Section: Radiodiagnosis

Original Research Article

RENAL ULTRASOUND SCORING SYSTEM FOR PREDICTING THE SEVERITY OF DIABETIC KIDNEY DISEASE: CORRELATION WITH ESTIMATED GLOMERULAR FILTRATION RATE

Alka Agrawal[1], Prem S Tripathi[2], Chandrajeet Yadav[3], Devanshi Joshi[4]

[1]*Professor and Head, Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India.*
[2]*Associate Professor, Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India.*
[3]*Associate Professor, Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India.*
[4]*Junior Resident, Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India.*

Received *: 13/06/2026*
Received in revised form *: 22/07/2026*
Accepted *: 05/08/2026*

Corresponding Author:
Dr. Devanshi Joshi,
Junior Resident, Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India.
Email: devanshi2410@gmail.com

DOI: 10.70034/ijmedph.2026.3.547

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 3496-3501

ABSTRACT

Background: Diabetic kidney disease (DKD) is a leading cause of chronic kidney disease (CKD) and end-stage renal disease, but conventional biochemical markers often fail to reflect early structural renal changes. High-resolution grey-scale ultrasonography can demonstrate such structural alterations non-invasively. This study developed a composite renal ultrasound (USG) score and evaluated its correlation with disease severity in diabetic kidney disease.

Materials and Methods: This hospital-based, cross-sectional study included 320 adults — 160 with diabetes mellitus and 160 non-diabetic controls. Renal length, cortical thickness, parenchymal thickness, parenchymal echogenicity, and cortical margin were assessed on grey-scale ultrasonography. A composite renal USG score (range 0–6) incorporating parenchymal echogenicity, cortical margin irregularity, cortical-to-parenchymal thickness (CT/PT) ratio, and renal length-to-patient-height (RL/PH) ratio was derived and correlated with estimated glomerular filtration rate (eGFR) and other biochemical parameters.

Results: Mean eGFR was significantly lower in diabetics than controls (48.6 ± 28.4 vs 106.4 ± 12.8 mL/min/1.73 m², $p < 0.001$), and 62.5% of diabetics had CKD stage 3 or higher. The mean composite renal USG score was significantly higher in diabetics than controls (3.6 ± 1.5 vs 1.18 ± 1.19, $p < 0.001$) and increased progressively across CKD stages, from 1.4 ± 0.6 in Stage 1 to 5.6 ± 0.5 in Stage 5 (ANOVA $p < 0.001$). The composite score correlated strongly with eGFR ($r = -0.82$, $p < 0.001$), outperforming individual parameters such as parenchymal echogenicity ($r = -0.74$) and cortical margin irregularity ($r = -0.68$). A cut-off score of ≥4 predicted advanced CKD (Stages 3–5) with an AUC of 0.91 (95% CI 0.86–0.96), sensitivity 86.5%, and specificity 79.2%.

Conclusion: The composite renal ultrasound score is a reliable, reproducible, and non-invasive tool that correlates strongly with renal function and reliably stratifies the severity of diabetic kidney disease. It may serve as a practical adjunct to biochemical monitoring, particularly in resource-limited settings.

Keywords: Diabetic kidney disease; renal ultrasonography; ultrasound renal score; cortical echogenicity; estimated glomerular filtration rate; chronic kidney disease.

INTRODUCTION

Diabetes mellitus is a heterogeneous group of metabolic disorders characterised by persistent hyperglycaemia.[1] Its global burden continues to rise, with an estimated 589 million adults affected in 2024, accounting for approximately 11.1% of the adult population, and India ranks second globally in disease burden.[2] This growing diabetic population has led to a parallel rise in diabetes-related complications, of which diabetic kidney disease (DKD) is among the most serious, contributing to significant morbidity, mortality, and healthcare cost.[3]

DKD is the leading microvascular complication of diabetes and a major cause of chronic kidney disease (CKD) and end-stage renal disease, developing in up to 40% of patients with type 2 diabetes,[3] and carrying a poorer prognosis than non-diabetic kidney disease4. Renal involvement typically progresses silently, and conventional biochemical markers such as serum creatinine, estimated glomerular filtration rate (eGFR), and urinary protein excretion may not adequately reflect early structural change,[5,6] serum creatinine, for instance, often does not rise until more than half of the nephron mass is already lost. Renal biopsy remains the diagnostic gold standard but is invasive and impractical for routine use.

Renal ultrasonography is a non-invasive, safe, and cost-effective initial imaging modality for kidney evaluation. Increased cortical echogenicity is associated with declining renal function, while reduced renal size and cortical thickness often reflect irreversible chronic damage.[7] Previous studies have shown that ultrasonographic findings differ between diabetic and non-diabetic individuals, with early-stage diabetics showing greater cortical echogenicity and larger renal dimensions,[8] and renal size correlating with microalbuminuria and disease progression.[9] These observations have prompted interest in composite ultrasound-based scoring systems that integrate multiple sonographic parameters to grade disease severity.[10,11]

This study was undertaken to evaluate renal ultrasonographic findings in patients with diabetic kidney disease compared with non-diabetic controls, to develop a composite ultrasound renal score, and to assess its ability to predict disease severity by correlating it with eGFR and other clinical and biochemical parameters.

MATERIALS AND METHODS

This hospital-based, cross-sectional observational study was conducted in the Department of Radiodiagnosis, M.G.M. Medical College and M.Y. Hospital, Indore, Madhya Pradesh, India, over one year, after approval from the institutional scientific and ethics committee. A total of 320 participants were enrolled: 160 adults with diabetes mellitus and 160 age- and sex-comparable non-diabetic controls, all of whom were referred for abdominal ultrasonography and provided written informed consent.

Exclusion criteria for cases included non-diabetic causes of nephropathy, obstructive uropathy, congenital renal anomalies, renal size asymmetry (≥2.0 cm difference between kidneys), coexisting hypertension, and age younger than 20 years.

Baseline demographic and clinical data were recorded, and laboratory parameters — eGFR (calculated using the CKD-EPI equation), serum creatinine, HbA1c, and serum albumin — were obtained from records. All renal ultrasound examinations were performed using a 3.5 MHz transducer with standard grey-scale B-mode imaging, with the patient in prone or supine position. Renal length (RL) was measured as the longest pole-to-pole distance in the sagittal plane; cortical thickness (CT) was measured from the medullary pyramid to the capsule and parenchymal thickness (PT) from the renal sinus fat to the capsule, at the upper, middle, and lower poles, and averaged. Renal length was adjusted for patient height (RL/PH ratio).

A composite renal ultrasound scoring system was then applied using four B-mode parameters: parenchymal echogenicity (0 = normal, 1 = mildly increased, 2 = markedly increased), cortical margin irregularity (0 = normal, 1 = mildly irregular, 2 = markedly irregular), CT/PT ratio (0 = above population median, 1 = below median), and RL/PH ratio (0 = above median, 1 = below median). The score was assessed for both kidneys individually, and the higher of the two kidney scores was taken as the final composite score, with a maximum achievable value of 6. The renal USG score was then correlated with CKD stage and eGFR.

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 25.0. Quantitative variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages. One-way analysis of variance (ANOVA) was used to compare mean ultrasonographic parameters across CKD stages, and Pearson's correlation coefficient assessed the relationship between ultrasonographic and biochemical parameters. Receiver operating characteristic (ROC) curve analysis was performed to determine the area under the curve (AUC), optimal cut-off, sensitivity, specificity, and diagnostic accuracy of the composite score for predicting advanced CKD (Stages 3–5). A p-value <0.05 was considered statistically significant.

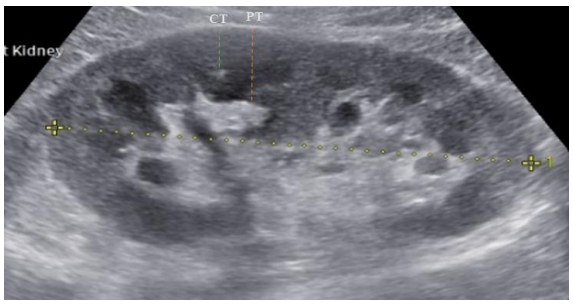


Figure 1: Longitudinal ultrasound image of the kidney demonstrating measurement of cortical thickness (CT) (green line) and parenchymal thickness (PT) (orange line) in the sagittal plane

RESULTS

A total of 320 participants were evaluated, comprising 160 diabetic patients and 160 non-diabetic controls. The two groups were comparable in age and sex distribution. Diabetic patients had a significantly higher body mass index than controls, and a higher proportion of diabetics were overweight or obese. More than half of the diabetic patients (52.5%) had a disease duration exceeding 10 years.

Table 1: Demographic and clinical characteristics of the study participants

Characteristic	Category	Diabetics (n=160)	Controls (n=160)
1	Age (years), mean ± SD	52.1 ± 11.4	51.6 ± 10.8
2	Male, n (%)	92 (57.5)	88 (55.0)
3	BMI (kg/m²), mean ± SD	26.8 ± 3.6	24.2 ± 3.1
4	Diabetes duration >10 years, n (%)	84 (52.5)	—

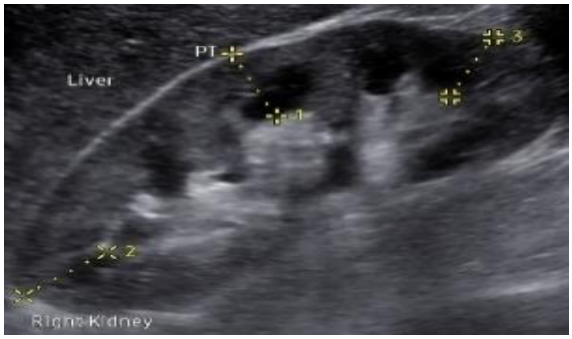
Diabetic patients had significantly lower eGFR, higher HbA1c and serum creatinine, and lower serum albumin than controls (all $p < 0.001$). (Table 2) Correspondingly, 62.5% of diabetics had CKD stage 3 or higher, and 18.7% had advanced CKD (Stages 4–5), whereas all controls had preserved renal function (eGFR ≥90 mL/min/1.73 m²).

Table 2: Biochemical and renal-function parameters — diabetics vs controls

S.No.	Parameter	Diabetics (n=160)	Controls (n=160)
1	eGFR (mL/min/1.73 m²)	48.6 ± 28.4	106.4 ± 12.8
2	HbA1c (%)	8.2 ± 1.8	5.4 ± 0.4
3	Serum creatinine (mg/dL)	2.4 ± 1.6	0.9 ± 0.2
4	Serum albumin (g/dL)	3.8 ± 0.6	4.2 ± 0.3

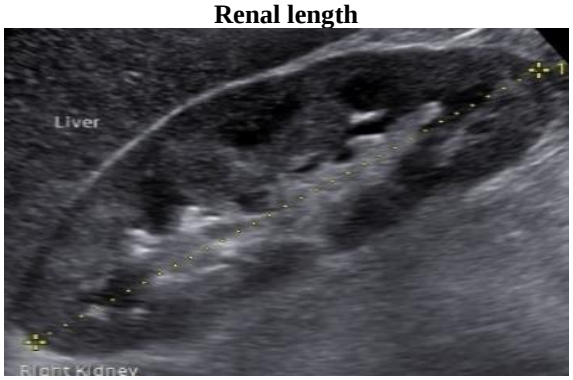
All comparisons $p < 0.001$ (independent t-test).

On grey-scale ultrasonography, markedly increased parenchymal echogenicity was seen in 22.5% of diabetics versus none of the controls, and markedly irregular cortical margins in 23.7% of diabetics versus none of the controls (both $p < 0.001$). The CT/PT and RL/PH ratios did not differ significantly between groups ($p = 0.39$ and $p = 0.362$, respectively), although a preserved CT/PT ratio was associated with significantly higher eGFR among diabetics (54.8 ± 24.6 vs 41.2 ± 20.8 mL/min/1.73 m², $p = 0.028$).



Cortical thickness

Renal length



Parenchymal thickness

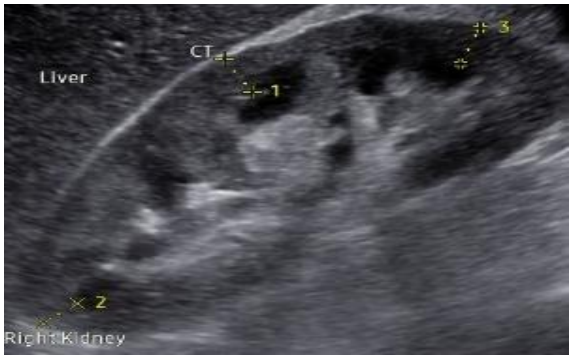


Figure 2: Right-kidney ultrasound images from the illustrative case: renal length, parenchymal thickness, and cortical thickness

The composite renal USG score was significantly higher in diabetics (3.6 ± 1.5) than controls (1.18 ± 1.19, p < 0.001). Most controls (67.5%) had scores of 0–1, while more than half of diabetics (55.0%) had scores ≥4; scores of 5 and 6 were observed only in diabetics. The mean score rose progressively across CKD stages and with increasing diabetes duration and worsening biochemical derangement. [Table 3]

Table 3: Mean composite renal USG score by CKD stage, diabetes duration, and biochemical category — diabetics (n = 160)

Category	Subgroup	n	Mean USG score ± SD
CKD stage (KDIGO)	Stage 1 (eGFR ≥90)	22	1.4 ± 0.6
	Stage 2 (60–89)	38	2.2 ± 0.8
	Stage 3a (45–59)	36	3.1 ± 0.7
	Stage 3b (30–44)	34	4.0 ± 0.9
	Stage 4 (15–29)	22	4.9 ± 0.8
	Stage 5 (<15)	8	5.6 ± 0.5
Diabetes duration	<5 years	28	1.8 ± 0.7
	>20 years	14	5.4 ± 0.6
HbA1c category	Well-controlled (<7%)	42	2.6 ± 1.1
	Poorly controlled (>9%)	40	4.6 ± 1.0
Serum albumin	Normal (≥3.5 g/dL)	112	3.1 ± 1.3
	Hypoalbuminemia (<3.5 g/dL)	48	4.8 ± 1.0

ANOVA/independent t-test p < 0.001 for all subgroup comparisons.

On correlation analysis, the composite renal USG score showed the strongest correlation with eGFR (r = −0.82, p < 0.001) among all parameters tested, outperforming individual components — parenchymal echogenicity (r = −0.74), cortical margin irregularity (r = −0.68), CT/PT ratio (r = +0.22), and RL/PH ratio (r = +0.18, not significant). The composite score also correlated strongly with serum creatinine (r = +0.78) and moderately with HbA1c (r = +0.54) and serum albumin (r = −0.42), all p < 0.001. [Table 4]

Table 4: Correlation of ultrasonographic and biochemical parameters with eGFR / composite USG score — diabetics (n = 160)

Parameter	Pearson's r	p-value
Parenchymal echogenicity score (vs eGFR)	−0.74	<0.001
Cortical margin irregularity score (vs eGFR)	−0.68	<0.001
CT/PT ratio (vs eGFR)	+0.22	0.028
RL/PH ratio (vs eGFR)	+0.18	0.062 (NS)
Composite renal USG score (vs eGFR)	−0.82	<0.001
Composite renal USG score (vs serum creatinine)	+0.78	<0.001
Composite renal USG score (vs HbA1c)	+0.54	<0.001
Composite renal USG score (vs serum albumin)	−0.42	<0.001

ROC curve analysis identified a composite renal USG score of ≥4 as the optimal cut-off for predicting advanced CKD (Stages 3–5), with an AUC of 0.91 (95% CI 0.86–0.96), sensitivity 86.5%, specificity 79.2%, positive predictive value 82.1%, negative predictive value 84.3%, and overall diagnostic accuracy of 83.1%. [Table 5]

Table 5: ROC analysis — diagnostic performance of composite renal USG score ≥4 for advanced CKD (Stages 3–5)

Diagnostic performance parameter	Value
Area under the curve (AUC)	0.91
95% Confidence interval	0.86–0.96
Optimal cut-off score	≥4
Sensitivity	86.5%
Specificity	79.2%
Positive predictive value	82.1%
Negative predictive value	84.3%
Diagnostic accuracy	83.1%

DISCUSSION

Diabetic kidney disease is now the most common cause of chronic kidney disease worldwide and accounts for approximately 40% of end-stage renal disease,[3] yet it typically progresses silently, with damage often well established before biochemical abnormalities become apparent.[3] Current screening relies chiefly on the urinary albumin-to-creatinine ratio and eGFR, which reflect function rather than underlying structural damage.[6,12] This study evaluated a composite ultrasound renal score — incorporating parenchymal echogenicity, cortical margin irregularity, and two size-based ratios — as

a non-invasive structural correlate of disease severity in 160 diabetics and 160 controls.

The diabetic and control groups were well matched for age and sex, consistent with reports that diabetic renal complications typically manifest in the fifth and sixth decades of life.[3,13] Diabetics had a markedly higher prevalence of overweight and obesity, reflecting the established link between adiposity and both type 2 diabetes and progression of diabetic kidney disease,[2,3] likely mediated by increased renal workload and metabolic and inflammatory stress.

In early disease (Stages 1–2), cortical and parenchymal thickness were greater than in controls, consistent with reports of early compensatory renal hypertrophy in diabetes,[8,9] whereas advanced disease (Stages 4–5) showed reduced cortical thickness, parenchymal thickness, and renal length, reflecting irreversible fibrosis and nephron loss.[7,13] Parenchymal echogenicity showed the strongest individual correlation with eGFR ($r = -0.74$), consistent with prior work linking increased echogenicity to advanced, often irreversible renal disease and underlying fibrosis or glomerulosclerosis,[23,25,27] while cortical margin irregularity — reflecting scarring — showed the second-strongest correlation ($r = -0.68$).[13,23] By contrast, the CT/PT and RL/PH ratios showed weak or non-significant correlations individually, in keeping with earlier observations that single size-based ratios have limited standalone predictive value,[11,18,24] although they contributed to the composite score by identifying patients with reduced renal mass.

The composite renal USG score outperformed all individual parameters, showing the strongest overall correlation with eGFR ($r = -0.82$) and rising progressively with CKD stage, diabetes duration, and worsening glycaemic and biochemical control. This is consistent with the reference ultrasound renal scoring model of Ham et al,[11] who similarly found that a composite score outperformed individual sonographic parameters and independently predicted disease progression. Even patients with less than five years of diabetes had mildly elevated scores, suggesting that structural change may be detectable before major functional decline — supporting a possible screening role for the score.[7,11]

A cut-off score of ≥4 predicted advanced CKD with good accuracy (AUC 0.91, sensitivity 86.5%, specificity 79.2%). While more advanced imaging modalities may offer higher precision, they are costlier and less accessible,[7] the composite USG score offers a practical balance of accuracy and feasibility, particularly relevant to resource-limited settings.[6,11]

This study's strengths include a large, well-matched sample spanning the full spectrum of CKD stages and bilateral renal assessment to reduce measurement bias. Limitations include its cross-sectional design, which precludes assessment of disease progression over time; the absence of histological correlation, since renal biopsy was not performed; possible observer variability in the visual grading of echogenicity; and its single-centre setting, which may limit generalisability. Larger, multicentric, longitudinal studies are needed to validate the score's prognostic value.

CONCLUSION

Renal ultrasonography is a valuable, non-invasive, and widely accessible tool for assessing diabetic kidney disease, providing structural information that complements — and in some respects precedes — changes detectable by biochemical markers. The composite renal ultrasound score developed in this study, incorporating parenchymal echogenicity, cortical margin irregularity, and size-based ratios, correlated strongly with eGFR and reliably stratified disease severity across all CKD stages, outperforming any individual sonographic parameter. A cut-off score of ≥4 identified patients with advanced CKD with good sensitivity and specificity. This scoring system may serve as a practical, reproducible adjunct to biochemical monitoring for the early detection and severity assessment of diabetic kidney disease, particularly in resource-limited settings; larger multicentre longitudinal studies are recommended to further validate its prognostic utility.

REFERENCES

1. American Diabetes Association Professional Practice Committee. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes—2024. Diabetes Care. 2024;47(Suppl 1):S20–42.
2. International Diabetes Federation. IDF Diabetes Atlas. 11th ed. Brussels: International Diabetes Federation; 2023.
3. Alicic RZ, Rooney MT, Tuttle KR. Diabetic Kidney Disease: Challenges, Progress, and Possibilities. Clin J Am Soc Nephrol. 2017;12(12):2032–45.
4. Tuttle KR, Bakris GL, Bilous RW, et al. Diabetic kidney disease: a report from an ADA Consensus Conference. Diabetes Care. 2014;37(10):2864–83.
5. Kramer HJ, Nguyen QD, Curhan G, Hsu CY. Renal insufficiency in the absence of albuminuria and retinopathy among adults with type 2 diabetes mellitus. JAMA. 2003;289(24):3273–7.
6. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Int Suppl. 2013;3(1):1–150.
7. O'Neill WC. Sonographic evaluation of renal failure. Am J Kidney Dis. 2000;35(6):1021–38.
8. Derchi LE, Martinoli C, Saffioti S, et al. Ultrasonographic imaging and Doppler analysis of renal changes in non-insulin-dependent diabetes mellitus. Acad Radiol. 1994;1(2):100–5.
9. Zerbini G, Bonfanti R, Meschi F, et al. Persistent renal hypertrophy and faster decline of glomerular filtration rate precede the development of microalbuminuria in type 1 diabetes. Diabetes. 2006;55(9):2620–5.
10. Yaprak M, Akan G, Cinar C, Karaagaoglu E, Aslan L. Ultrasonographic CKD score for chronic kidney disease: correlation with estimated glomerular filtration rate. Ren Fail. 2013;35(1):45–52.
11. Ham YR, Kim JH, Na KR, et al. Ultrasound Renal Score for Predicting Prognosis of Diabetic Kidney Disease. J Diabetes Res. 2023;2023:3259261.

12. de Boer IH, Caramori ML, Chan JCN, et al. Executive summary of the 2020 KDIGO Diabetes Management in CKD Guideline: evidence-based advances in monitoring and treatment. Kidney Int. 2020;98(4):839–48.
13. Thomas MC, Brownlee M, Susztak K, et al. Diabetic kidney disease. Nat Rev Dis Primers. 2015;1:15018.
14. Yamashita SR, von Atzingen AC, Iared W, et al. Value of renal cortical thickness as a predictor of renal function impairment in early renal disease patients. Radiol Bras. 2015;48(1):12–6.
15. Lucisano G, Comi N, Pelagi E, et al. Can renal sonography be a reliable diagnostic tool in the assessment of chronic kidney disease? J Ultrasound Med. 2015;34(2):299–306.
16. Fiorini F, Barozzi L. The role of ultrasonography in the study of medical nephropathy. J Ultrasound. 2007;10(4):161–7.
17. Beland MD, Walle NL, Machan JT, Cronan JJ. Renal cortical thickness measured at US: is it better than renal length as an indicator of renal function in chronic kidney disease? Radiology. 2010;256(3):865–73.
18. Liboróio AB, Andrade L, Pereira GH, Esmeraldo RM, Nunes DH. Quantitative renal echogenicity for identifying advanced chronic kidney disease in patients with glomerulopathy. Clin Kidney J. 2011;4(6):454–8.
19. Gopalakrishnan N, Duraisamy P, Thirumalvalavan K, Durai M, Srinivasaprasad N. Ultrasonographic renal findings and their correlation with histopathological changes in diabetic nephropathy. Indian J Nephrol. 2015;25(4):216–20.
20. John GT, Korula RJ, Vijayalekshmi GS, Balakrishnan N, Neelakantan N, Jacob CK. Renal outcome in type 2 diabetic patients with overt nephropathy in South India. Indian J Nephrol. 2001;11(1):18–22.