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Role of Diffusion Weighted MRI in Assessment of Renal Lesions

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ABSTRACT

Background: Renal lesions are being discovered with increasing frequency due to rapid development and advances in cross-sectional imaging studies being applied in clinical practice.

Objective: The aim of the current work was to evaluate the ability of MRI with diffusion images and ADC values in assessment, characterization of renal lesions and its ability to differentiate benign from malignant lesions.

Patients and Methods: This prospective study included a total of thirty patients with suspected renal lesions, referred from Urology and Internal Medicine Departments of Suez Canal authority hospital. This study was conducted between January 2019 and July 2019. Patients were examined by MRI with diffusion images and ADC values.

Results: The mean apparent diffusion coefficient (ADC) value of normal renal parenchyma was higher than the mean ADC values of benign and malignant lesions. The mean ADC value of all benign lesions was higher than that of malignant lesions. However, there was overlap between ADC values of inflammatory, solid benign lesions and ADC values of malignant lesions.

Conclusion: There is overlap between ADC values of inflammatory, solid benign lesions and ADC values of malignant lesions. Using of ADC value alone may lead to inaccurate assessment of renal lesions. The combination of conventional MRI and ADC value in the diagnosis of renal lesions can increase the diagnostic accuracy.

Keywords: Diffusion, MRI, renal lesions, parenchyma.

INTRODUCTION

Accurate assessment of renal lesions is important for establishing whether tumors require surgical intervention or not. CT and MRI are the primary investigative tools for diagnosing and characterization of cystic or solid renal masses discovered accidentally by ultrasonography [(1)].

To determine whether (solid or cystic) renal lesion is benign or malignant, the mass is initially examined by ultrasound (US), computed tomography (CT), MRI, or a combination of these techniques. MRI offers an alternative to US and CT for the evaluation of renal lesions. MR imaging can be particularly helpful when renal lesions are detected but are not well characterized by other imaging modalities as US and CT [(2)].

Renal lesions are commonly evaluated using contrast-enhanced computed tomography (CT) and magnetic resonance imaging (MRI), with attempts to identify enhancing soft tissue foci suggestive of malignancy. Despite all efforts false-negative results can occur when imaging substantially necrotic or cystic malignant lesions, which may be mistakenly written off as complex renal cysts because of a lack of extensive enhancement [(3)].

On the other hand, oncocytomas or non-lipomatous angiomyolipomas (AML) may show enhancement, and such false-positive results will prompt radiologists to recommend surgical intervention [(3)]. Contrast-enhanced studies are also commonly precluded in patients who have renal impairment or allergies to contrast agents. These limitations have led to the growing desire for other

useful imaging techniques, such as diffusion-weighted (DW) MRI, which can enhance analysis by providing both qualitative and quantitative tissue characterization [(3)].

Diffusion-weighted imaging (DWI) is a functional technology that develops image contrast based on the inhibition of migration of water molecules in tissues by tissue microstructures. As a result of the dense cellularity, malignant tissue has restricted diffusion, which is reflected by a low mean apparent diffusion coefficient (ADC) [(4)].

Diffusion-weighted imaging (DWI) sequences characterize the restriction of random (Brownian) movement of water molecules within tissues. The strength of diffusion weighting is characterized by the b value. Through linear regression, images taken at various b-values can be used to calculate the apparent diffusion coefficient (ADC) in a particular region of interest [(3)]. Restriction to the molecular diffusion in neoplastic tissues can be related to the greater cellular density in the tissues, generated by the high index of neoplastic replication with a consequent reduction in the width of intercellular spaces, and to the ultra-structural alteration of the kidney tissue [(5)].

Renal abscess and focal pyelonephritis can both mimic a malignant renal mass. Similarly, an extensively necrotic RCC may masquerade as a complex cystic/inflammatory lesion. Both may exhibit areas of fluid attenuation/intensity and show little

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peripheral contrast enhancement, making it difficult to distinguish between them based on conventional CT/MRI [6].

Moreover, the administration of contrast agents for both CT and MR are associated with risks, especially in patients with deranged renal functions. Thus, if proven, unenhanced imaging investigations such as DW MRI could serve as an ideal choice in such patients **[6].**

Because water transport is the predominant renal function due to the role of kidneys in water reabsorption and concentration–dilution, the diagnosis of various renal diseases including renal insufficiency, renal artery stenosis, ureteral obstruction, renal tumors can benefit from measuring the diffusion characteristics of the kidney. DW-MRI of the kidneys is able to provide information about renal function **[7]**.

DW-MRI can be evaluated in two ways: qualitatively, by visual assessment of signal intensity, and quantitatively, by measurement of the apparent diffusion coefficient (ADC) **[3]**.

The ADC value has been conventionally calculated from a small region of interest (ROI) arbitrarily positioned in a small part of the targeted lesion, it was advocated that detailed profiles of lesions diffusion environments should be analyzed from the ROI contoured around the targeted lesion **[8].**

Abdominal region applications are more challenging due to respiratory movements, the magnetic susceptibility of air in the lungs and bowel, and movement and pulsatility artifacts which can seriously affect the image quality in the abdominal region **[9].**

For examination of urogenital system, the majority of DWI is performed in the axial plane during "free breathing" or by using "breathing trigger," in addition to common MRI sequences, with extra time about 4–10 min **[10]**.

The aim of the current work was to evaluate the ability of MRI with diffusion images and ADC values in assessment, characterization of renal lesions and its ability to differentiate benign from malignant lesions.

PATIENTS AND METHODS

This prospective study included a total of thirty patients with suspected renal lesions, referred from urology and Internal Medicine Departments of Suez Canal authority hospital. This study was conducted between January 2019 and July 2019.

Ethical approval

The study was approved by the Ethics Board of Al-Azhar University. Written informed consent from all the subjects for doing MRI study at Suez Canal authority hospital were obtained.

Patients were seventeen male (56.7%) and thirteen females (43.3%). Their age ranging from 21 to 73 years (mean age of 47.7).

Inclusion Criteria: Patients with suspected renal lesions or renal parenchymal disease.

Exclusion Criteria: Contraindications for MRI

- Implanted pacemaker or defibrillator
- A cochlear implant
- ferromagnetic aneurysm clips
- Metallic foreign bodies
- Some varieties of ocular implants

MR imaging

The MRI examinations were performed using a 1.5-Tesla MR scanner (GyroscanIntera, Philips medical systems, Netherlands) equipped with a body/surface phased array coil. Patients were lying supine in head first position at complete rest. Hands were placed behind head. All instructions were given to the patient about timing and manner of breath holding.

For morphologic evaluation of the kidneys, respiratory triggered axial and coronal T2-weighted fast spin-echo sequences, axial T2-weighted SPAIR (spectral Attenuated inversion recovery) with fat suppression were initially performed, followed by axial T1-weighted fast low angle shot (FLASH) GRE sequence, and T1-weighted dual-echo in-phase and out-of-phase sequences.

Image analysis

First, the morphological features of the lesions were reviewed including (number, site, size and signal intensity) using T1W MRI, T2W MRI and fat suppression (STAIR) sequences. In all solid lesions the relation to surrounding tissues, local and distant spread were identified and documented.

Diffusion Imaging

Respiratory triggering axial Diffusion-weighted MR images were obtained by using a single-shot spin echo-planar sequence. The diffusion gradient was applied in 3 orthogonal directions (x, y, and z).

Diffusion-weighted MR images were acquired with a diffusion factor b 0, 500 and 1000 seconds/mm^2. The DWIs were transferred to a workstation (Philips extended workspace workstation). ADC maps were calculated automatically with the MRI system and ADC values were expressed in square millimeters per second.

ADC calculation: ADCs were measured from each lesion for b1000 s/mm^{2}gradient value by using three circumferential ROIs (regions of interest). Necrotic portions or lesion margins were excluded from the ROIs.

Circular ROIs were placed in the normal renal parenchyma for the measurement of ADC values. For patients with renal parenchymal diseases, the ADC values were calculated by placing ROIs in upper, mid zone and lower pole of each kidney, calculating the mean ADC value of each kidney then the mean ADC value of two kidneys.

Standard of references

The standard of the study is the histopathological results in the majority of cases and follow up in some cases. The finding in MRI and DWI of each patient were compared and correlated with histopathology of malignant lesions and follow up in case of suspected inflammatory lesions such as acute pyelonephritis.

Statistical analysis

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 24.

Comparisons between quantitative variables were done using the non-parametric Kruskal-Wallis and Mann-Whitney tests. Correlations between quantitative variables were done using Spearman correlation coefficient**.**

RESULTS

Twenty-two patients out of thirty had focal lesions. Ten patients had malignant lesions (33.3%), twelve patients had benign lesions (40%). The remaining part of cases (eight) were patients with renal parenchymal diseases (26.7%) **(Fig 1).**

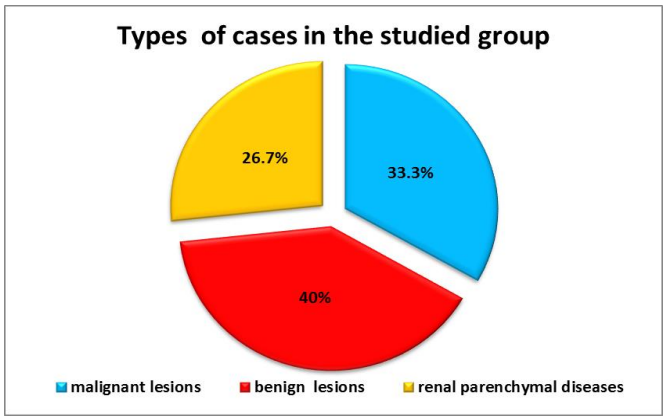


Fig (1): Types of cases in the studied group.

There were seven patients with renal cell carcinoma RCC (31.8%), two cases of transitional carcinoma TCC (9.09%), one case of squamous cell carcinoma (4.54%), two cases of renal and peri-renal abscess (9.09%), two cases of angiomyolipoma (9.09%), one case of oncocytoma (4.54%), one case of acute pyelonephritis(4.54%), one case of emphysematous pyelonephritis (4.54%),four cases of simple cyst (18.18%) and one case of hemorrhagic complicated renal cyst (4.54%) **Fig (2).**

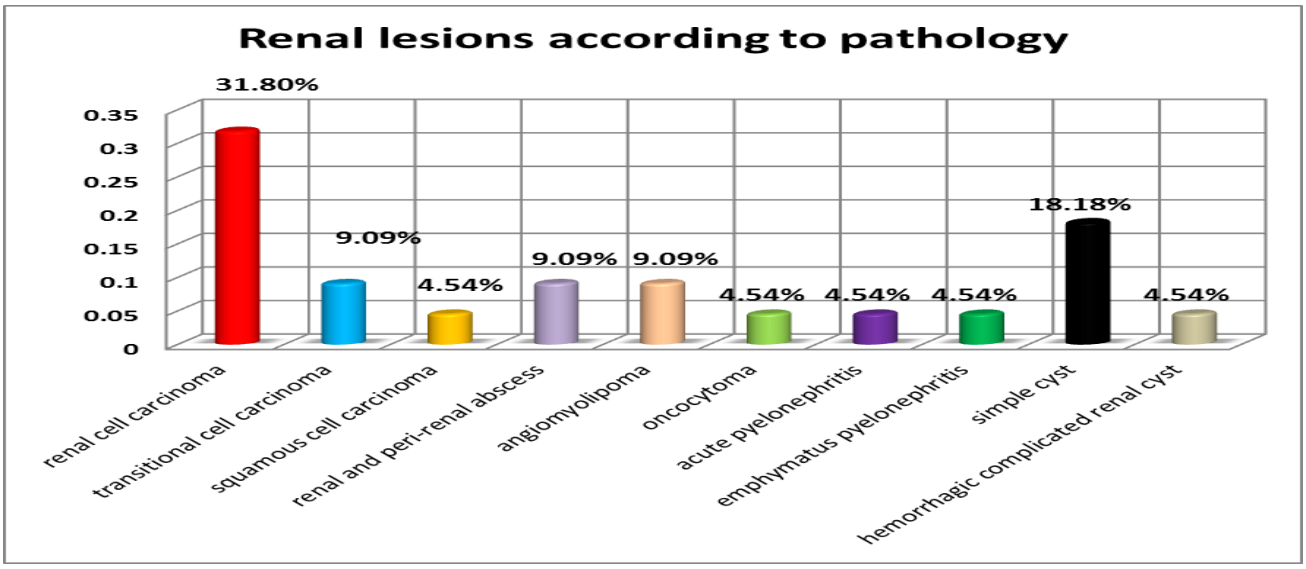


Fig (2): Types of the renal lesions in the study group according to pathology.

Radiological finding in MRI with T1W, T2W, Fat suppression and DWI of each case is compared with it is own pathology in majority of cases and with follow up in others cases such as inflammatory renal lesions (acute pyelonephritis.etc).

Twelve patients underwent surgery that confirmed with pathology, the rest of the lesions had been followed up (Table 1).

Table (1): Lesions characteristics of the study group (n = 22).

Diagnosis	**No of patients**	%	**Confirmed by pathology**
Malignant lesions	10	45.46	10
- Renal cell carcinoma	7	31.8	7
- Transitional cell carcinoma	2	9.09	2
- Squamous cell carcinoma	1	4.54	1
Benign lesions	12	54.54	2
- Oncocytoma	1	4.54	1
- AML	2	9.09	-
- Hemorrhagic cyst (Bosniak III)	1	4.54	-
- Simple cyst (Bosniak I)	4	18.18	-
- Emphysematous Pyelonephritis	1	4.54	-
- Acute Pyelonephritis	1	4.54	-
- Renal-perirenal abscess	2	9.09	-
Total	22		12

Diffusion Features of Studied Lesions:

I- Diffusion characteristics:

Diffusion weighted image were obtained using b 0, 500 and 1000 s/mm^2. We noticed that the all malignant lesions in our study demonstrated restricted diffusion (bright signal in DWI and dark signal in ADC map) in the solid areas of the lesions.

Table (2): Diffusion signals of malignant renal lesions.

	ADC	**DWI**	**No. of cases**	**The LESION**
Restricted diffusion	Dark	Bright	***7***	RCC
Restricted diffusion	Dark	Bright	***2***	TCC
Restricted diffusion	Dark	Bright	***1***	SCC

Most cases of benign lesions also displayed restricted diffusion in form of bright signal in DWI and dark signal in ADC map. This overlap between malignant and benign lesions in signal intensity make calculating ADC value is mandatory to determine nature of some lesions accurately in addition to conventional MRI.

Table (3): Diffusion signal of benign lesions in the studied group.

	ADC	**DWI**	**No.**	**The LESION**
Restricted diffusion	Dark	Bright	1	Oncocytoma
Restricted diffusion	Dark	Bright	2	AMl
Restricted diffusion	Heterogonous	Heterogonous	1	Hemorrahgic cyst (Bosniak III)
Non-restricted diffusion	Bright	Dark	4	Simple cyst (Bosniak I)
Restricted diffusion	Dark	Bright	1	Acute Pyelonephritis
Restricted diffusion	Dark	Bright	1	Emphysematous Pyelonephritis
Restricted diffusion	Dark	Bright	2	Renal–Perirenal Abscess

II-ADC Values of the lesions In The studied Group:

Apparent diffusion coefficient (ADC) of normal kidney parenchyma, and different renal lesions were calculated with b value of 0, 500 and 1000 s/mm^2.

ADC Values of Normal Renal Parenchyma, Benign and Malignant Lesions:

ADC of normal renal parenchyma ranged between 1.5x10^{-3}mm^2/s and 2.8x10^{-3}mm^2/s (mean 2.14x10^{-3}mm^2/s), while ADC of malignant renal lesions ranged from 0.9 x10^{-3}mm^2/s to 1.49x10^{-3}mm^2(mean 1.15x10^{-3}mm^2/s), the ADC value of benign lesion extend between 0.58 x10^{-3}mm^2 and 3.4 x10^{-3}mm^2 (mean 1.85x10^{-3}mm^2/s) (**Table 4**).

Table (4): Mean ADC values of normal parenchyma, benign and malignant lesions at b1000 value.

		Normal	Benign	Malignant
ADC Value	**Range**	***1.5-2.8***	***0.58-3.4***	***09-1.49***
	Mean	***2.14***	***1.85***	***1.15***

The ADC value of normal renal parenchyma is significantly higher than ADC value of benign and malignant renal lesions **Fig (3).**

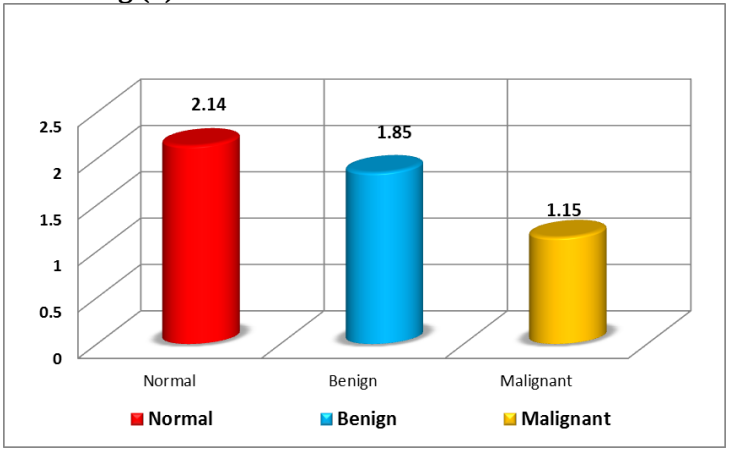


Fig (3): Comparison between ADC normal renal parenchyma, benign and malignant lesions.

The cut-off ADC value obtained and used for differentiation between benign and malignant lesions was 1.11 x 10^{-3} mm^2/s. it revealed a sensitivity of 65% and specificity of 75%. Despite the statically difference in the mean ADC values of benign and malignant lesions, there was an overall considerable overlap between two groups **(Table 5)** and **(Fig 4).**

Table (5): Diagnostic performance of ADC in discrimination of malignant patients and benign patients.

Cut off	Area under the curve	Sensitivity	Specificity	PPV	NPV	p-value
1.11	**0.66**	**60 %**	**75 %**	**70.5 %**	**65.2 %**	**0.187**

PPV: positive predictive value. **NPV: Negative predictive value.**

Using ROC curve, it was shown that ADC can be used to discriminate between malignant and benign lesions at a cutoff level of 1.11, with 0.66 AUC, 60% sensitivity, 75% specificity, 70.5% PPV, 65.2% NPV and p-value of 0.187.

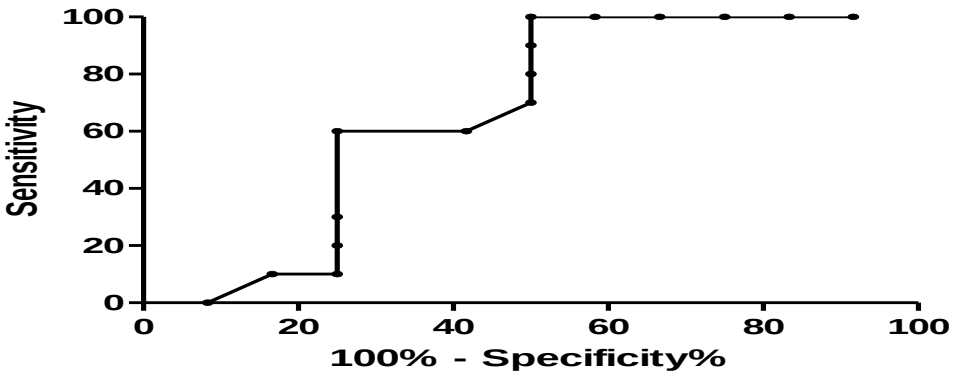


Fig (4): ROC curve between malignant patients and benign lesions as regard ADC.

ADC VALUES OF MALIGNANT RENAL LESIONS:

The ADC of renal cell carcinoma (n=7) ranged from**1.03x$10^{-3}$$mm^2/s$ to 1.49 x $10^{-3}$$mm^2/s$ (*mean 1.2x$10^{-3}$$mm^2$/s)** , ADC values of transitional cell carcinoma and Squamous cell carcinoma **1.10 x$10^{-3}$$mm^2/s$ and 0.9 x$10^{-3}$$mm^2$ /s** respectively **(Table 6), (Fig 5).**

Table (6): ADC values of malignant renal lesions in the studied group at b1000 value

		SCC	RCC	TCC
ADC of mass	**Range**	***0.9***	***1.03-1.49***	***1.1***
	Mean	***0.9***	***1.2***	***1.1***

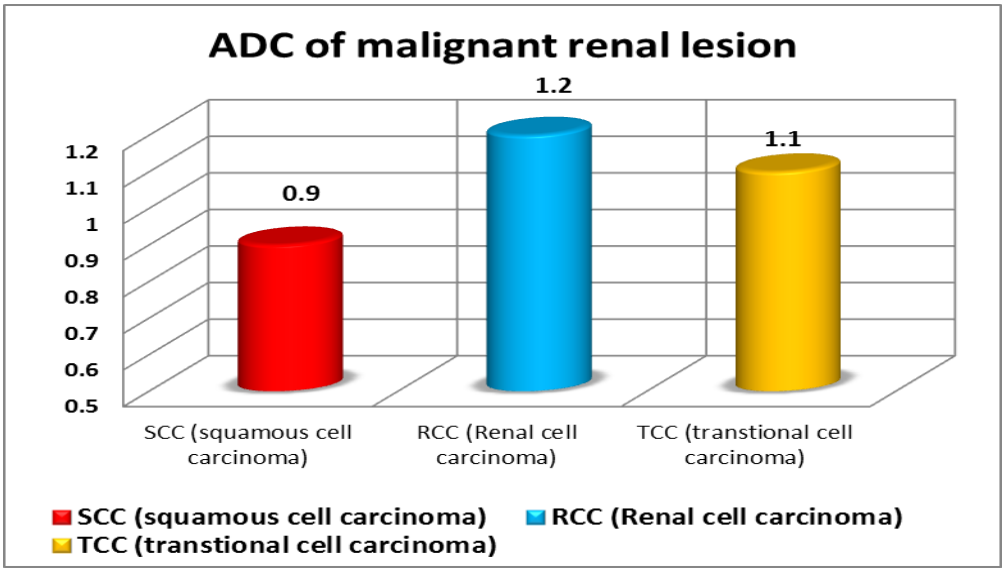


Fig (5): ADC values of malignant renal lesions in the studied group.

ADC VALUES OF BENIGN RENAL LESIONS:

The ADC values of the benign renal lesions ranged from 0.58 x$10^{-3}$$mm^2$/s to 3.4x$10^{-3}$$mm^2$/s. The mean ADC value of AML (0.75x$10^{-3}$$mm^2$/s), ADC value of oncocytoma (1.82x$10^{-3}$$mm^2$/s), ADC value of hemorrhagic cyst (1.9x10^{-3} mm^2/s), mean ADC of simple cysts (3.17x10^{-3} mm^2/s). ADC value of emphysematous pyelonephritis (0.9 x$10^{-3}$$mm^2$/s) was lower than ADC value of acute pyelonephritis (1.2x$10^{-3}$$mm^2$/s) and mean ADC value of renal–perirenal abscesses (1.12 x$10^{-3}$$mm^2$/s) (**Table 7) and (Fig 6).**

Table (7): ADC values of benign lesions in the studied group

		Acute pyelonephritis	Emphysematous pyelonephritis	Renal–perirenal abscesses	Hemorrhagic cyst	Oncocytoma	AML	Simple cyst
ADC of mass	**Range**	***1.2***	***0.9***	***1.12***	***1.9***	***1.82***	***0.58 – 0.91***	***3.08 – 3.4***
	Mean	***1.2***	***0.9***	***1.12***	***1.9***	***1.82***	***0.75***	***3.17***

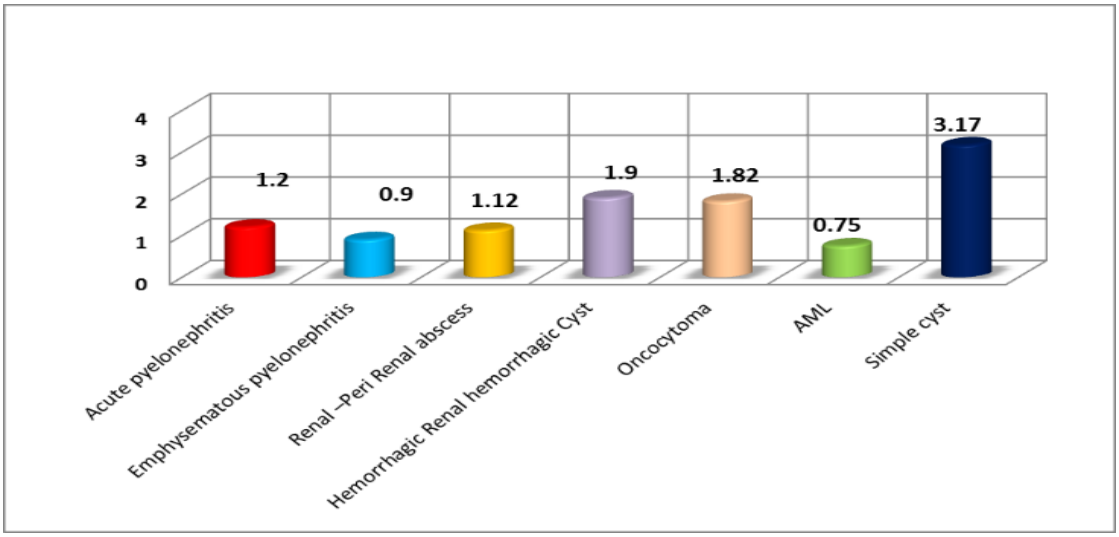


Fig (6): ADC values of benign lesions in the studied group.

ADC Values in Renal Parenchymal Diseases Patients Group (N=8).

Eight patients who had renal parenchymal diseases included three patients had long standing diabetes mellitus (37.5%), three patients had long standing systemic hypertension (37.5%), one patient had systemic lupus erythromatus SLE (12.5%) and one patient had renal artery stenosis (12.5%). The mean ADC values of renal parenchymal diseases lower than the mean ADC value of normal renal parenchyma which was ($1.68 \times 10^{-3} mm^2/s$ versus $2.14 \times 10^{-3} mm^2/s$) respectively **(Fig 7).**

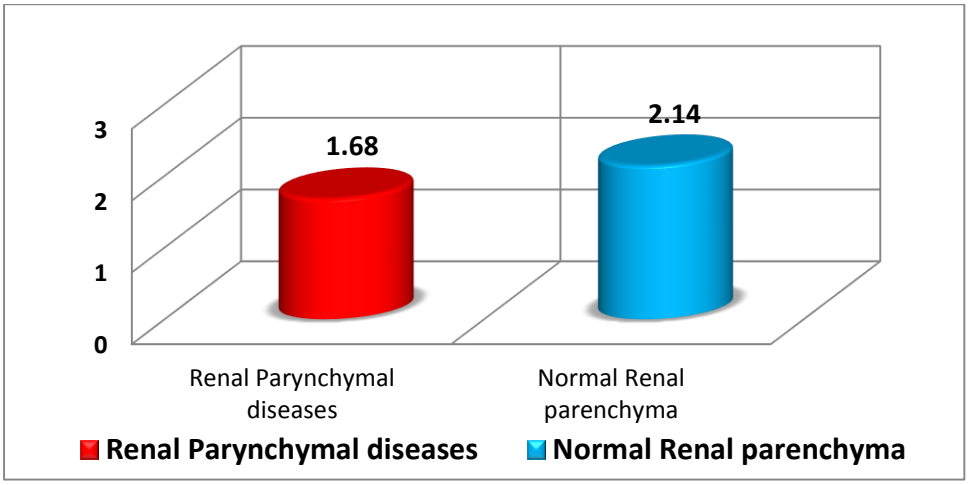
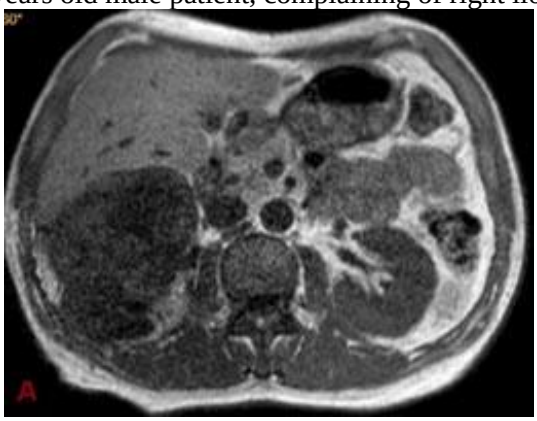


Fig (7): Comparison between ADC of normal renal parenchyma and renal parenchymal diseases.

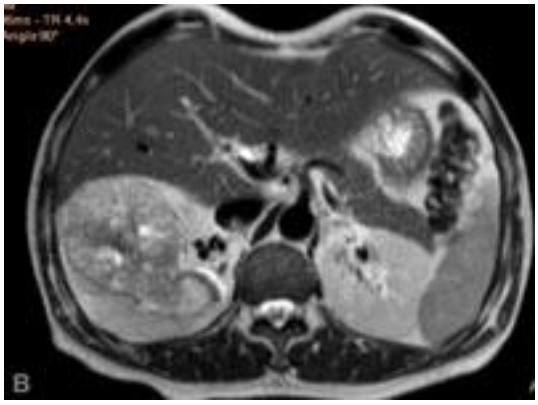
ILLUSTRATIVE CASES

CASE NUMBER 1

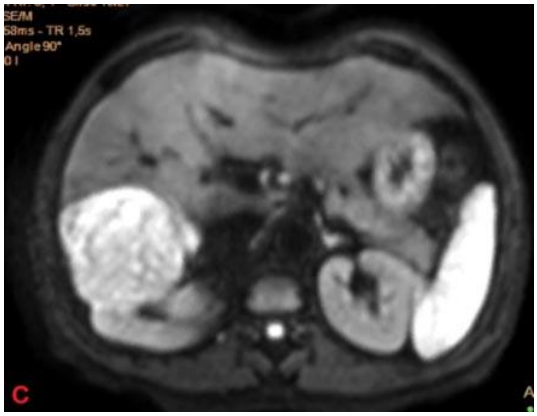
68 years old male patient, complaining of right lion pain, CT revealed a mass lesion in the right kidney.



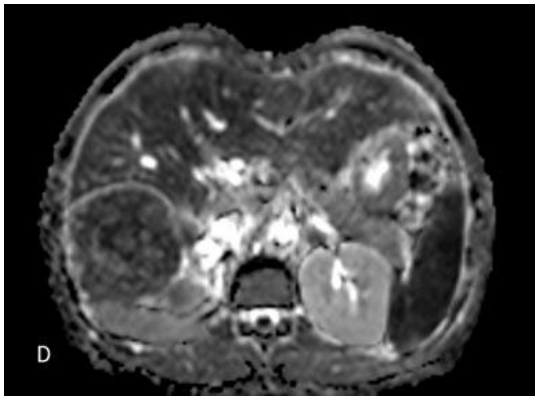
Axial T1



Axial T2



Diffusion 1000



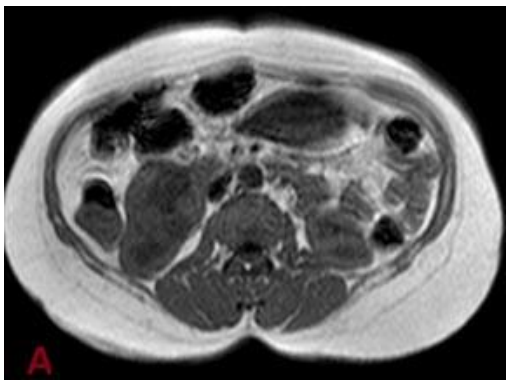
ADC map at b1000

Fig (8): *(A) axial T1WI and (B) axial T2WI Show right mid zonal solid renal lesion with small central breakdown eliciting low signal in T1, heterogeneous in T2. (C) DWI with b value 1000 and (D) ADC map show restricted diffusion. ADC value of the lesion was $1.07 \times 10^{-3} mm^2/s$.*

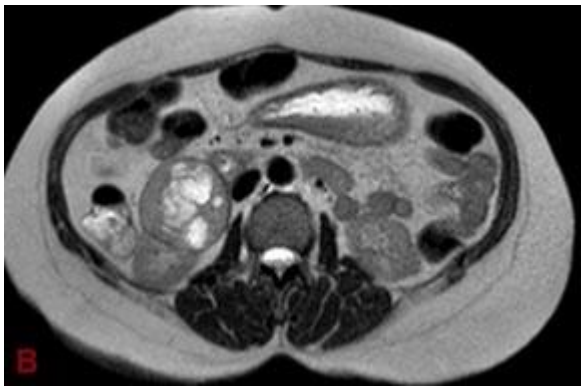
Final Diagnosis:*Patient underwent right nephrectomy and the pathology revealed renal cell carcinoma RCC.*

CASE NUMBER 2

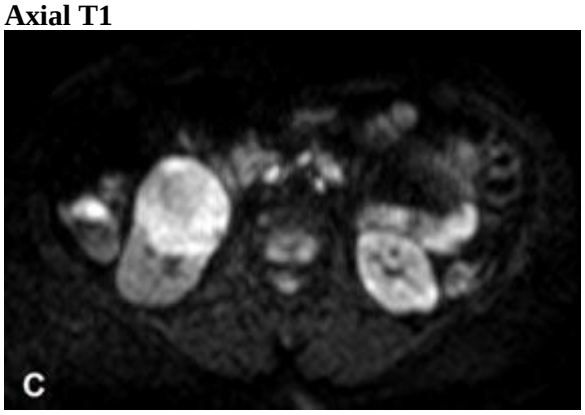
65 years old female patient, with right solid renal lesion discovered accidently by US.



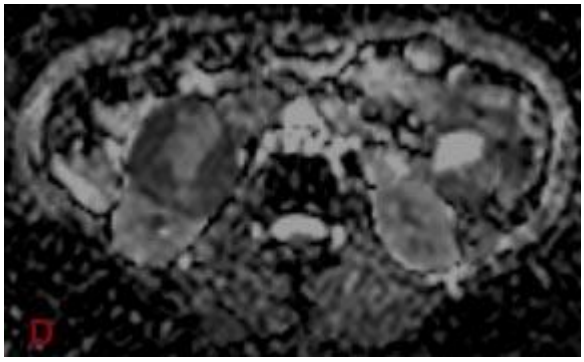
Axial T1



Axial T2



Diffusion 1000



ADC map at b1000

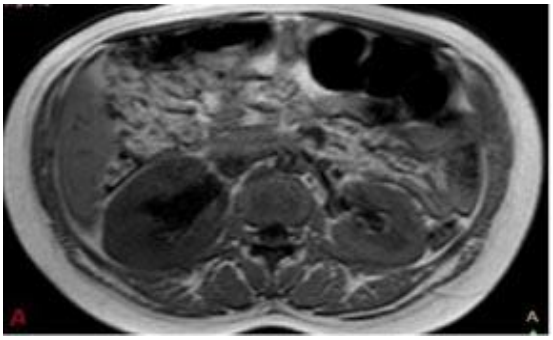
Fig (9): *(A) axial T1WI and (B) axial T2WI show right lower polar solid renal lesion with central breakdown eliciting low signal in T1 and heterogeneous signal in T2. (C) DWI with b value 1000 and (D) ADC map show restricted diffusion. ADC value of the lesion was 1.82x10^{-3}mm^{2}/s.*

Final Diagnosis:

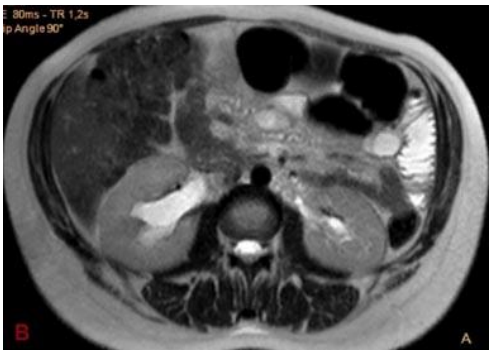
The patient underwent right partial nephrectomy and the pathology revealed oncocytoma.

CASE NUMBER 3

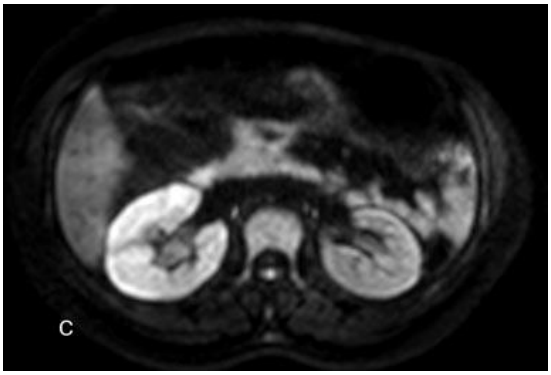
28 years old female patient, complaining with right lion pain and burning micturition. US shows back pressure changes and swollen of the right kidney.



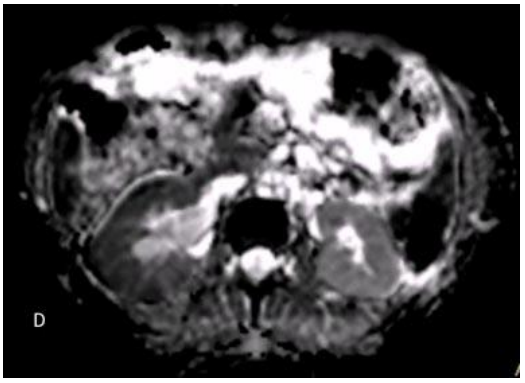
Axial T1



Axial T2



Diffusion 1000



ADC map at b1000

Fig (10): *(A) axial T1WI and (B) axial T2WI show diffuse enlargement of right kidney with mild back pressure changes. (C) DWI b1000 and (D) ADC map show restricted diffusion. ADC value of the right kidney was 1.20x10^{-3}mm^2/s.*

Final Diagnosis:

Clinically diagnosed as right acute pyelonephritis. The patient treated medically with antibiotic and follow up.

DISCUSSION

Accurate assessment of renal lesions is important for establishing whether tumors require surgical intervention or not. CT and MRI are the primary investigative tools for diagnosing, characterizing of cystic or solid renal masses discovered accidentally by ultrasonography [(1)].

In many cases, the imaging tests still cannot easily differentiate benign from malignant lesions. Studies have shown that 16–33% of nephrectomies are performed on benign lesions [(11)].

To determine whether a solid or cystic renal lesion is benign or malignant, the mass is initially examined by ultrasound (US), computed tomography (CT), MRI, or a combination of these techniques. MRI offers an alternative to US and CT for the evaluation of renal lesions. MR imaging can be particularly helpful when renal lesions are detected but are not well characterized by other imaging modalities as US and CT [(2)].

With Contrast enhanced MRI (CE-MRI), the composition of renal lesions can be suggested, and the differential diagnosis of the disease can be narrowed down. However, in view of recently reported concerns regarding the development of nephrogenic systemic fibrosis in patients with renal insufficiency that undergo CE-MRI, there is increasing interest in assessing non enhanced imaging modalities that might be useful for characterizing renal lesions [(12)].

DWI MRI technique is used to show molecular diffusion, which is the Brownian motion of the spins in biological tissues; but it cannot be explained only by this motion. Other additional factors have been considered, such as perfusion in the capillary network. Therefore, the diffusion phenomenon is measured by the ADC [(13)].

Diffusion-weighted imaging (DWI) is a functional technology that develops image contrast based on the inhibition of migration of water molecules in tissues by tissue microstructures. As a result of the dense cellularity, malignant tissue has restricted diffusion, which is reflected by a low mean apparent diffusion coefficient (ADC) [(4)].

Abdominal region applications are more challenging due to respiratory movements, the magnetic susceptibility of air in the lungs and bowel, and movement and pulsatility artifacts which can seriously affect the image quality in the abdominal region **(9).**

For examination of urogenital system, the majority of DWI is performed in the axial plane during "free breathing" or by using "breathing trigger," in addition to common MRI sequences, with extra time about 4–10 min **(10)**.

The kidney is well suited for diffusion studies because of its high blood flow and its fluid transport function. According to some authors; these factors can explain the higher renal ADC values as compared with other organs ***(13)*.**

DW-MRI provides unique insight into tissue cellularity, tissue organization, integrity of cells and membranes, as well as the tortuosity of the extracellular space, which can be helpful for detecting malignant diseases, and for distinguishing tumor tissues from non-tumor tissues ***(7)***.

The ADC has been related to the state of tissue during the growth of tumors or progression of cancer. With proliferating cells, there is an increase in cellular density and a decrease in the amount of intracellular space or extracellular space available, leading to a reduction in the ADC ***(7)***.

Restriction to the molecular diffusion in neoplastic tissues can be related to the greater cellular density in the tissues, generated by the high index of neoplastic replication with a consequent reduction in the width of intercellular spaces, and to the ultra-structural alteration of the kidney tissue ***(5)*.**

In this study we assessed the diagnostic potential of diffusion-weighted imaging and quantitative assessment of ADC value for the characterization of malignant and benign renal lesions.

The ADC value has been reported to be valuable for quantitatively distinguishing malignant from benign lesions. When applying a high *b* values, the ADC value approximates the true diffusion. Low b-values are influenced by both perfusion and diffusion **(14).**

An image of low b-value (0s/mm^2) has higher SNR, less distortion, but less diffusion weighting. Conversely, high b-factor (500–1000 s/mm^2) images have more diffusion weighting but suffer from low signal-to-noise ratio and severe image distortion. DWI using b values of 0, 400 and800 s/mm^2 was included in the routine MRI examination to differentiate benign and malignant kidney masses. Some investigators have recommended a b value >400 s/mm^2 because it can reduce ''T2 shine-through'' and intra-voxel perfusion effects ***(15)*.**

This study was conducted with b values (0, 500 and 1000), ***Inci et al* .(1)** *and* ***Zhang et al.*** ***(16)*** have reported the use of similar b values in diffusion weighted imaging of the kidney.

The ADC values of normal renal parenchyma and renal lesions with b value of 1000 were calculated.

The mean ADC value for normal renal parenchyma in our study was ***(2.14×10^{-3} mm^2/sec)***. This was close to the results of ***Inci et al.*** **(1)** who reported a mean ADC value of **(*2.18 ×10^{-3} mm^2/sec)***.

In a study by ***Kilickesmez et al.*** ***(5)*** the mean ADC value of normal renal parenchyma was **(2.08±0.22×10^{-3}mm^2/sec)**.

Our results demonstrated the diagnostic potential of combined conventional MRI and diffusion sequence in the differentiation between benign and malignant renal lesions.

Among 22 lesions, 10 lesions were diagnosed as malignant, 12 lesions diagnosed as benign lesions.

The mean ADC value of benign renal lesions was **(*1.85 x 10^{-3}mm^2/s*)**. It was significantly lower than mean ADC of normal renal parenchyma ***(2.14 x 10^{-3}mm^2/s).***

The mean ADC of malignant renal lesions was ***(1.15 x 10^{-3} mm^2/s)***, it was significantly lower than normal parenchyma ADC **(2.14x10^{-3}m^2/s)**. This was in concordance with previous studies by ***Inci et al.*** **(1)** and ***Zhang et al.*** ***(16)*.**

The cut-off ADC value obtained and used for differentiation between benign and malignant lesions was 1.11 x 10^{-3} mm^2/s. it revealed a sensitivity of 65% and specificity of 75%. Despite the statically difference in the mean ADC values of benign and malignant lesions, there was an overall considerable overlap between two groups.

DWI MR has a promising role in the characterization of renal masses. Highly cellular neoplasms, such as solid renal cell carcinomas (RCCs), typically maintain bright signal intensity compared to normal renal parenchyma on high b-value images. Conversely, renal masses with low cellularity such as benign cysts typically have less restricted water diffusion and lose signal on high b-value images ***(17)*.**

Nonetheless, RCC can have a varied appearance on DW MRI owing to differing degrees of cellularity and elements of cystic change, necrosis, or hemorrhage. In complex renal masses, solid enhancing tumor components demonstrate lower ADC values than necrotic or cystic regions ***(16)*.** Areas of restricted diffusion in a mixed solid and cystic renal mass may help differentiate an RCC with cystic or necrotic areas from a benign complicated cyst that might otherwise

appear similar on conventional MRI obtained without contrast [16].

In this study 7 cases proved to have solid RCC. The mean ADC value of Renal cell carcinoma ***(1.2x10^{-3}mm^2/s),*** which was significantly lower than the mean ADC value of normal renal parenchyma and mean ADC value of all benign renal lesions**.**

The mean ADC of RCC was also significantly lower than high ADC of hemorrhagic renal cyst (BosniakIII) ***(1.9x10^{-3}mm^2/s).*** This was an agreement with the previous reports by **Zhang *et al.*** [16] and **Inci *et al.*** [1]. However, ***Yoshikawa et al.*** [15] reported no significant difference between the ADC of RCC and the ADC of complex cysts.

Urothelial carcinomas also exhibit restricted diffusion due to high cellularity; they stand out as areas of bright signal intensity against a background of suppressed signal within the collecting system and adjacent normal renal parenchyma on high b-value images while demonstrating low signal on the corresponding ADC map [18].

Yoshida et al. [19] have found that the accuracy and sensitivity for detecting upper urinary tract carcinoma at MRI can be significantly improved by adding DW imaging to standard anatomic and fluid-sensitive sequences.

There were two cases of **TCC** in our study with mean ADC value was ***(1.10 x 10^{-3} mm^2/s)*** that was lower than mean ADC of normal renal parenchyma (***2.14 x10^{-3}mm^2/s***), this was close to ***Yoshida et al*** [19] who reported lower ADC values in TCC (***1.29x10^{-3} mm^2/s***) compared with renal parenchyma **(2.19x10^{-3} mm^2/s).**

In this study two cases diagnosed as angiomyolipoma. The mean of ADC value of AML was **(0.75 x 10^{-3}mm^2/s)** which even significantly lower than RCC **(1.2 x 10^{-3}mm^2/s).**This results are similar to those of previous studies by **Taouli *et al.*** [14]**,**
Yoshikawa *et al.* [15] **and Zhang *et al* .**[16]**.**

Only one case was diagnosed as oncocytoma in our study with ADC value was **1.82 x 10^{-3} mm^2/s**. This result was close to results of **Inci et al** [1] **(1.66±0.99x10^{-3}mm^2/s).**

In the current study 4 cases were diagnosed as simple renal cyst (bosniakI) with mean ADC value **(3.1 x10^{-3} mm^2/s)** which is close to study by **Inci *et al.*** [1] who reported by mean of ADC value **(3.09x10^{-3} mm^2/s).**

In this study there was one case of hemorrhagic renal cyst (Bosniak III) with ADC value (***1.9 x 10^{-3} mm^2/s)*** that was significantly higher than the mean ADC of RCC **(1.2 x 10^{-3} mm^2/s).**This was agreement with previous studies by ***Zhang et al.*** [16]***and Inci et al.*** [1]**.**

Sandrasegaran and his colleagues have concluded that complicated benign cysts with increased blood or protein content show reduced diffusion compared with simple cysts. The presence of large molecules or cellular debris within a complex cyst may impede diffusion [20]**.**

Renal hemorrhagic cysts can sometimes demonstrate low signal on the ADC map, a finding that may relate to the ‘‘T2 blackout’’ effects of an intrinsically T2 hypo intense lesion and/or restricted diffusion in blood products [21]. ***Cogley et al.*** [18] have demonstrated that the presence of fluid–fluid or hematocrit levels observed in some hemorrhagic cysts and the absence of solid enhancing components can help in the diagnosis of hemorrhagic cyst, however the small lesion size and motion artifact may decrease accurate evaluation.

Renal infection and some associated complications (renal abscess...etc) also demonstrate restricted diffusion and should not be mistaken for malignancy. Pyelonephritis results in patchy non-mass like areas of restricted diffusion in portions of the renal parenchyma, a finding that may relate to inflammatory cell infiltration and possible ischemic effects of infection [22]**.**

In this study, one case was diagnosed as acute pyelonephritis, one case of emphysematous pyelonephritis and two cases of renal-perirenal abscess. The mean ADC value of all inflammatory lesions was ***(1.08x 10^{-3}mm^2/s)*** that was lower than mean ADC of renal cell carcinoma ***(1.2 x10^{-3}mm^2/s).***Those results were similar to previous study by ***Goyal et al.*** [6] have stated that the mean ADC values of inflammatory lesions ***(1.12±0.21 × 10^{-3}mm^2/s)*** were significantly lower than that of RCC ***(1.2±0.40 × 10^{-3}mm^2/s)***.

In this study, the mean ADC value in chronic renal failure patients ***(1.68 x10^{-3}mm^2/s***) was significantly lower than ADC value of healthy kidneys (***2.28x10^{-3}mm^2/s***) which was consistent with previous studies by ***Yoshikawa et al.*** [15] *and* ***Xu et al.*** [23]**.**

The limitations of this study include small sample size and the single–shot echo planer imaging used with higher b value had a lower signal to noise ratio resulting in image distortion, poor anatomic localization and relatively poor spatial resolution.

Until now, the optimal b value for abdominal diffusion weighted imaging has not been determined. Some investigators recommended a b value larger than 400 s/mm^2 to reduce “T2 shine-through” and intravoxel perfusion effects However; a higher b value leads to a lower signal to-noise ratio (SNR).

CONCLUSION AND RECOMMENDATION

It could be concluded that there is overlap between ADC values of inflammatory, solid benign

lesions and ADC values of malignant lesions, the use of ADC value alone may lead to inaccurate assessment of renal lesions. The combination of conventional MRI and ADC value in the diagnosis of renal lesions can increase the diagnostic accuracy.

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