

Association between Ultrasound-Measured Renal Cortical Thickness and Estimated Glomerular Filtration Rate in Adults with Chronic Kidney Disease

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ABSTRACT

Background:

Chronic kidney disease (CKD) is associated with progressive structural and functional deterioration of the kidneys. Renal cortical thickness measured by ultrasonography may provide a simple, non-invasive structural indicator of renal impairment. This study evaluated the association between ultrasound-measured renal cortical thickness and estimated glomerular filtration rate (eGFR) in adults with CKD.

Methods:

This retrospective analytical cross-sectional study included 100 adults with documented CKD who underwent renal ultrasonography at the Department of Radio-Diagnosis, Sri Venkateswara Medical College Hospital and Research Institute, Chennai, India, between May 2025 and April 2026. Renal cortical thickness and renal length were assessed by ultrasonography, while eGFR was used as the principal measure of renal function. Correlations between ultrasound parameters and eGFR were evaluated using Pearson's correlation, and multiple linear regression was performed to assess the independent association of cortical thickness with eGFR.

Results:

The study included 51 (51.0%) men and 49 (49.0%) women, with a mean age of 57.3 ± 10.8 years. Diabetes mellitus was present in 51 (51.0%) participants and hypertension in 66 (66.0%). Mean bilateral renal cortical thickness was 4.57 ± 1.15 mm, and mean eGFR was 36.5 ± 20.4 mL/min/1.73 m². Cortical thickness showed a strong positive correlation with eGFR ($r = 0.805$, $p < 0.001$). Renal length also demonstrated a significant positive correlation with eGFR ($r = 0.796$, $p < 0.001$). Cortical thickness decreased progressively across CKD stages ($p < 0.001$). In multivariable regression, cortical thickness remained independently associated with eGFR, and the overall model explained 78.9% of the variance in eGFR (adjusted $R^2 = 0.775$).

Conclusion:

Ultrasound-measured renal cortical thickness showed a strong association with eGFR and decreased progressively with advancing CKD. It may serve as a useful, non-invasive complementary marker of renal functional impairment when interpreted alongside established clinical and biochemical measures.

Keywords: Chronic kidney disease; renal cortical thickness; ultrasonography; estimated glomerular filtration rate; renal function; renal morphology.

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1. INTRODUCTION:

Chronic kidney disease (CKD) is a major global health problem associated with substantial morbidity, premature mortality, cardiovascular risk and progressive loss of kidney function. The Kidney Disease: Improving Global Outcomes (KDIGO) guideline defines CKD as abnormalities of kidney structure or function that are present for at least 3 months and classifies the disease according to cause, glomerular filtration rate (GFR) category and albuminuria category. This framework emphasizes that CKD isn't solely a disorder of reduced filtration; persistent structural abnormalities may also provide important evidence of chronic kidney injury and disease progression [1]. In India, CKD represents an increasingly important public-health burden, with recent community-based evidence indicating a considerable prevalence and substantial regional variation [2].

Estimated glomerular filtration rate (eGFR) is the principal routinely used measure for assessing kidney function and staging CKD. Although eGFR is clinically indispensable, it is an indirect estimate derived from serum biomarkers and demographic variables and may be affected by factors that are not directly related to filtration. Consequently, functional assessment alone may not fully describe the structural consequences of chronic renal injury. Current approaches increasingly favour race-free GFR estimation equations, while recognizing the complementary value of structural assessment when evaluating patients with CKD [1,3].

Renal ultrasonography provides a practical means of evaluating renal morphology without ionizing radiation and is widely available in routine clinical practice. It can demonstrate renal size, symmetry, cortical and parenchymal thickness, echogenicity, corticomedullary differentiation and urinary tract obstruction. Most importantly, reduced renal size and reduced cortical thickness can support the presence of chronic structural kidney damage, particularly when interpreted alongside clinical and biochemical findings [1,4]. Thus, ultrasound may provide morphological information that complements the functional information obtained from eGFR.

Renal cortical thickness has attracted particular interest because the renal cortex contains the glomeruli and a substantial proportion of the functional nephron mass. With chronic kidney injury, progressive nephron loss, tubular atrophy and interstitial fibrosis may result in cortical thinning. From a radiological perspective, this provides a plausible anatomical basis for examining whether cortical thickness reflects the degree of

functional impairment. Beland *et al.* demonstrated a significant relationship between sonographically measured renal cortical thickness and eGFR in patients with non-dialysis CKD and reported that cortical thickness showed a closer relationship with renal function than renal length [5]. Similarly, Yamashita *et al.* found a moderate positive correlation between renal cortical thickness and GFR and reported good interobserver reproducibility of cortical-thickness measurements [6].

Subsequent studies have further supported the potential clinical value of renal cortical thickness. Korkmaz *et al.* reported a strong positive association between cortical thickness and eGFR in patients with CKD, with cortical thickness decreasing as renal function deteriorated over follow-up [7]. In an Indian hospital-based case-control study, Gupta *et al.* identified reduced cortical thickness as an independent ultrasonographic predictor of CKD, together with other sonographic parameters such as renal length and cortical echogenicity [8]. These findings suggest that cortical thickness may serve as a useful structural marker of chronic renal impairment, particularly when evaluated systematically and in conjunction with biochemical measures of kidney function.

Despite these observations, the relationship between renal cortical thickness and eGFR is not necessarily uniform across all populations. Differences in patient selection, CKD stage, underlying etiology, ultrasound technique, measurement site, operator experience and the equation used to estimate GFR can influence the observed association. Moreover, there remains a need for additional data from Indian tertiary-care settings, where the spectrum of CKD causes and disease severity may differ from that reported in other populations. Establishing the strength and clinical relevance of the association in a defined local population may help clarify whether a simple ultrasound measurement can provide useful information about functional renal impairment.

The present study was therefore undertaken to evaluate the association between ultrasound-measured renal cortical thickness and eGFR in adults with CKD at the "Department of Radio-Diagnosis, Sri Venkateswara Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India". The study was designed as a single-centre retrospective analytical cross-sectional study covering the period from "1 May 2025 to 30 April 2026". By examining the relationship between a readily obtainable sonographic structural parameter and an established functional indicator of renal

status, this study aims to assess the potential value of renal cortical thickness as a complementary imaging marker of renal functional impairment in adults with CKD.

2. MATERIALS AND METHODS:

2.1 Study Design and Study Setting

This Study was a single-centre retrospective analytical cross-sectional study conducted in the “Department of Radio-Diagnosis, Sri Venkateswara Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India”. The study period extended from “1 May 2025 to 30 April 2026”, corresponding to a total study duration of 12 months. The study was undertaken to evaluate the association between ultrasound-measured renal cortical thickness and estimated glomerular filtration rate (eGFR) in adult patients with chronic kidney disease (CKD). Renal cortical thickness was considered the principal structural imaging parameter, while eGFR was used as the principal indicator of renal functional status.

2.2 Sample Size

A total sample size of 100 adult patients with documented CKD was included in this study. The sample consisted of eligible patients meeting the predefined inclusion and exclusion criteria during the study period. As this was a retrospective single-centre study, the final sample represented the available eligible records during the defined 12-month study period. The sample size was fixed at 100 participants for the present analysis.

2.3 Study Population

The study population consisted of 100 adult patients with documented CKD who underwent renal ultrasonography during the study period and for whom the required clinical, biochemical, and imaging information was available. Eligible patients were identified retrospectively from the institutional radiology information system and hospital medical records. Relevant demographic, laboratory, clinical, and ultrasonographic information was extracted using a standardized data-collection format.

2.4 Inclusion Criteria

Patients were included if they were aged ≥ 18 years, had a documented diagnosis of CKD, underwent renal ultrasonography during the study period, had adequate visualization of at least one kidney for measurement of cortical thickness, and had serum creatinine and an eGFR value or sufficient laboratory information to determine eGFR. Adequate demographic, clinical, laboratory, and radiological records were also required for inclusion.

2.5 Exclusion Criteria

Patients were excluded when the ultrasound examination was technically inadequate for reliable assessment of renal cortical thickness or when essential laboratory or clinical information required for analysis was unavailable. Patients with

substantial structural abnormalities that prevented reliable identification of the renal cortex or substantially distorted normal renal architecture were also excluded from the cortical-thickness analysis. These included extensive hydronephrosis, large renal masses, severe congenital renal abnormalities, extensive replacement of renal parenchyma by cystic lesions, or other conditions making cortical measurement unreliable. Measurements were avoided across focal areas of obvious structural distortion or pathology.

2.6 Data Collection

Data were retrospectively extracted from institutional medical records and the radiology database. The variables collected included age, sex, CKD diagnosis, serum creatinine, eGFR, renal length, renal cortical thickness, kidney laterality, cortical echogenicity, corticomedullary differentiation, renal symmetry, hydronephrosis, renal cystic changes, renal calculi, and other relevant structural abnormalities. Where available, clinically relevant comorbidities, including hypertension and diabetes mellitus, were also recorded. Each participant was assigned a study identification number, and personally identifying information was excluded from the analytical dataset.

2.7 Renal Ultrasonography

Renal ultrasonography was performed as part of routine clinical evaluation using a diagnostic ultrasound system equipped with an appropriate abdominal curvilinear transducer. Patients were examined in supine, prone, or lateral decubitus positions according to the acoustic window required for optimal visualization. Both kidneys were evaluated whenever technically feasible. The kidneys were examined in longitudinal and transverse planes. Renal length, renal width/anterior-posterior dimension, cortical thickness, cortical echogenicity, corticomedullary differentiation, renal symmetry, and associated structural abnormalities were assessed. Renal length was measured along the maximal longitudinal axis from pole to pole, excluding surrounding perirenal tissues.

2.8 Measurement of Renal Cortical Thickness

Renal cortical thickness was the principal ultrasound variable of interest. Cortical thickness was measured on a longitudinal ultrasound image using electronic calipers. The measurement represented the distance between the outer renal capsule and the corticomedullary interface, measured approximately perpendicular to the renal capsule. Measurements were obtained from clearly visualized cortex and avoided areas affected by focal lesions, prominent vessels, cystic abnormalities, or substantial architectural distortion. Right and left cortical thickness measurements were recorded separately whenever both kidneys could be adequately assessed.

Measurements were recorded in centimetres and converted to millimetres where required for statistical analysis. When valid measurements from both kidneys were available, the mean bilateral cortical thickness was calculated for the participant-level primary analysis; when only one kidney could be reliably measured, the available valid measurement was retained and laterality was documented.

2.9 Assessment of Renal Morphology

Renal morphology was assessed in addition to cortical thickness. Cortical echogenicity was compared qualitatively with the adjacent liver or spleen where technically appropriate. Corticomedullary differentiation was assessed according to its sonographic appearance. Renal asymmetry and structural abnormalities, including cysts, calculi and hydronephrosis, were documented. These results were treated as secondary imaging characteristics and were not used alone to establish the diagnosis of CKD.

2.10 Assessment of Renal Function

Renal function was assessed using eGFR, expressed in mL/min/1.73 m². The serum creatinine value corresponding to the study assessment was used for eGFR estimation according to the equation documented in the patient's clinical record or study database. eGFR was treated primarily as a continuous variable for the primary analysis. Participants could additionally be categorized according to KDIGO GFR categories: G1 ≥ 90 , G2 60–89, G3a 45–59, G3b 30–44, G4 15–29, and G5 <15 mL/min/1.73 m².

2.11 Study Outcomes

The primary outcome was the association between renal cortical thickness and eGFR. Secondary outcomes included the association between renal length and eGFR, differences in cortical thickness across CKD GFR categories, relationships between cortical thickness and age or serum creatinine, and the independent association between cortical thickness and eGFR after adjustment for relevant demographic and clinical variables.

2.12 Statistical Analysis

All statistical analyses were planned for the 100 included participants. Continuous variables were assessed for distribution using histograms, Q-Q plots, and the Shapiro-Wilk test. Normally distributed continuous variables were summarized as mean $\pm$ standard deviation (SD), whereas non-normally distributed variables were summarized as median with interquartile range (IQR). Categorical variables were summarized as frequencies and percentages.

The primary analysis evaluated the relationship between renal cortical thickness and eGFR. Pearson's correlation coefficient (r) was used when both variables were approximately normally distributed and the assumptions of linear correlation were satisfied. Spearman's rank correlation coefficient (ρ) was used when variables were non-normally distributed or when the assumptions for Pearson correlation were not met. Correlation coefficients were reported with 95% confidence intervals and two-sided p-values.

Differences in renal cortical thickness across more than two CKD GFR categories were assessed using one-way analysis of variance (ANOVA) for normally distributed data. When the overall ANOVA was significant, an appropriate post-hoc multiple-comparison procedure was applied. For non-normally distributed data, the Kruskal-Wallis test was used, followed by adjusted post-hoc pairwise comparisons where appropriate. For comparisons between two independent groups, the independent-samples t-test was used for normally distributed continuous data and the Mann-Whitney U test for non-normally distributed data.

Multiple linear regression analysis was used as the principal adjusted analysis to evaluate whether renal cortical thickness was independently associated with eGFR. eGFR was entered as the dependent variable, with renal cortical thickness as the principal independent variable. Potential covariates included age, sex, diabetes mellitus, hypertension, and renal length where these variables were available and clinically appropriate. Serum creatinine was not included as a routine covariate in the primary regression model because eGFR is derived from serum creatinine and adjustment for a component of the outcome calculation could introduce mathematical dependency and misleading inference. Regression coefficients (β), standard errors, 95% confidence intervals, p-values, and model R² were reported. Model assumptions, including linearity, independence, homoscedasticity, normality of residuals, and multicollinearity, were evaluated before interpretation.

Right and left renal cortical thickness measurements were initially evaluated separately. Correlations of right-sided and left-sided cortical thickness with eGFR were assessed using Pearson or Spearman correlation according to distribution. When bilateral measurements were available, the mean bilateral cortical thickness was used for the principal participant-level analysis, consistent with the predefined measurement approach.

2.13 Missing Data

The completeness of demographic, laboratory, and ultrasound variables was assessed before analysis. Participants without a valid primary cortical-thickness measurement or usable eGFR were excluded from the primary correlation

analysis. For secondary analyses, available-case analysis was used when individual variables were missing. No numerical values were imputed for missing cortical-thickness or eGFR measurements unless a separate prespecified imputation protocol was established.

2.14 Statistical Significance

All statistical tests were two-tailed, and a p-value <0.05 was considered statistically significant. Where applicable, effect estimates were presented with 95% confidence intervals. Interpretation emphasized the magnitude and precision of associations in addition to statistical significance.

2.15 Statistical Software

Statistical analysis was performed using SPSS 2021.

2.16 Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki and applicable institutional requirements for retrospective clinical research. Ethical approval was obtained from the Institutional Ethics Committee of “Sri Venkateswara Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India”, prior to analysis of the study records.

RESULTS:

The present study was conducted in 100 adults with CKD Patient. There were 51 men (51.0%) and 49 women (49.0%). Mean age was 57.3 ± 10.8 years. Diabetes mellitus was present in 51 (51.0%) and hypertension in 66 (66.0%).

1. Demographic and clinical characteristics:

Table 1. Demographic and clinical characteristics

Variable	Value	Range
Age, years	57.3 ± 10.8	33–84
Male sex	51 (51.0%)	—
Female sex	49 (49.0%)	—
Diabetes mellitus	51 (51.0%)	—
Hypertension	66 (66.0%)	—
Serum creatinine, mg/dL	0.84 ± 0.29	0.70–2.09
eGFR, mL/min/1.73 m ²	36.5 ± 20.4	5.7–89.0

2. CKD-stage distribution and ultrasound parameters:

In present study it shown that, mean bilateral cortical thickness was 4.57 ± 1.15 mm and mean renal length was 8.92 ± 0.60 cm. Mean eGFR was 36.5 ± 20.4 mL/min/1.73 m².

Table 2. CKD-stage distribution and ultrasound parameters

Stage	n	%	eGFR	Cortical thickness (mm)	Renal length (cm)
G2	15	15%	72.6 ± 9.5	6.43 ± 0.78	9.79 ± 0.49
G3a	20	20%	47.4 ± 6.1	5.02 ± 0.55	9.12 ± 0.36
G3b	25	25%	36.8 ± 3.8	4.48 ± 0.85	9.02 ± 0.34
G4	25	25%	$21.9 \pm$	3.75 ± 0.66	$8.51 \pm$

			5.4		0.36
G5	15	15%	9.8 ± 2.3	3.65 ± 0.55	8.30 ± 0.39

3. Correlation of ultrasound parameters with eGFR

In this study, Pearson correlation demonstrated a positive association between mean cortical thickness and eGFR ($r=0.805$, $p<0.001$). Mean renal length was also positively correlated with eGFR ($r=0.796$, $p<0.001$). Simple regression yielded $R^2=0.648$.

Table 3. Correlation of ultrasound parameters with eGFR

Parameter	Unit	Pearson r	p value
Mean cortical thickness	mm	0.805	<0.001
Mean renal length	cm	0.796	<0.001

4. Comparison across CKD stages:

In the present study, mean eGFR differed across CKD stages ($F=291.39$, $p<0.001$). Cortical thickness also differed among stages ($F=43.91$, $p=0.0000$).

Table 4. Comparison across CKD stages

Outcome	F statistic	p value
eGFR	291.39	<0.001
Cortical thickness	43.91	0.0000

5. Multiple linear regression for eGFR:

The present study, multivariable model explained 78.9% of the variance in eGFR (adjusted $R^2=0.775$).

Table 5. Multiple linear regression for eGFR

Predictor	β	SE	t	p	95% CI
Intercept	- 138.489	16.700	- 8.29	8.268 e-13	- 171.652 to - 105.325
Cortical thickness (mm)	9.091	1.109	8.20	1.314 e-12	6.888 to 11.293
Age (years)	- 0.155	0.092	- 1.69	0.095 08	- 0.338 to 0.028
Male sex	- 1.211	1.960	- 0.62	0.537 9	- 5.103 to 2.680
Diabetes	2.124	1.966	1.08	0.282 8	- 1.780 to 6.027
Hypertension	- 0.359	2.070	- 0.17	0.862 9	- 4.469 to

					3.752
Mean renal length (cm)	15.930	2.111	7.55	2.981e-11	11.738 to 20.123

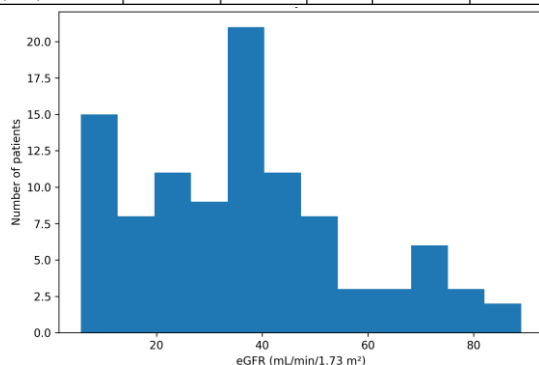


Figure 1. Distribution of eGFR in the present study

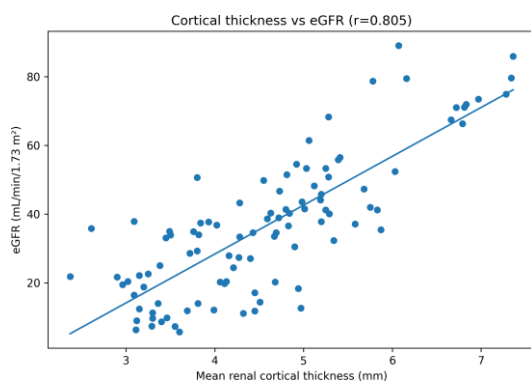


Figure 2. Mean cortical thickness versus eGFR (Pearson $r=0.805$).

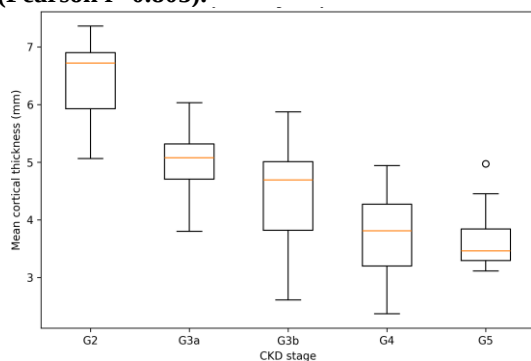


Figure 3. Mean cortical thickness according to CKD stage.

Representative renal ultrasonography:



Figure 4. Representative anonymized right renal ultrasound image.



Figure 5. Representative anonymized left renal ultrasound image.

The present study demonstrated a strong positive association between ultrasound-measured renal cortical thickness and estimated glomerular filtration rate (eGFR) in adults with chronic kidney disease (CKD). Mean cortical thickness was 4.57 ± 1.15 mm, while mean eGFR was 36.5 ± 20.4 mL/min/1.73 m². Importantly, mean cortical thickness showed a strong positive correlation with eGFR ($r = 0.805$, $p < 0.001$), indicating that patients with greater preservation of renal cortical thickness tended to have better renal functional status. This finding supports the concept that renal cortical thickness can provide structural information that complements biochemical assessment of kidney function.

The observed relationship is biologically plausible because the renal cortex contains the majority of glomeruli and an important proportion of the functional nephron mass. Progressive CKD is associated with nephron loss, tubular atrophy and interstitial fibrosis, processes that can result in reduction of cortical thickness. Therefore, a decrease in cortical thickness may reflect cumulative structural damage accompanying declining renal function. The strong correlation observed in the present study suggests that this anatomical change may parallel functional deterioration across different stages of CKD.

The findings are consistent with previous investigations evaluating renal cortical thickness by ultrasonography. Beland et al. reported a significant relationship between cortical thickness and eGFR and suggested that cortical thickness may be more

closely associated with renal function than renal length in patients with non-dialysis CKD [5]. Similarly, Yamashita et al. demonstrated a moderate correlation between cortical thickness and renal function and found good reproducibility of cortical-thickness measurements between observers [6]. Korkmaz et al. subsequently reported a strong association between mean cortical thickness and eGFR, with cortical thickness showing a greater relationship with renal function than renal length during follow-up [7]. These observations are broadly comparable with the present findings, although the strength of association in the current study ($r = 0.805$) was relatively high.

The present results are also supported by longitudinal evidence. Imai et al. reported that cortical thickness was associated with subsequent decline in renal function in patients with CKD and suggested that cortical thickness may have prognostic value for clinically important renal deterioration [9]. Although the present study was cross-sectional and therefore cannot establish whether reduced cortical thickness predicts future loss of renal function, the consistency between these findings and the current strong cross-sectional association strengthens the potential clinical relevance of cortical thickness as a structural marker.

An important observation in the current study was the progressive reduction in mean cortical thickness across CKD stages. Mean cortical thickness declined from 6.43 ± 0.78 mm in G2 to 5.02 ± 0.55 mm in G3a, 4.48 ± 0.85 mm in G3b, 3.75 ± 0.66 mm in G4 and 3.65 ± 0.55 mm in G5. The difference in cortical thickness across CKD stages was statistically significant ($F = 43.91$, $p < 0.001$). This stage-wise pattern provides further support for the association between renal morphology and functional impairment. The progressive reduction was particularly evident between the earlier and more advanced CKD categories, suggesting that cortical thinning becomes more pronounced as renal dysfunction advances.

The stage-wise findings are in agreement with the observations of Korkmaz et al., who reported declining cortical thickness in association with worsening renal function during follow-up [7]. The present results also correspond with findings from an Indian study demonstrating positive correlations between eGFR and several sonographic renal parameters, including mean cortical thickness [10]. The similarity of these findings in an Indian population is particularly relevant because renal morphology may vary according to age, body habitus, disease etiology and characteristics of the study population. The present study therefore adds further evidence from an Indian tertiary-care setting.

Renal length also showed a strong positive correlation with eGFR in the present study ($r = 0.796$, $p < 0.001$). This finding is expected because progressive CKD may be accompanied by loss of renal mass and reduction in kidney size. However, the correlation between cortical thickness and eGFR was slightly stronger than that observed for renal length. This difference, although relatively small, is clinically meaningful because cortical thickness may provide a more direct representation of the renal parenchymal component affected by chronic nephron loss. Previous studies have similarly suggested that cortical thickness may be closely associated with renal function [5,6].

The multivariable analysis further strengthens the findings. After adjustment for age, sex, diabetes mellitus, hypertension and mean renal length, cortical thickness remained independently associated with eGFR. The regression coefficient for cortical thickness was $9.091 \text{ mL/min/1.73 m}^2$ per millimetre increase in cortical thickness, with a 95% confidence interval of $6.888\text{--}11.293$ and $p < 0.001$. Mean renal length was also independently associated with eGFR, whereas age, sex, diabetes and hypertension were not statistically significant predictors within this model. Overall, the model explained 78.9% of the variance in eGFR, with an adjusted R^2 of 0.775. These findings indicate that renal morphological parameters, particularly cortical thickness and renal length, account for a substantial proportion of the variation in renal functional status in this cohort.

The persistence of the association after adjustment for demographic and clinical factors is noteworthy. It suggests that the relationship between cortical thickness and eGFR was not simply attributable to differences in age, sex, diabetes or hypertension. Nevertheless, the cross-sectional nature of the analysis means that the findings should be interpreted as an association rather than evidence of causality. In addition, renal length and cortical thickness are anatomically related variables, and their simultaneous inclusion in regression analysis may introduce some degree of collinearity. Therefore, the regression findings should be interpreted together with the correlation and stage-wise analyses rather than considered in isolation.

The clinical usefulness of renal cortical thickness lies partly in the accessibility of ultrasonography. Unlike imaging modalities involving ionizing radiation, conventional renal ultrasonography is non-invasive and widely available in routine clinical practice. It can be performed repeatedly and can simultaneously provide information regarding renal size, cortical echogenicity, corticomedullary differentiation, obstruction, cystic changes and other structural abnormalities. In patients with CKD, combining these morphological findings with biochemical measures such as eGFR

may therefore provide a more comprehensive assessment of renal status.

At the same time, cortical thickness should not be considered a replacement for eGFR. Current CKD classification is based primarily on GFR and albuminuria in addition to the underlying cause and evidence of kidney damage [1,4]. Cortical thickness is better regarded as a complementary structural parameter. Its interpretation may also be influenced by technical factors, including ultrasound equipment, imaging plane, measurement site, patient body habitus, renal anatomy and operator experience. Yamashita et al. demonstrated that cortical-thickness measurements can be reproducible when standardized ultrasound methods are used [6], emphasizing the importance of consistent measurement protocols.

The present study has several strengths. First, it included patients across multiple CKD GFR categories, allowing the relationship between cortical thickness and functional impairment to be examined across a broad spectrum of renal dysfunction. Second, cortical thickness was measured using a defined ultrasound technique, and bilateral measurements were averaged when both kidneys could be reliably assessed. Third, the analysis considered both simple correlations and multivariable regression, allowing the independent contribution of cortical thickness to be explored. Finally, the study was conducted in an Indian tertiary-care setting, providing additional regional evidence regarding the clinical relationship between renal morphology and renal function.

Several limitations should nevertheless be considered. The study was retrospective, single-centre and cross-sectional, with a relatively modest sample size of 100 participants. Consequently, selection bias and limitations in the completeness of routinely recorded clinical information cannot be excluded. The study also cannot establish the temporal sequence between cortical thinning and decline in renal function. A longitudinal study would be necessary to determine whether baseline cortical thickness independently predicts future eGFR decline, progression to advanced CKD or initiation of renal replacement therapy. Furthermore, the exact eGFR equation used in the source records was not specified in the available study documentation. This issue should be clarified before final submission because different estimation equations may produce different eGFR values.

Another limitation is that the study did not provide detailed analysis according to individual CKD etiologies. Diabetes and hypertension were recorded as important comorbidities, but CKD may result from several different pathological processes that can produce different patterns of structural renal change. In addition, other potentially relevant factors such as body height, body surface area,

duration of CKD and albuminuria were not incorporated into the present analysis. These factors may influence both renal morphology and renal function and should be considered in future investigations.

The findings also highlight the need for standardization of renal cortical-thickness measurement. Differences in measurement site, renal pole selection, ultrasound plane and operator technique can contribute to variability between studies. Future multicentre studies should therefore adopt a standardized protocol and assess interobserver and intraobserver reproducibility. Incorporating height-adjusted or body-size-adjusted cortical thickness may also improve comparability between individuals, as previous longitudinal research has suggested that adjusted cortical measurements may have prognostic value [9].

Overall, the present study provides evidence that ultrasound-measured renal cortical thickness is strongly associated with eGFR in adults with CKD. The progressive decline in cortical thickness across CKD stages, the strong correlation with eGFR and the persistence of the association after adjustment for selected demographic and clinical variables collectively support its role as a useful complementary imaging marker of renal functional impairment. However, cortical thickness should be interpreted alongside eGFR, albuminuria, clinical history and other sonographic findings rather than as an independent substitute for established CKD assessment methods. Prospective multicentre studies with standardized ultrasound protocols and longitudinal follow-up are warranted to determine whether cortical thickness can also serve as a reliable predictor of future CKD progression.

CONCLUSION:

The present study showed a strong positive association between ultrasound-measured renal cortical thickness and estimated glomerular filtration rate (eGFR) in adults with chronic kidney disease. Renal cortical thickness decreased progressively across advancing CKD stages and showed a strong correlation with eGFR ($r = 0.805$, $p < 0.001$). Renal length also demonstrated a significant positive correlation with eGFR ($r = 0.796$, $p < 0.001$), although the association with cortical thickness was slightly stronger.

Furthermore, renal cortical thickness remained independently associated with eGFR after adjustment for age, sex, diabetes mellitus, hypertension and renal length. The multivariable model explained a substantial proportion of the variability in eGFR, supporting the potential value of cortical thickness as a structural indicator of renal functional impairment.

These present studies suggest that renal cortical thickness measured by routine ultrasonography may serve as a useful, accessible and non-invasive complementary marker of renal function in patients

with CKD. However, it should not replace established biochemical assessment with eGFR or other recommended CKD markers. Instead, cortical thickness may provide additional structural information when interpreted together with clinical, laboratory and other sonographic findings. Prospective multicentre studies with standardized measurement protocols and longitudinal follow-up are warranted to determine whether renal cortical thickness can predict future decline in renal function and CKD progression.

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