

# Ultrasound Evaluation of Renal Measurements in Type 1 Diabetes Patients: Impact of Disease Duration

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## Abstract

**Background:** Type 1 diabetes mellitus (T1DM) is a chronic metabolic disorder associated with progressive renal complications, often leading to diabetic nephropathy. Early detection of renal morphological changes is essential for prevention and management. This study aimed to evaluate the impact of T1DM duration on renal size and morphology using ultrasound, with a focus on kidney length, width, thickness, and cortical characteristics.

**Methods and Results:** A retrospective cross-sectional study was conducted on 94 patients with T1DM in Taif, Saudi Arabia, between November 2024 and May 2025. Patients of both sexes, aged 1–70 years, underwent renal ultrasound in accordance with standard hospital protocols. Kidney dimensions (length, width, thickness) and cortical echogenicity were measured and compared across different disease durations and age groups.

Slight renal enlargement was observed in 73.7% of patients, predominantly in younger age groups (10–20 years), while 26.3% demonstrated slight renal atrophy, more frequent among older patients. The length and width of the kidneys gradually decreased 10 years after disease onset, reflecting progressive loss of parenchyma. The duration of longer diabetes appears to increase the likelihood of kidney atrophy, especially in older patients.

**Conclusion:** Ultrasound is a non-invasive and effective tool for monitoring renal morphological changes in patients with T1DM. Early-stage kidney hypertrophy trend appears to progress toward atrophy with longer disease duration, especially in older patients, underscoring the importance of routine renal monitoring to identify early diabetic nephropathy and guide timely intervention. (International Journal of Biomedicine. 2026;16(2):197-200.)

**Keyword:** ultrasound • kidney dimensions • type 1 diabetes mellitus

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## Introduction

Type 1 diabetes mellitus (T1DM), also known as insulin-dependent diabetes mellitus, is a chronic autoimmune disease characterized by the immune-mediated destruction of the insulin-producing  $\beta$ -cells of the pancreas, leading to an insulin deficiency. This deficiency impairs the proper regulation of blood glucose levels, leading to hyperglycemia and lifelong dependence on daily exogenous insulin therapy.

Type 1 diabetes mellitus often appears in childhood or young adulthood, though it can develop at any age.<sup>1</sup> Patients with T1DM often experience symptoms such as increased thirst, frequent urination, and weight loss. In acute cases,

patients may present with diabetic ketoacidosis, a serious complication. Early diagnosis depends on detecting specific antibodies that signal an immune response against the pancreas.<sup>1</sup>

In Saudi Arabia, the incidence of diabetes is rising, including in younger populations. The high rates of diabetes make it essential to understand the impact on other organs, especially the kidneys, which are often affected by long-term high blood glucose.

This research examined how kidney size and shape change over time in patients with T1DM, using ultrasound to track these changes and considering how disease duration may affect kidney health and size. Ultrasound diagnostics enable

the detection of anomalies in kidney shape and size. However, kidney dimensions may vary not only with pathology but also with the patient's physique, age, and race.<sup>2</sup>

Normal kidney measurements, the length of the kidney is between 9-12 cm, more than 2 cm is diagnosed with abnormal kidney enlargement, as for the width, it is between 4-6 cm, and the thickness is 3.5 cm, and a slight difference in measurement is not considered abnormal due to the difference in measurements according to the scanning angle.<sup>3</sup>

The renal sinus is a highly echogenic region due to the presence of calyces, vessels, and fat.<sup>4</sup> The measurement of cortical thickness to determine the well-being of the kidneys. The echogenicity of the kidney tissue assesses changes in echotexture to determine the presence of fibrosis or scarring. One important evaluation method for the renal system is Doppler ultrasound, which can be used to compute resistance index values, useful for assessing vascular resistance. Doppler also assesses blood flow, which can detect flow disorders. As regards most patients with advanced chronic kidney disease (CKD), cysts or calcifications are typically present in X-rays.<sup>5</sup>

Diabetes mellitus causes chronic hyperglycemia, leading to secondary microvascular complications through endothelial damage, capillary thickening, and tissue ischemia. Both maladaptive and adaptive responses are possible from the damaged kidney. The size and function of the remaining tubules, as well as glomerular pressure, increase in response to early adaptive reactions that increase blood flow to the remaining glomeruli.<sup>6</sup> A section of the kidney dies; however, increased glomerular pressure causes each nephron to generate more filtration (hyperfiltration), resulting in overall organ hypertrophy. If injury to normal nephrons progresses, the early adaptive response becomes more pronounced, leading to a gradual reduction in kidney size and function.<sup>7</sup> Diabetic nephropathy is described as the combination of structural and functional problems in the kidneys caused by diabetes. This involves atrophy (reduction in size), hypertrophy (abnormal increase in size), thickening of glomerular and tubular basement membranes, formation of extracellular matrix in the glomerulus (glomerulosclerosis), and tubular atrophy.<sup>8</sup>

Although diabetes is highly prevalent in Saudi Arabia, limited data exist on how T1DM affects renal dimensions across different age groups using ultrasound. The objective of this study was to investigate the impact of T1DM duration on kidney measurements using ultrasound across different age groups.

## Materials and Methods

A retrospective cross-sectional study was conducted in Taif city from November 2024 to May 2025. The study population comprises 94 T1DM patients. The study included males and females aged 1 to 70 years. The patient's kidneys were scanned by ultrasound at Taif hospitals, following the hospital's routine scan protocols. The ultrasound technique started with preparation and position.<sup>9</sup>

For kidney scanning, a 3.5 MHz transducer is used, while the 5.0 MHz transducer is used for children or thin patients.<sup>2</sup> The transducer was placed on the upper right or left side and

started with a longitudinal scan, then a transverse scan, with the liver acting as an acoustic window for the right kidney. The lateral position was used in cases of gas retention, or the patient was asked to drink water, thus filling the stomach with fluid as an acoustic window that allows us to see the kidneys.<sup>9</sup>

Researchers measured the kidney size (length, width, thickness) and the shape (echogenicity and cortical thickness). Data collection was conducted using a specialized registration form developed by the researchers, which included all variables necessary for this study.

Statistical analysis was performed using SPSS v.25.0 (SPSS Inc., Armonk, NY; IBM Corp.). Baseline characteristics were summarized as frequencies and percentages. Group comparisons were performed using the chi-square test. A  $P$ -value  $< 0.05$  was considered statistically significant.

## Results

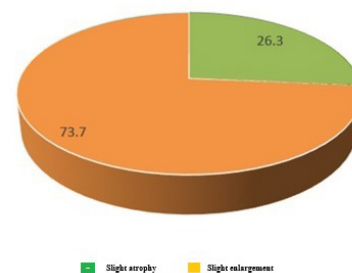
The distribution of kidney measurements across different age groups is summarized in Table 1. The majority of T1DM patients (73.7%) showed slight kidney enlargement, while 26.3% had slight atrophy (Figure 1). Among younger patients (10–19 years and 20–29 years), slight enlargement was predominant, with 100% and 88.2% of cases, respectively. In contrast, the frequency of slight atrophy increased progressively with advancing age, reaching 50% in the 70–79 age group. Despite this apparent trend toward increased atrophy with age, the difference in kidney measurements among the age groups was not statistically significant ( $P = 0.105$ ) (Table 1).

**Table 1.**

**Distribution of kidney measurement changes across age groups in T1DM patients.**

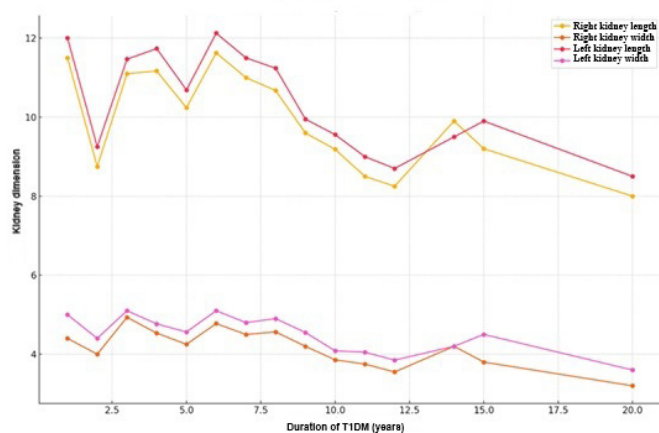
Age Range (years)	Slight Atrophy n (%)	Slight Enlargement n (%)	Total n (%)
10–19	0 (0.0%)	14 (100.0%)	14 (100.0%)
20–29	2 (11.8%)	15 (88.2%)	17 (100.0%)
30–39	4 (40.0%)	6 (60.0%)	10 (100.0%)
40–49	4 (30.8%)	9 (69.2%)	13 (100.0%)
50–59	6 (33.3%)	12 (66.7%)	18 (100.0%)
60–69	8 (38.1%)	13 (61.9%)	21 (100.0%)
70–79	1 (50.0%)	1 (50.0%)	2 (100.0%)
Total	25 (26.3%)	70 (73.7%)	95 (100.0%)

*Chi-square test:  $P = 0.105$*



**Fig. 1.** Kidney dimensions.

Ultrasound measurements of renal dimensions in patients with T1DM demonstrated distinct trends correlated with disease duration (Figure 2). Both kidney length and width were assessed over a disease span of 1 to 20 years.



**Fig. 2.** Changes in kidney length and width over time in T1DM patients as measured by ultrasound.

By Year 1 of disease onset, both kidneys were slightly enlarged, with the left measuring approximately 12 cm in length, slightly exceeding the right. This finding is consistent with early-stage diabetic renal hypertrophy, likely reflecting compensatory glomerular hyperfiltration.

By Year 2, a notable reduction in kidney dimensions was observed, particularly in the right kidney. This abrupt decrease may indicate early parenchymal changes or variability in individual physiological responses during the initial phase of glycemic control.

Between Years 3 and 10, renal measurements remained relatively stable, with only minor fluctuations. The left kidney consistently measured longer and wider than the right, consistent with established anatomical asymmetry. Beginning around Year 10, a gradual and sustained decline in both renal length and width was evident bilaterally. By Year 20, renal dimensions had markedly decreased, with the right kidney width approaching 3.5 cm. These findings are indicative of progressive nephron loss and chronic parenchymal damage associated with diabetic nephropathy.

## Discussion

Our findings support the hypothesis that the duration of T1DM influences kidney morphology through gradual, measurable changes in size and shape that could ultimately affect kidney health. In our sample of 95 T1DM patients, the majority exhibited slight renal enlargement (73.7%), while a smaller proportion demonstrated slight renal atrophy (26.3%). These findings are consistent with previous studies, including those by Tonneijc et al.,<sup>10</sup> which identified early-stage renal hypertrophy associated with glomerular hyperfiltration in patients with T1DM. With a mean duration of diabetes of approximately 7.4 years in our cohort, early renal enlargement predominates in most patients, supporting the idea that, in the initial stages,

kidney changes may be associated with hyperfiltration and compensatory enlargement.<sup>11</sup> As the disease progresses, however, the prevalence of renal atrophy increases, suggesting that long-term hyperglycemia may eventually lead to kidney structural deterioration. This aligns with our hypothesis that kidney size and shape change gradually and measurably as the duration of diabetes increases, with these changes potentially having a lasting effect on kidney health.<sup>12</sup> Further analysis of age groups revealed a trend toward greater renal atrophy in older patients, though this association was not statistically significant ( $P=0.105$ ). Interestingly, patients in the age of 30-39 years showed a 40% of renal atrophy, hinting that those with longer disease duration, even at a relatively young age, may be more susceptible to kidney structural changes. While the results were not statistically conclusive, they reinforce the hypothesis that kidney morphology in younger patients, particularly those in the early stages of T1DM, tends to be either preserved or enlarged. In contrast, older patients, or those with longer disease duration, are more likely to exhibit signs of renal atrophy.<sup>13</sup> Overall, this study highlights the utility of ultrasonography as an effective, non-invasive tool for detecting early morphological changes in diabetic kidneys. These changes, particularly with longer diabetes duration, may be critical in assessing kidney health and the potential risk for chronic kidney disease.<sup>14</sup> Our results suggest that monitoring kidney size and shape over time could provide valuable insights into the progression of kidney damage in T1DM patients, emphasizing the importance of early intervention and regular assessment to prevent long-term renal complications.<sup>15</sup>

The major strength of this study is the fact that it used ultrasound. Ultrasound is a non-invasive, practical, and widely available imaging technique for the early detection of morphological changes in the kidneys of individuals with diabetes. This will allow follow-up and early intervention strategies to be implemented in time to prevent long-term kidney complications.

However, some limitations should be noted. Primarily, generalizing the findings to the whole population is somewhat hampered by the relatively small sample size and the study's limited scope to one center. Second, it cannot be proven that a direct link exists between structural changes and kidney dysfunction due to the lack of biochemical correlates, such as serum creatinine, glomerular filtration rate, and urinary albumin.

Nevertheless, the results we obtained are clinically significant. Monitoring kidney size and shape over time using ultrasound is an effective tool for detecting diabetic nephropathy. Integrating ultrasound with kidney biomarkers may contribute to future studies, improve risk assessment, and enable timely intervention. Ultimately, these strategies may play a crucial role in reducing the burden of chronic kidney disease in patients with T1DM.

## Conclusion

Ultrasound imaging is an effective and safe way to measure the kidneys, detect early changes, and monitor and intervene in kidney health in T1DM. To determine the correct kidney measurements, it is necessary to know the measurements of healthy adults, as they are affected by various factors. Our

study supports the hypothesis that the duration of T1DM leads to gradual changes, and most of them showed renal hypertrophy (73.7%), with some showing renal dystrophy (26.3%).

In this study, these changes are in line with previous studies on early-stage renal hypertrophy and glomerular hyperfiltration. The duration of longer diabetes appears to increase the likelihood of kidney atrophy, especially in older patients. We found at King Abdulaziz Specialist Hospital (KASH) in Taif city and at King Faisal that there is a need to study the normal values of kidney size among Saudis, and we recommend expanding the scope of this study throughout Saudi Arabia.

Since T1DM is a growing problem in Saudi Arabia, more research is needed in other parts of the country to better understand its complications and risk factors to reduce its burden.

## Authors Contributions

**Elrashed AbdElrahim:** Supervision, Conceptualization, Methodology, Data analysis and interpretation, Writing – review and editing.

**Raghad Jemeen Al-Malki:** Methodology, Writing – original draft.

**Rehab Ali Al-Kathiri:** Methodology, Writing – original draft.

**Jana Awad Al-Thobaity:** Investigation, Data curation

**Shahad Abdullah Al-Kaabi:** Investigation, Data curation

**Ibtihal Saud Al-Withainani:** Investigation, Data curation

**Mona Elhaj:** Data analysis and Interpretation, Writing – original draft.

**Bahaedin A. Elkhader:** Methodology, Writing – original draft.

**Hamid Osman:** Supervision, Conceptualization, Methodology, Writing – review and editing.

All authors have read and approved the final manuscript.

## Ethical Statement

The Local Bioethics Committee and Research Administration of Taif Health Cluster, Saudi Arabia, accepted this study (approval number: E-32-2025; IRB registration number: H-02-T-123). All patients, their parents, or legal guardians provided informed consent before participation.

## Conflict of Interest

The authors have declared no conflict of interest.

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