T1-hyperintense renal masses occurring in patients in whom a diagnosis of malignancy or benignity could be confidently established pathologically or by stringent criteria on follow-up imaging.

Materials and Methods

This single-center retrospective study was performed in compliance with HIPAA, and the requirement for informed consent was waived by the institutional review board of the Washington University School of Medicine.

Study Cohort

Adult patients (18 years and older) were identified by queries of our institutional radiology and surgical pathology databases (Fig. 1). Pathologic proof was required to establish a mass as malignant. The surgical pathology database, which included specimen reports from June 2010 through July 2018, was searched using the terms “renal mass,” “renal lesion,” “renal tumor,” “nephrectomy,” and “partial nephrectomy” to identify biopsy or resection specimens that were submitted for an indication of “mass.” The radiology database, which included imaging reports from June 2010 through July 2018, was simultaneously queried by current procedure terminology code to identify all abdominal MRI studies performed during this interval. A script written in MATLAB version R2018a (MathWorks) was applied to these database outputs to identify patients who underwent abdominal MRI within 6 months before biopsy or resection. If a patient had more than one abdominal MRI that preceded the biopsy or resection, only the study immediately preceding tissue acquisition was considered for inclusion. Medical records and imaging data for candidate masses were reviewed by one of two radiology residents in their 3rd and 4th years of training. Masses were included if they were less than 4 cm, appeared hyperintense on T1-weighted MRI, and if there was definitive correspondence between the mass on imaging and pathology. A size threshold of 4 cm was chosen to define a small renal mass in accordance with the TNM classification system and American Urologic Association guidelines, which consider renal cell carcinoma smaller than 4 cm to be T1a stage and a candidate for partial nephrectomy [17, 18]. T1 hyperintensity was defined as a signal intensity within at least 50% of the mass that was equivalent to or greater than the adjacent renal cortex. Masses that did not meet criteria for T1

hyperintensity, as assessed by a senior abdominal radiologist with more than 20 years of abdominal imaging experience, were excluded ($n = 18$). If multiple malignant masses were present, only the largest mass smaller than 4 cm was selected for inclusion.

Benignity of a mass was established by a predefined hierarchy of pathologic proof, follow-up ultrasound showing a definitively benign simple cyst, or follow-up imaging showing more than 5 years of stability in size and features. This methodologic choice was made to facilitate inclusion of a sufficiently large number of benign masses, which are most frequently followed with serial imaging and are rarely biopsied or resected. Pathologically proven T1-hyperintense benign masses were included using the same approach described above (i.e., radiology and pathology database correspondence). Sequential searching of our radiology database was performed to identify an abdominal MRI describing a T1-hyperintense renal lesion (terms: “T1 hyperintense,” “T1 hyperintensity,” or “T1 bright”; “mass” or “lesion”; or “hemorrhagic cyst” or “proteinaceous cyst”) and a subsequent renal ultrasound describing a benign simple cyst (term: “simple cyst”). Similarly, sequential searching was performed to identify an abdominal MRI describing a T1-hyperintense renal mass and a follow-up MRI, CT, or ultrasound more than 5 years later. Candidate masses were also reviewed by one of two radiology residents to identify those that were small and appeared T1 hyperintense and that corresponded to a benign simple cyst on ultrasound or were stable on a follow-up imaging study more than 5 years later. Masses that did not meet criteria for T1 hyperintensity or did not correspond to the benign simple cyst on ultrasound, as assessed by the senior abdominal radiologist, were excluded ($n = 3$). If multiple benign masses were present, the largest T1-hyperintense mass smaller than 4 cm was selected for inclusion. Patients were excluded if they also harbored a malignant renal mass or had been treated for a prior renal cell carcinoma.

MRI Protocol

All abdominal MRI studies were performed using a phased-array body coil on one of 13 Siemens scanners at 1.5 T or 3 T. Imaging protocols varied slightly on the different scanners as well as over the course of the study period, but all included free-breathing DWI using b values of 50, 400, and 800 s/mm^2 and a slice thickness of 8–10 mm. ADC maps were automatically generated by the scanner. A unenhanced 3D spoiled gradient-echo T1-weighted fat-suppressed volumetric interpolated breath-held examination (VIBE; slice thickness of 3 mm) was performed as part of each study and was used to assess for mass T1 hyperintensity. Additional sequences, which generally included T2-weighted single-shot fast spin-echo, T2-weighted turbo spin-echo with fat saturation, contrast-enhanced VIBE (when acquired), and in-phase and opposed-phase T1-weighted images, were not evaluated as part of this study.

Apparent Diffusion Coefficient Measurements

Two fellowship-trained abdominal radiologists with 4 and 6 years of postfellowship experience independently analyzed ADC images. Both readers had access to patient age and sex, but were blinded to clinical information such as original imaging interpretation and pathologic diagnosis. Series number, image number, laterality, and mass size were provided to the readers; additional spatial identifying information was provided when multiple masses

were visible on the specified image. ADC value of the lesion (ADC_{lesion}) was calculated by drawing the largest ellipsoid ROI that would fit entirely within the lesion (Fig. 2). Circular ROIs were also drawn on the background ipsilateral ($ADC_{\text{ipsilateral}}$) and contralateral ($ADC_{\text{contralateral}}$) kidneys that included both cortex and medulla. ADC_{ratio} was calculated as the ADC_{lesion} divided by $ADC_{\text{ipsilateral}}$ [9, 19]. A few cases were excluded by both raters because of an invalid medical record number ($n = 1$, benign), lack of measurable background renal parenchyma ($n = 1$, malignant), and no identifiable lesion on ADC ($n = 1$, benign). Lesions that could not be measured confidently by both raters were excluded because of no identifiable lesion on ADC ($n = 10$, 9 benign and 1 malignant), lack of background parenchyma ($n = 2$, both malignant), or poor ADC map quality ($n = 3$, 2 benign and 1 malignant).

Statistical Analysis

Descriptive statistics were summarized using mean $\pm$ SD for continuous variables and frequency (percentage) for categorical variables. Interrater reliability for continuous variables was assessed using the intraclass correlation coefficient (ICC). Agreement was scored as poor ($\kappa < 0.00$), slight ($\kappa = 0.00$ – 0.20), fair ($\kappa = 0.21$ – 0.40), moderate ($\kappa = 0.41$ – 0.60), substantial ($\kappa = 0.61$ – 0.80), or almost perfect ($\kappa = 0.81$ – 1.00) [20]. Differences in means between continuous variables were assessed using the Student *t* test. A value of $p < 0.05$ was indicative of a significant difference. Multivariate binary logistic regression was used to control for lesion size. ROC analysis was used to identify optimal threshold of quantitative parameters for prediction of malignancy and was used to calculate AUC, sensitivity, specificity, and Youden index. All statistical analysis was performed using SPSS Statistics version 25 (IBM).

Results

Patient and Lesion Characteristics

The final cohort included 95 masses in 95 patients (Table 1). A slight majority of the patients were male ($n = 51$; 54%), and the average age was 61 ± 14 years. Of the 95 masses, 37 (39%) were malignant and 58 (61%) were benign. Nearly all the malignant masses were renal cell carcinoma ($n = 35$; 95%). Papillary was the most common subtype (20 of 35, 57%), followed by clear cell (12 of 35, 34%), mixed subtype (2 of 35, 6%), and chromophobe (one of 35, 3%). Of the malignant masses that were not renal cell carcinoma, one was leiomyosarcoma (one of 37, 3%) and one was melanoma metastasis (one of 37, 3%). Of the benign masses, the majority were included based on 5 years of imaging stability (36 of 58, 62%). A smaller subset of masses was included based on a subsequent ultrasound showing a benign simple cyst (20 of 58, 34%). A minority of benign masses were pathologically proven (two of 58, 3%), as benign masses infrequently underwent biopsy or resection.

Interrater Reliability Analysis

Interrater agreement for ADC_{lesion} , $ADC_{\text{ipsilateral}}$, $ADC_{\text{contralateral}}$, and ADC_{ratio} were almost perfect (Table 2). ICC ranged from 0.836 to 0.934, and was greatest for ADC_{lesion} .

Benign Versus Malignant Masses

Representative malignant and benign masses are shown in Figure 3, and comparison of size and ADC measurements between malignant and benign masses are shown in Table 3. Malignant masses were significantly larger than benign masses (2.66 ± 0.86 cm vs 1.50 ± 0.65 cm; $p < 0.001$). ADC_{lesion} and ADC_{ratio} were significantly lower in malignant versus benign masses ($1.45 \pm 0.75 \times 10^{-3}$ mm²/s vs $2.17 \pm 0.64 \times 10^{-3}$ mm²/s, $p < 0.001$; and 0.65 ± 0.29 vs 1.03 ± 0.32 , $p < 0.001$; respectively) (Fig. 4). There was no difference in $ADC_{\text{ipsilateral}}$ or $ADC_{\text{contralateral}}$ in malignant versus benign masses. The relationship between ADC_{ratio} and lesion size among benign and malignant masses is depicted in Figure 5. In a multivariate binary logistic regression model that included mass size and ADC_{ratio} , size and ADC_{ratio} remained significant predictors of malignancy (Table 4). After accounting for lesion size, each 0.1 unit decrease in ADC_{ratio} conferred a 1.49 (95% CI, 1.20–1.84) times higher odds of malignancy. An ADC_{ratio} less than 0.89 discriminated malignant from benign lesions, with a sensitivity and specificity of 0.74 and 0.78, respectively (AUC, 0.82; 95% CI, 0.73–0.90; Youden index, 0.53), as shown in Figure 6.

Discussion

In this study, we have shown that for small T1-hyperintense renal masses, ADC_{ratio} is significantly lower in malignant masses than in benign masses. Prior studies, including three recent meta-analyses, have shown the utility of DWI for distinguishing benign from malignant renal masses [10, 11, 21]. However, data pertaining to characterization of T1-hyperintense renal masses remain sparse. Intralesional hemorrhage, which appears as T1 hyperintensity, is known to impair the measurement of ADC owing to susceptibility-weighted signal loss [15, 16]. Indeed, a prior study applying DWI to renal masses showed an inverse correlation between T1 signal intensity and ADC, which held true regardless of lesion pathology [14]. Hemorrhage complicating the interpretation of DWI has also been shown in the prostate [22]. Despite this relationship, our study supports the notion that ADC values can help distinguish malignant from benign renal masses with intrinsic T1 hyperintensity.

Our requirement for T1 hyperintensity skewed our population of malignant masses toward those previously shown to be associated with intralesional hemorrhage. Specifically, papillary renal cell carcinoma has a propensity to show intralesional hemorrhage [18, 23], and accounted for 57% of our malignant masses, despite only representing 10–15% of all renal cell carcinoma [24]. Prior studies examining T1-hyperintense renal lesions similarly reported enriched proportions of papillary renal cell carcinoma, ranging from 32% to 46% [25, 26]. Furthermore, studies focusing on papillary renal cell carcinomas showed high frequencies of T1 hyperintensity [27, 28].

In clinical practice, it is not rare to encounter a T1-hyperintense and T2-hypointense renal lesion that invokes a differential diagnosis of hemorrhagic cyst versus papillary renal cell carcinoma. Although enhancement should distinguish a papillary renal cell carcinoma in this setting, the modest enhancement that is classically found in these lesions may be difficult to detect, especially when the lesion is small [29, 30]. A recent study that used visual assessment of the pattern of T1 hyperintensity on MRI to distinguish benign from malignant

T1-hyperintense renal lesions found hemorrhagic cysts to have a diffusely homogeneous and markedly increased T1 hyperintensity when compared with renal cell carcinoma [25]. These characteristics, when present, were helpful to exclude renal cell carcinoma; however, many hemorrhagic cysts did not show this pattern and sensitivity was limited (< 0.60). Therefore, in the setting of an indeterminate T1-hyperintense renal mass, quantitative data in the form of an ADC_{ratio} may be helpful, especially if the findings in the current study can be replicated in a larger prospective study.

Despite using a size cutoff of less than 4 cm, malignant masses were significantly larger than benign masses in our study. The reason for this size difference in our cohort remains unclear. Multiple studies of renal masses have reported an association between a larger size at identification and a higher likelihood of malignancy [31–33]. In this study, we did not compare the size of malignant and benign masses at first identification, as only the MRI study immediately preceding tissue acquisition was assessed for the malignant masses. Thus, interval growth of a malignant lesion after initial identification and a larger size before tissue acquisition may have contributed to the difference in size observed in this study. Alternatively, larger T1-hyperintense cysts may be less likely to have an indeterminate imaging appearance as lack of enhancement may be more apparent and as a result may be less likely to undergo imaging follow-up.

ADC_{ratio} served as a highly reliable parameter, with an ICC of approximately 0.9. This finding is in accordance with prior studies, which showed ICC ranging from 0.77 to 0.91 for ADC measurements [9, 34, 35]. In contrast, qualitative parameters typically have lower interrater agreement. For instance, in a study comparing the pattern of T1 hyperintensity in benign versus malignant renal lesions, interrater agreement for qualitative imaging features had kappa values ranging from 0.47 to 0.54 [25]. Quantitative approaches to characterize indeterminate renal lesions may therefore prove more robust than qualitative approaches, provided they are simple to incorporate in clinical practice. ADC_{ratio} may prove a valuable addition to the armamentarium for comprehensive noninvasive renal mass characterization (i.e., the virtual biopsy [36]).

Our study has several important limitations, notably its single-center retrospective design that may introduce bias. Second, although pathologically proven malignant renal lesions were identified in a homogeneous manner, our approach to constructing the benign renal lesion population varied. While some of the benign lesions had an indeterminate appearance leading to additional investigations such as renal ultrasound, other renal lesions had a confidently benign appearance (i.e., hemorrhagic renal cyst) at initial imaging and were then followed to fulfill the 5 years of imaging stability to be included in the benign category. Although this approach increases confidence in the benign diagnosis, these lesions are probably not reflective of those that pose a challenge in clinical practice. Third, imaging was performed on any of 13 MRI scanners over a period of nearly 8 years. Indeed, scanner variability is known to decrease the reliability of ADC measurements [21]. To address this, the ADC of the lesion was normalized to that of the background ipsilateral kidney and expressed as ADC_{ratio} . However, the ADC of the renal parenchyma is also subject to variability with hydration status [37] and underlying renal parenchymal disease [38, 39]. Fourth, owing to the slice thickness used for DWI (i.e., 8–10 mm), the partial volume effect

may have impaired ADC measurements in lesions smaller than 20 mm. Benign masses, which had a smaller average size, would have been disproportionately affected. Fifth, a sizeable number of exclusions occurred at two separate steps in our study, which has the potential to limit generalizability of findings. In the first step, application of criteria for T1 hyperintensity (T1 signal intensity equal to or greater than cortex in more than 50% of the lesion) led to the exclusion of 21 lesions. Although this seems like a large proportion of the population, lesions that were equivocal for T1 hyperintensity may have been included in earlier steps to cast a wide net for subsequent review and exclusion by a senior abdominal radiologist. In the second step, 10% of lesions (11 of 113) were excluded because the lesion could not be confidently identified by both raters on the ADC map. This implies that the lesions were not conspicuous compared with the background renal parenchyma and therefore probably had an ADC_{ratio} closer to 1, similar to the benign lesions in our study. Indeed, 10 of the 11 excluded lesions were benign lesions. A final limitation of our study is that we did not evaluate other MR-derived parameters such as enhancement and T2 characteristics, both of which contribute to lesion identification [9]. The combination of parameters, including ADC_{ratio} , likely will outperform any single parameter in discriminating malignant from benign renal masses.

In conclusion, ADC_{ratio} was a highly reproducible measure in T1-hyperintense small renal masses, and was significantly lower in malignant renal masses compared with benign renal masses. In the context of an indeterminate T1-hyperintense renal mass, ADC_{ratio} may be helpful to distinguish malignancy, provided these findings can be replicated in a larger prospective study.

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Fig. 1—.

Flowchart shows process of identification of T1-hyperintense benign and malignant renal masses. Pathologic proof was required for malignant lesions, which was accomplished by identifying patients with abdominal MRI and subsequent pathologic specimen within 6 months. Benign lesions were identified by predefined hierarchy of pathologic proof, subsequent ultrasound (US) showing benign simple cyst, and 5 years of stability on follow-up imaging. Medical records and imaging data were reviewed for all candidate lesions for size, T1 hyperintensity, and correspondence. T1 hyperintensity was confirmed by senior radiologist. Additionally, lesions were excluded if apparent diffusion coefficient (ADC) of lesion or background parenchyma could not be confidently measured by both radiologists.

Fig. 2—.

Method for measuring apparent diffusion coefficient (ADC) in images of 47-year-old man with papillary renal cell carcinoma. **A**, Axial T1-weighted MR image shows representative T1-hyperintense renal mass (*arrows*).

B, Apparent diffusion coefficient value of lesion (ADC_{lesion}) was measured by drawing largest ellipsoid ROI that would fit entirely within lesion (*solid circle*) on corresponding ADC map. ADC of ipsilateral kidney ($ADC_{\text{ipsilateral}}$) and contralateral kidney ($ADC_{\text{contralateral}}$) were measured by drawing circular ROIs on background of ipsilateral and contralateral kidneys, respectively, which included both cortex and medulla (*dashed circles*). Ratio of ADC was calculated as ratio of ADC_{lesion} to $ADC_{\text{ipsilateral}}$.

Fig. 3—

Representative appearance of malignant and benign lesions included in this study. **A and B**, 60-year-old man with papillary renal cell carcinoma. Axial T1-weighted MR image (**A**) and corresponding apparent diffusion coefficient (ADC) map (**B**) show malignant lesion (*arrows*).

C and D, 76-year-old woman with papillary renal cell carcinoma. Axial T1-weighted MR image (**C**) and corresponding ADC map (**D**) show malignant lesion (*arrows*).

E and F, 81-year-old woman with benign lesion. Axial T1-weighted MR image (**E**) and ADC map (**F**) show lesion (*arrows*) deemed benign after 5 years of imaging stability.

G and H, 37-year-old woman with benign lesion. Axial T1-weighted MR image (**G**) and ADC map (**H**) show lesion (*arrows*) deemed benign after 5 years of imaging stability.

Fig. 4—
Box-and-whisker plot shows ADC_{ratio} (ratio of apparent diffusion coefficient [ADC] of lesion to ADC of background ipsilateral kidney) in benign versus malignant lesions. Boxes represent interquartile range and whiskers represent maximum and minimum within 1.5 times interquartile range. Horizontal line within each box is median value. Circles show outliers. ADC_{ratio} was significantly lower in malignant than in benign lesions ($p < 0.001$).

Fig. 5—Scatterplot shows relationship between ADC_{ratio} (ratio of apparent diffusion coefficient [ADC] of lesion ROI to ADC of background ipsilateral kidney) and lesion size among benign (*open circles*) and malignant (*closed circles*) lesions.

Fig. 6—

Graph shows ROC analysis of ratio of apparent diffusion coefficient (ADC) of lesion ROI to ADC of background of ipsilateral kidney (ADC_{ratio}) for prediction of malignancy. ADC_{ratio} of less than 0.89 provided sensitivity of 0.74 and specificity of 0.78 for identification of malignant lesions (AUC, 0.82; 95% CI, 0.73–0.90; Youden index, 0.53). Diagonal line is line of reference.

TABLE 1:**Patient and Lesion Characteristics (*n* = 95)**

Characteristic	Value
Sex	
Male	51 (54)
Female	44 (46)
Age (y)	
Overall	
Mean $\pm$ SD	61 $\pm$ 14
Range	19–91
Male	
Mean $\pm$ SD	62 $\pm$ 12
Range	28–87
Female	
Mean $\pm$ SD	62 $\pm$ 15
Range	19–91
Final lesion classification (<i>n</i> = 95)	
Malignant	37 (39)
Benign	58 (61)
Pathology of malignant lesions (<i>n</i> = 37)	
Renal cell carcinoma	35 (95)
Papillary	20 (57)
Clear cell	12 (34)
Chromophobe	1 (3)
Mixed subtype	2 (6)
Leiomyosarcoma	1 (3)
Melanoma	1 (3)
Proof for benign lesions (<i>n</i> = 58)	
Pathology	2 (3)
Cyst	1 (50)
Oncocytoma	1 (50)
Benign cyst on US	20 (34)
Imaging stability (5 years)	36 (62)
MRI	19 (53)
CT	15 (42)
US	2 (6)

Note—Values in parentheses are percentages. Percentages do not total 100 because of rounding. US = ultrasound.

TABLE 2:

Interrater Reliability Analysis

ADC	κ (95% CI)	Level of agreement
ADC _{lesion}	0.934 (0.903–0.956)	Almost perfect
ADC _{ipsilateral}	0.836 (0.763–0.888)	Almost perfect
ADC _{contralateral}	0.856 (0.790–0.902)	Almost perfect
ADC _{ratio}	0.897 (0.849–0.930)	Almost perfect

Note—Intraclass correlation coefficients were scored as showing poor ($\kappa < 0.00$), slight ($\kappa = 0.00$ – 0.20), fair ($\kappa = 0.21$ – 0.40), moderate ($\kappa = 0.41$ – 0.60), substantial ($\kappa = 0.61$ – 0.80), or almost perfect ($\kappa = 0.81$ – 1.00) agreement. ADC = apparent diffusion coefficient, ADC_{lesion} = ADC value of the lesion, ADC_{ipsilateral} = ADC of ipsilateral kidney, ADC_{contralateral} = ADC of contralateral kidney, ADC_{ratio} = ratio of ADC_{lesion} to ADC_{ipsilateral}.

TABLE 3:

Comparison of Benign and Malignant Lesions

Parameter	Benign (<i>n</i> = 58)	Malignant (<i>n</i> = 37)	<i>P</i>
Size (cm)	1.50 ± 0.65	2.66 ± 0.86	< 0.001
ADC			
^a ADC _{lesion}	2.17 ± 0.64	1.45 ± 0.75	< 0.001
^a ADC _{ipsilateral}	2.16 ± 0.42	2.17 ± 0.43	0.89
^a ADC _{contralateral}	2.16 ± 0.39	2.18 ± 0.47	0.81
ADC _{ratio}	1.03 ± 0.32	0.65 ± 0.29	< 0.001

Note—Except for *p* values, values are expressed as mean ± SD. ADC = apparent diffusion coefficient, ADC_{lesion} = ADC value of the lesion, ADC_{ipsilateral} = ADC of ipsilateral kidney, ADC_{contralateral} = ADC of contralateral kidney, ADC_{ratio} = ratio of ADC_{lesion} to ADC_{ipsilateral}.

^aExpressed as values × 10^{−3} mm²/s.

TABLE 4:

Multivariate Binary Logistic Regression

Parameter	β	p	Odds Ratio (95% CI)	Interpretation
Size (cm)	1.86	< 0.001	6.42 (2.81–14.60)	Each 1-cm increase in size confers 6.42 (2.81–14.60) times higher odds of malignancy.
ADC _{ratio}	−3.98	< 0.001	0.019 (0.002–0.156)	Each 0.1-unit decrease in ADC _{ratio} confers 1.49 (1.20–1.84) times higher odds of malignancy.
Constant	−0.76	0.50	0.47	

Note—ADC_{ratio} = ratio of apparent diffusion coefficient (ADC) of lesion to ADC of background ipsilateral kidney.