**RESEARCH PAPER**

# A Cross-Sectional Study to Evaluate the Role of Diffusion Weighted Imaging in Chronic Kidney Disease in Tertiary Care Centre In Chengalpattu District, Tamil Nadu

**Dr. Raghavendar Kishore S[1], Dr. Kaliaperumal V.G[2*], Dr. Harshavardhan B[3], Dr. Jenikar Paulraj[4], Dr. Sai Shankar M.G[5] and Dr. Remya R[6]**

*[1]Junior Resident, Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Sri Balaji Vidyapeeth (Deemed to be University), Chennai Campus, India*

*[2*]Professor & Head, Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Sri Balaji Vidyapeeth (Deemed to be University), Chennai Campus, India*

*[3]Assistant Professor, Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Sri Balaji Vidyapeeth (Deemed to be University), Chennai Campus, India*

*[4]Professor, Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Sri Balaji Vidyapeeth (Deemed to be University), Chennai Campus, India*

*[5]Associate Professor, Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Sri Balaji Vidyapeeth (Deemed to be University), Chennai Campus, India*

*[6]Assistant Professor, Department of Radiodiagnosis, Shri Sathya Sai Medical College and Research Institute, Sri Balaji Vidyapeeth (Deemed to be University), Chennai Campus, India*

*[1]raghavkishore05@gmail.com, [2*]drkaliaperumal@gmail.com, [3]harshavardhanb@sssmcri.ac.in, [4]drjenikar@gmail.com, [5]vanhelsing250@gmail.com and [6]drremya1986@gmail.com*

*ORCID ID: [1]https://orcid.org/0009-0003-0893-6583, [2*]https://orcid.org/0009-0008-3394-5525, [3]https://orcid.org/0000-0001-7738-5154, [4]https://orcid.org/0000-0002-3136-8882, [5]https://orcid.org/0000-0002-2420-1240 and [6]https://orcid.org/0000-0002-3893-0022*

***Corresponding author:** Dr. Kaliaperumal V.G*
*drkaliaperumal@gmail.com*

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**ABSTRACT**

**Introduction:** Chronic kidney disease is a progressive condition requiring accurate, non-invasive evaluation. Diffusion-weighted imaging provides functional assessment of renal parenchyma through ADC values, reflecting microstructural changes and offering potential correlation with biochemical markers of renal dysfunction.

**Aim and Objectives:** To evaluate the relationship between MR-DWI derived ADC values and biochemical parameters including serum creatinine, blood urea, and eGFR, and to assess the utility of ADC values in staging chronic kidney disease.

**Methods:** A cross-sectional study was conducted on 79 CKD patients. ADC values were obtained using MRI-DWI and correlated with serum creatinine, blood urea, and eGFR. Statistical analysis was performed using SPSS version 17.

**Results:** ADC values decreased progressively from 2.12 ± 0.21 in stage 2 to 1.32 ± 0.20 in stage 5 ($p=0.001$), with strong correlation to eGFR ($r=0.72$) and inverse correlation with creatinine ($r=-0.69$) and urea ($r=-0.63$).

**Conclusion:** MR-DWI derived ADC values show significant correlation with renal function parameters and provide a reliable, non-invasive tool for assessment and staging of CKD.

**Keywords:** *Brain ischemia, Magnetic Resonance Spectroscopy, N-acetylaspartate, Lactate, Cerebral infarction, Metabolite ratios, Stroke prognosis, MRI brain.*

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**Author for Correspondence: drkaliaperumal@gmail.com*

## INTRODUCTION

Chronic kidney disease (CKD) is a major global health problem, affecting a significant proportion of the adult population and leading to increased morbidity and mortality if not detected early. It is characterized by a gradual loss of kidney function, often remaining asymptomatic in early stages, which delays diagnosis and timely intervention Nephrology. Early identification and monitoring are therefore essential to prevent disease progression and complications [1]. Conventional diagnostic methods such as serum creatinine and estimated glomerular filtration rate (eGFR) have limitations, as they may not accurately reflect early structural changes in renal tissue [1,2].

Magnetic resonance imaging (MRI), particularly diffusion weighted imaging (DWI), has emerged as a promising non-invasive tool for evaluating renal microstructure and function Diffusion Weighted Imaging. DWI measures the movement of water molecules within tissues, providing quantitative parameters such as the apparent diffusion coefficient (ADC), which reflects tissue cellularity and integrity [3]. Studies have shown that ADC values decrease in CKD due to fibrosis, tubular atrophy, and interstitial changes [4].

Recent research highlights the role of DWI and multiparametric MRI in assessing the severity and progression of CKD. These imaging techniques can detect early renal damage, correlate with serum biomarkers, and differentiate between stages of disease [5,6]. Additionally, DWI has shown potential in evaluating renal fibrosis and predicting disease outcomes, making it a valuable adjunct to conventional diagnostic methods [7,8].

## MATERIALS & METHODS

**Study design:** Cross-sectional study

**Study area:** Tertiary Care Centre in Chengalpattu district.

**Inclusion criteria:**
Patients who were clinically diagnosed with medical renal disease with deranged eGFR.

**Exclusion criteria:**

**Study variables:**

**Primary findings:** ADC values, blood urea, serum creatinine.

**Secondary findings:** eGFR (calculated).

**Patients with**

- Dehydration
- Claustrophobia, unstable condition
- Contraindications to undergo MRI (ferromagnetic implants / pacemakers / aneurysm clips).

**Sample Size:** 79

## DATA ANALYSIS

Collected data were represented in the form of diagrams and tables. Statistical calculations were performed. Data were entered using Microsoft Excel and analyzed using the Statistical Package for Social Science (SPSS), standard version 17. Data were analyzed to assess the significant correlation between MR-DWI ADC values and eGFR.

## RESULTS

**Table 1.** Sociodemographic Profile of Study Population (n = 79)

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Age (years) | 31–40 | 12 | 15.2 |
| | 41–50 | 18 | 22.8 |
| | 51–60 | 26 | 32.9 |
| | 61–70 | 17 | 21.5 |
| | >70 | 6 | 7.6 |
| Sex | Male | 46 | 58.2 |
| | Female | 33 | 41.8 |
| Education | Illiterate | 14 | 17.7 |
| | Primary | 21 | 26.6 |
| | Secondary | 24 | 30.4 |
| | Graduate and above | 20 | 25.3 |
| Socioeconomic status (Kuppuswamy) | Lower | 28 | 35.4 |
| | Upper lower | 24 | 30.4 |
| | Lower middle | 16 | 20.3 |
| | Upper middle | 11 | 13.9 |

Table 1 Shows the population consisted of 79 patients, with the majority belonging to the 51–60 years age group (32.9%), followed by 41–50 years (22.8%). Males predominated (58.2%) compared to females (41.8%). Most

participants had secondary (30.4%) or primary education (26.6%), while 17.7% were illiterate. In terms of socioeconomic status, a large proportion belonged to the lower (35.4%) and upper-lower (30.4%) classes, indicating that most patients were from lower socioeconomic strata.

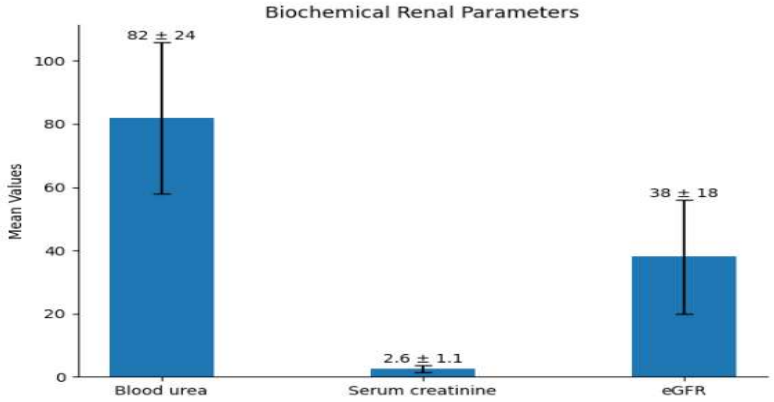


**Figure 1.** Biochemical Renal Parameters

In Figure 1 the mean blood urea level was 82 ± 24 mg/dL and mean serum creatinine was 2.6 ± 1.1 mg/dL, indicating impaired renal function in the study population. The mean eGFR was 38 ± 18 ml/min/1.73 m², consistent with moderate chronic kidney disease.

**Table 2.** Distribution of CKD Stages Based on eGFR

| CKD Stage | eGFR Range (ml/min/1.73 m²) | n | % |
|---|---|---|---|
| Stage 2 | 60–89 | 14 | 17.7 |
| Stage 3a | 45–59 | 17 | 21.5 |
| Stage 3b | 30–44 | 20 | 25.3 |
| Stage 4 | 15–29 | 19 | 24.1 |
| Stage 5 | <15 | 9 | 11.4 |

In Table 2, most patients were in CKD stage 3b (25.3%) and stage 4 (24.1%), followed by stage 3a (21.5%). Stage 2 accounted for 17.7% and stage 5 for 11.4% of patients. Overall, the majority of the study population had moderate to advanced stages of chronic kidney disease.

**Table 3.** Renal ADC Characteristics

| Parameter | Mean ADC (×10⁻³ mm²/s) | SD | p-value |
|---|---|---|---|
| Right kidney | 1.82 | 0.28 | 0.42 |
| Left kidney | 1.79 | 0.3 | |
| Upper pole | 1.85 | 0.27 | 0.31 |
| Interpolar region | 1.8 | 0.28 | |
| Lower pole | 1.78 | 0.29 | |
| Overall mean | 1.81 | 0.29 | — |

In Table 3, the mean ADC value was 1.82 ± 0.28 ×10⁻³ mm²/s in the right kidney and 1.79 ± 0.30 ×10⁻³ mm²/s in the left kidney, with no statistically significant difference (p = 0.42). Regional analysis showed comparable ADC values across the upper pole (1.85 ± 0.27), interpolar region (1.80 ± 0.28), and lower pole (1.78 ± 0.29 ×10⁻³ mm²/s), with no significant variation (p = 0.31). The overall mean ADC was 1.81 ± 0.29 ×10⁻³ mm²/s, indicating uniform diffusion characteristics between kidneys and across renal regions.

**Table 4.** ADC and Biochemical Changes Across CKD Stages

| CKD Stage | ADC (Mean ± SD) | Creatinine (Mean ± SD) | Urea (Mean ± SD) | p-value |
|---|---|---|---|---|
| Stage 2 | 2.12 ± 0.21 | 1.4 ± 0.4 | 52 ± 12 | |
| Stage 3a | 1.95 ± 0.23 | 1.9 ± 0.5 | 66 ± 14 | |
| Stage 3b | 1.78 ± 0.25 | 2.4 ± 0.6 | 82 ± 16 | 0.001 |
| Stage 4 | 1.55 ± 0.24 | 3.3 ± 0.8 | 104 ± 18 | |
| Stage 5 | 1.32 ± 0.20 | 4.8 ± 1.0 | 136 ± 22 | |

In Table 4 mean renal ADC decreased progressively from stage 2 (2.12 ± 0.21 ×10⁻³ mm²/s) to stage 5 (1.32 ± 0.20 ×10⁻³ mm²/s). In contrast, serum creatinine increased from 1.4 ± 0.4 mg/dL in stage 2 to 4.8 ± 1.0 mg/dL in stage 5, and blood urea increased from 52 ± 12 mg/dL to 136 ± 22 mg/dL. This trend was statistically significant (p = 0.001), indicating that worsening renal function is associated with a progressive decline in ADC values.

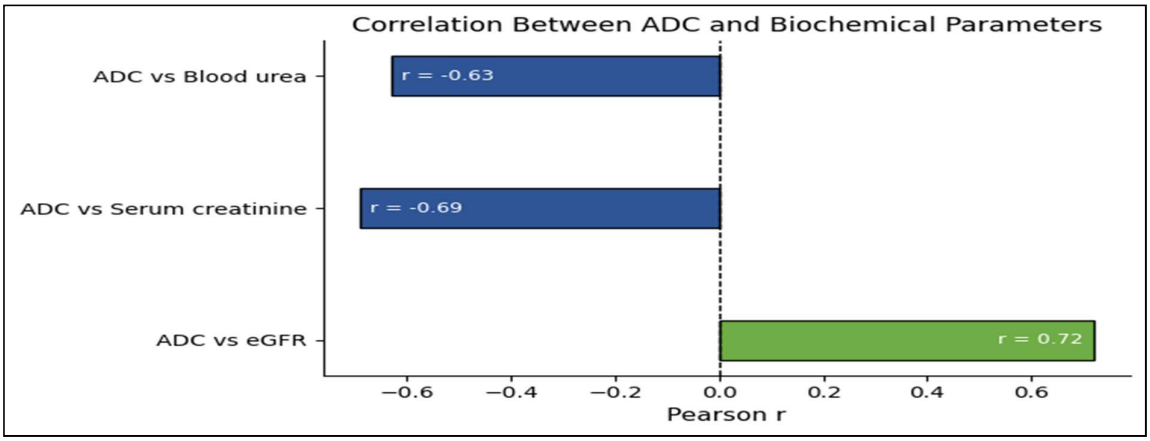


**Figure 2.** Correlation of ADC with Renal Function Parameters

In Figure 2, renal ADC showed a strong positive correlation with eGFR (r = 0.72) and strong negative correlations with serum creatinine (r = −0.69) and blood urea (r = −0.63), all statistically significant (p = 0.001), indicating that lower ADC values were associated with worsening renal function.

## DISCUSSION

The sociodemographic and biochemical profile of the present study demonstrates a predominance of patients in the 51–60 years age group (32.9%) with male preponderance (58.2%), which is consistent with the age-related progression of CKD observed in Hua C et al. (2023) [7], where disease severity increased with advancing age and showed significant correlation with declining renal function parameters (p < 0.001). Similarly, the mean eGFR of 38 ± 18 ml/min/1.73 m² and elevated serum creatinine (2.6 ± 1.1 mg/dL) and blood urea (82 ± 24 mg/dL) reflect moderate to advanced renal dysfunction, aligning with Han L et al. (2024) [9], which reported significant microstructural alterations in CKD patients associated with worsening biochemical markers. The predominance of stage 3b (25.3%) and stage 4 (24.1%) further supports progressive renal impairment comparable to imaging-biochemical correlations noted in Hua C et al. (2023) [7]. In contrast, Yao S et al. (2025) [10] demonstrated no significant association between physiological variables and disease burden (OR 0.94), highlighting the distinct pathophysiological behavior in non-renal imaging contexts. Unique to this study is the detailed socioeconomic distribution, with 35.4% belonging to the lower class, which was not evaluated in the compared studies. The present study demonstrates a progressive decline in ADC values from stage 2 (2.12 ± 0.21) to stage 5 (1.32 ± 0.20) with corresponding increases in creatinine and urea (p=0.001), showing strong correlation with eGFR (r=0.72), which is consistent with Hua C et al. (2023) [7], where diffusion parameters significantly decreased with worsening CKD (p<0.001). Similarly, Han L et al. (2024) [9] reported altered diffusion metrics correlating with biochemical changes. The uniform ADC distribution between kidneys (p=0.42) and regions (p=0.31) aligns with consistent parenchymal involvement. In contrast, Yao S et al. (2025) [10] showed no significant imaging correlation (OR 0.94), differing from renal-specific findings.

## CONCLUSION

The present study demonstrates a significant relationship between renal parenchymal ADC values and biochemical markers of renal dysfunction in chronic kidney disease. A progressive decline in ADC values from 2.12 ± 0.21 in stage 2 to 1.32 ± 0.20 in stage 5, along with rising serum creatinine and blood urea, indicates worsening renal impairment. A strong positive correlation between ADC and eGFR (r = 0.72, p = 0.001) and negative correlation with serum creatinine (r = −0.69) and blood urea (r = −0.63) confirms the diagnostic value of diffusion-weighted imaging.

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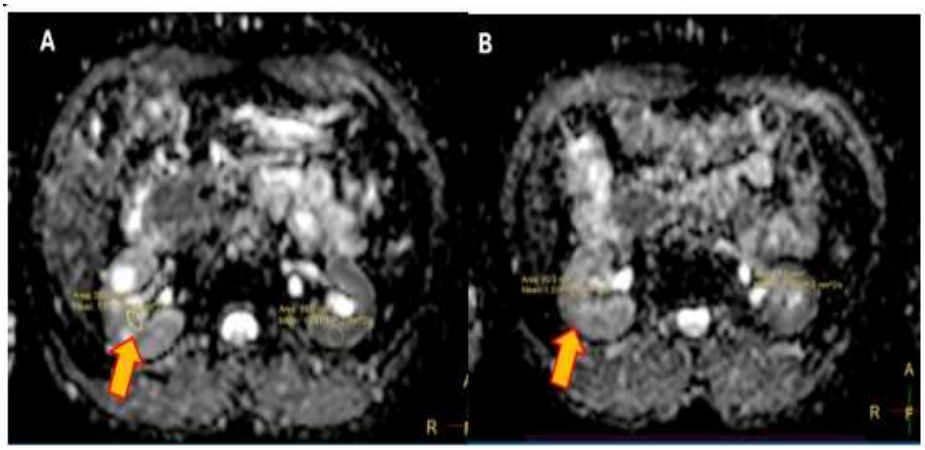
**SAMPLE IMAGES:**

**CASE 1**

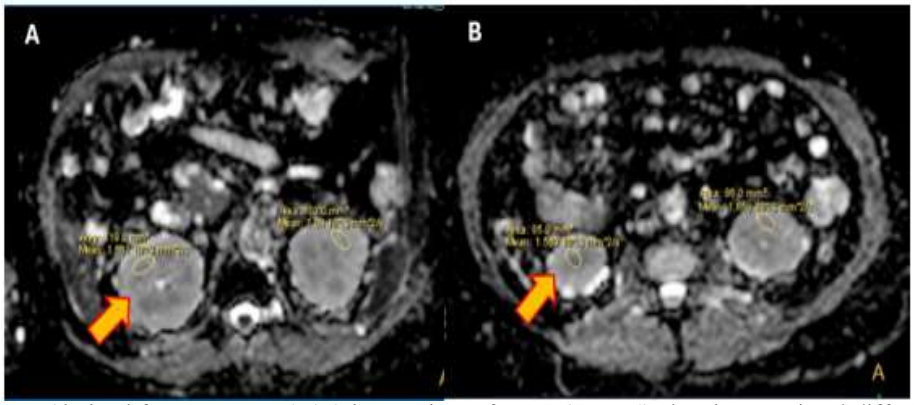



**(A, B):** ADC map (derived from DW-MRI) (A) in a patient of CKD (stage-5) showing restricted diffusion in the renal parenchyma bilaterally with Right ADC value of 1.611 and left ADC value of 1.310 a mean ADC value of **1.473 mm $^2$ /s.**

ADC map in a patient with normal renal function showing no restriction of diffusion and ADC value range was **1.8542 – 2.342 mm$^2$/s.** The circles depict examples of ROI placement.

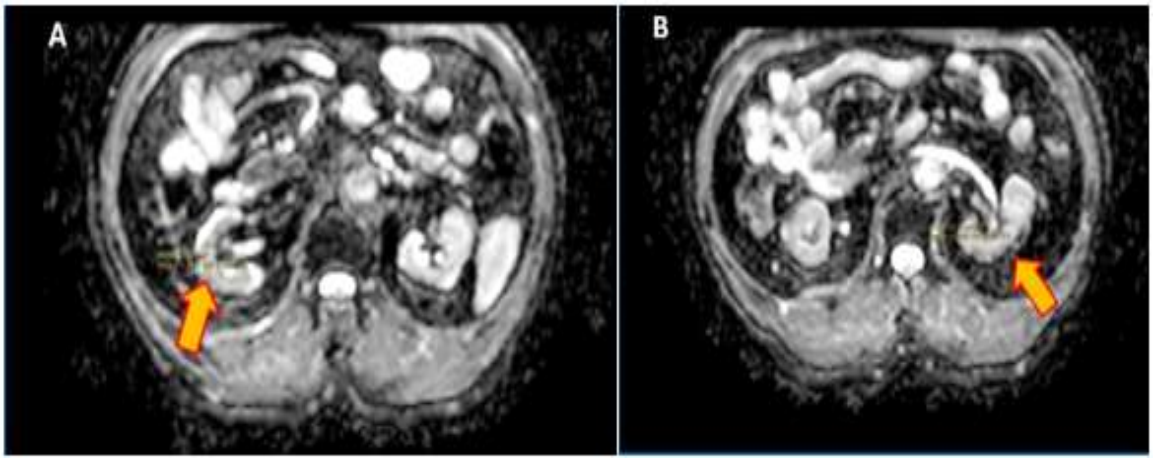
Patients Blood urea – 101 mg/dl, Sr. Creatinine – 4.6, Calculated – eGFR – 14 (Stage-5).

**CASE 2**




**(A, B):** ADC map (derived from DW-MRI) (A) in a patient of CKD (stage-4) showing restricted diffusion in the renal parenchyma bilaterally with a mean ADC value of **1.621 mm $^2$ /s.** ADC map in a patient with normal renal function showing no restriction of diffusion and ADC value range was **1.8542 – 2.342 mm$^2$/s.** The circles depict examples of ROI placement. Patients Blood urea – 97.7 mg/dl, Sr. Creatinine – 3.4, Calculated – eGFR – 18.8 (Stage-4)

**CASE 3**

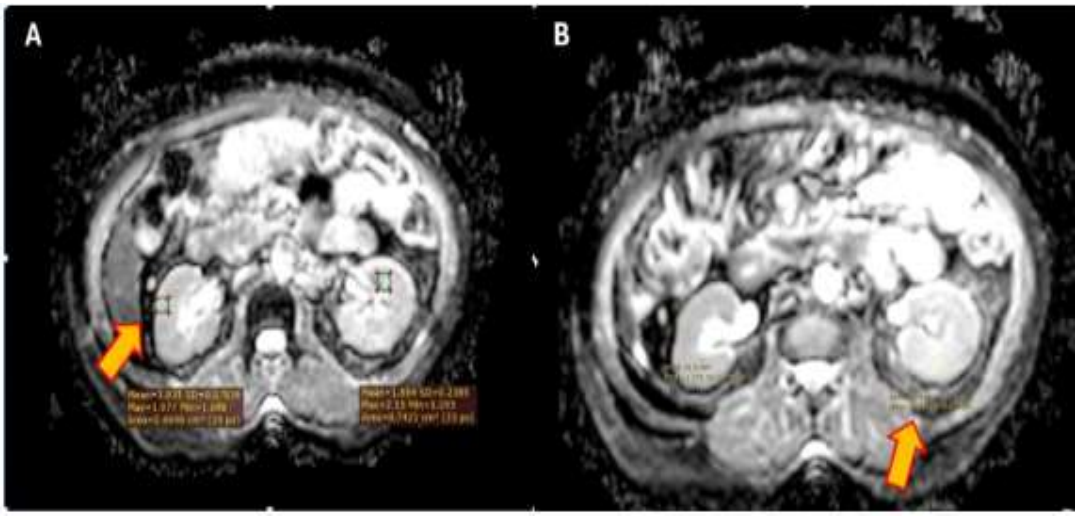



**(A, B):** ADC map (derived from DW-MRI) (A) in a patient of CKD (stage-3B showing restricted diffusion in the renal parenchyma bilaterally with Right ADC value of 1.662 and left ADC value of 1.668, mean ADC value of **1.598 mm $^2$ /s.**

ADC map in a patient with normal renal function showing no restriction of diffusion and ADC value range was **1.8542 – 2.342 mm$^2$/s.** The circles depict examples of ROI placement.

Patients Blood urea – 46.0 mg/dl, Sr. Creatinine – 1.8, Calculated – eGFR – 46.8 (Stage-3B)

**CASE 4**

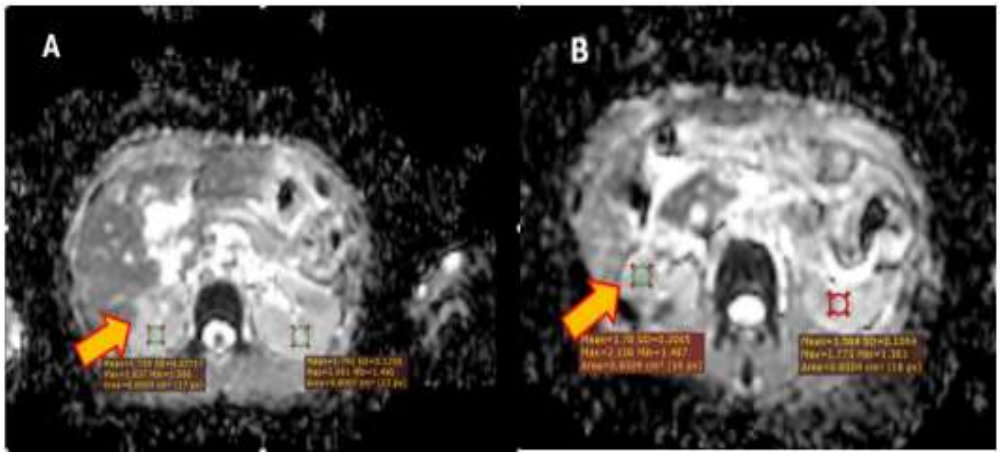



**(A, B):** ADC map (derived from DW-MRI) (A) in a patient of CKD (stage-3B showing restricted diffusion in the renal parenchyma bilaterally with Right ADC value of 1.779 and left ADC value of 2.2 mean ADC value of **1.9 mm $^2$ /s.**

ADC map in a patient with normal renal function showing no restriction of diffusion and ADC value range was **1.8542 – 2.342 mm$^2$/s.** The circles depict examples of ROI placement.

Patients Blood urea – 27 mg/dl, Sr. Creatinine – 2.0, Calculated – eGFR – 49 (Stage-3B).

**CASE 5**




**(A, B):** ADC map (derived from DW-MRI) (A) in a patient of CKD (stage-G5 showing restricted diffusion in the renal parenchyma bilaterally with Right ADC value of 1.729 and left ADC value of 1.564 mean ADC value of **1.60 mm $^2$ /s.**

ADC map in a patient with normal renal function showing no restriction of diffusion and ADC value range was **1.8542 – 2.342 mm$^2$/s.** The circles depict examples of ROI placement.

Patients Blood urea – 32 mg/dl, Sr. Creatinine – 0.9, Calculated – eGFR – 7 (Stage-G2)