



## Original Research Article

# MORPHOMETRIC ANALYSIS AND CONGENITAL ANOMALIES OF KIDNEY AND URETER IN ADULT CADAVERS: A CROSS-SECTIONAL STUDY

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**ABSTRACT**

**Background:** Measurement of morphometric parameters of the kidney and ureter plays a crucial role in clinical practice, as the variations existing can influence clinical diagnosis and surgical procedure

**Materials and Methods:** A descriptive cross-sectional study was conducted in the Department of Anatomy at a tertiary medical institute, over the period of five years from February 2020 till March 2025. Total of 50 pairs of adult cadaveric kidneys and ureters were examined. Morphometric parameters including renal length, width, thickness, weight, and ureteric length were measured using vernier callipers and a digital weighing machine. Statistical analysis was performed using IBM SPSS version 27.

**Results:** The left kidney consistently demonstrated greater length, width, thickness, and weight compared to the right kidney ( $p < 0.0001$ ). No statistically significant difference was observed in ureteric length between sides ( $p = 0.949$ ). Pearson's correlation analysis showed a weak positive correlation between renal length and ureteric length on both sides, which was not statistically significant. Congenital anomalies were observed in 14% of cadavers.

**Conclusion:** The study provides baseline morphometric data of kidneys and ureters in adult cadavers and highlights the presence of congenital anomalies that could have clinical significance in surgical and radiological practice.

**Keywords:** Kidney morphometry, Cadaveric study, Congenital renal anomalies, ureter morphometry.

## INTRODUCTION

Kidneys and Ureters are integral components of human renal system, which are responsible for blood filtration, maintenance of fluids and electrolytic balance, regulation of acid base homeostasis and excretion of toxins out from the body. Human body consists of a pair of kidneys located retroperitoneally on the posterior abdominal wall on either side of the vertebral column, extending from level of 12th thoracic vertebrae to 3rd lumbar vertebrae.<sup>[1]</sup> At the time of birth, kidneys are lobulated in appearance which disappears during infancy and later develop into thick and circular superior pole with thin and pointed inferior pole. Ureters are narrow muscular tubes that transport urine from renal pelvis to urinary bladder.<sup>[2]</sup> Usually

the kidney has a length of 11 cm, a breadth of 6 cm, width of 3 cm and weighs around 150 gm each, while ureters typically are 20 to 30 centimetres long and 3 to 4 millimetres in diameter.<sup>[3]</sup>

Congenital anomalies of kidney and urinary tract (CAKUT) consists of variety of developmental disorders occurring in either of the kidneys or ureters. They mainly include nephropathies such as renal aplasia, hypoplasia, dysplasia, oligomeganephronia, ectopic kidneys, and horseshoe kidney. In addition, uropathies including multiple ureters, vesicoureteral reflux, bladder exstrophy-epispadias complex, posterior urethral valve, and ureteroceles are all described in CAKUT.<sup>[4]</sup> Congenital anomalies of the kidney and urinary tract are relatively common and are around 3–6% of live births.<sup>[5]</sup>

Thus, measurement of morphometric parameters of the kidney and ureter plays a crucial role in clinical practice. Parameters such as renal length, width, thickness, weight, and ureteric length serve as important indicators for differentiating normal anatomical variations from pathological anomalies.<sup>[6]</sup> Understanding these anatomical variations in the cadaveric kidneys will help in improving the accuracy of diagnosis and surgical interventions options. These studies also allow the identification of anomalies which might remain undetected or asymptomatic.

Despite the availability of imaging-based studies, comprehensive cadaveric research focusing on the morphometric characteristics and congenital anomalies of the kidney and ureter in adult populations remains limited. Also, most of the existing studies emphasize on paediatric or radiological findings, leaving a gap in anatomical literature regarding adult cadaveric observations. Therefore, the main aim of present study is to provide the morphometric data and various congenital anomalies found in cadaveric kidneys collected over past five years in anatomy department, so that findings can be clinically implicated for better decision making and early detection strategies.

## MATERIALS AND METHODS

**Study Design:** A descriptive cross-sectional study was conducted in the Department of Anatomy at NRIIMS, Sangivalasa, Visakhapatnam over the period of five years from February 2020 till March 2025.

**Sample Size:** All the available cadaver during the study period mentioned were included, comprising of 50 pair (100 kidneys) of well preserved human kidney and ureters of adult cadavers (both genders) in formalin

**Selection Criteria:** All specimens were included irrespective of anatomical variations, however kidneys which were putrefied, poorly preserved, or showed visible surgical cuts or trauma were excluded.

Morphometric parameters like length, width, and thickness of each kidney were assessed using vernier callipers (accuracy of 0.01mm). Renal length was measured as the distance from superior pole to inferior pole (Figure 1), the renal width was considered as transverse diameter between medial border and lateral border (Figure 2,3,4), and renal thickness was measured and recorded from the maximum anteroposterior diameter of the kidney. All the linear dimensions were recorded in millimetres.

The weight of the kidneys was measured by using a digital weighing machine in grams. Each measurement was taken three times to maximize the accuracy and the mean value was taken for statistical analysis. This study was conducted in

accordance with institutional ethical guidelines, governing the use of the cadaveric specimens which were designed for academic and research purposes.



**Figure 1: Measurement of right kidney length using vernier callipers**



**Figure 2: Measurement of Left kidney width at upper pole**



Figure3: Measurement of Left kidney width at Lower pole



Figure 4: Measurement of Left kidney width at hilum level



Figure 5: Abnormal kidney width at lower pole showing dysplasia



Figure 6: Abnormal kidney width at the hilum showing dysplasia



Figure 7: Left Ureter opening in lower pole of left kidney which has dysplasia

**Statistical Analysis:** Data was analyzed using IBM SPSS (Version 27). Morphometric variables were expressed as mean±standard deviation. Comparison of left and right sides was done using paired t test, considering p value <0.05 to be statistically significant. Pearson's Correlation was used to evaluate relationship between length of kidney and ureter. Congenital anomalies of Kidney and Ureter (Figure 5,6,7) were documented and presented in frequency and percentage bases from the total number of cadavers studied.

## RESULTS

**Table 1: Morphometric measurements and comparison of Kidney and Ureter**

Parameter	Left side	Right side	Mean difference	t-value	p-value	Significance
Kidney Length (mm)	109.11±6.60	103.94±5.98	5.17	18.68	<0.0001	Significant
Width (Superior pole)	49.88 ± 2.98	46.26 ± 3.31	3.62	18.918	<0.0001	Significant
Width (Hilum)	59.182±4.18	54.253±4.164	4.93	24.642	<0.0001	Significant
Width (Inferior pole)	47.98±3.002	44.568±3.204	3.41	20.648	<0.0001	Significant
Kidney Thickness	35.274 ±2.026	32.678 ± 1.822	2.6	21.074	<0.0001	Significant
Kidney Weight	145.98 ± 6.576	133.42 ± 7.947	12.56	17.887	<0.0001	Significant
Ureter length	269.39 ± 17.864	269.36 ± 17.882	0.03	0.064	0.9492	Not Significant

**Table 2: Comparison of Renal length on left and right side**

Parameter	Left Kidney (mm)	Right Kidney (mm)
Mean ± SD	109.11 ± 6.60	103.94±5.98
Median (IQR)	107.5 (10.5)	102.0 (9.50)
Minimum	98	92
Maximum	123	116
Range	25	24

**Table 3: Comparison of Renal Width at three levels on left and right side**

Kidney	Level	Mean ± SD	Median	Min–Max	Interquartile range (IQR)
Left	Superior pole	49.88 ± 2.98	50.05	44.7 - 54.8	5.25
	Hilum	59.182±4.18	59.05	52.1 - 67.2	5.33
	Inferior pole	47.98±3.002	48.25	42.8 - 52.8	5.52
Right	Superior pole	46.26 ± 3.31	46.35	40.4 - 54.4	5.65
	Hilum	54.253±4.164	54.10	46.7 - 63.2	7.35
	Inferior pole	44.568±3.204	44.7	36.7 - 50.60	5.52

**Table 4: Comparison of Renal thickness at left and right side**

Parameter	Left Kidney	Right Kidney
Mean ± SD	35.274 ±2.026	32.678 ± 1.822
Median (IQR)	35.30 (2.30)	32.50 (2.22)
Minimum	30.20	29.30
Maximum	39.80	37.60
Range	9.60	8.30

**Table 5: Comparison of Renal Weight at left and right side**

Parameter	Left Kidney	Right Kidney
Mean ± SD	145.98 ± 6.576	133.42 ± 7.947
Median (IQR)	146.40 (9.60)	132.60 (10.13)
Minimum	129.70	117.30
Maximum	157.20	151.90
Range	27.50	34.60

**Table 6: Comparison of Ureter length on right and left side**

Parameter	Left Ureter (mm)	Right Ureter (mm)
Mean ± SD	269.39 ± 17.864	269.36 ± 17.882
Median (IQR)	267.90 (33.05)	267.80 (33.05)
Minimum	241.90	241.90
Maximum	299.40	299.40
Range	57.50	57.50

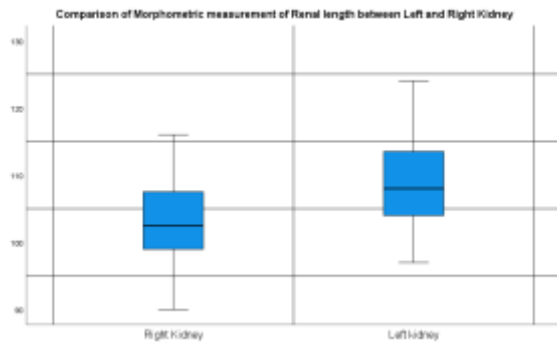
Pearson's correlation analysis was performed which showed a weak positive correlation between kidney length and ipsilateral ureter length on both sides, and analysis showed that the correlation was not statistically significant. [Table No.7]

**Table 7: Correlation analysis between kidney and ureter length**

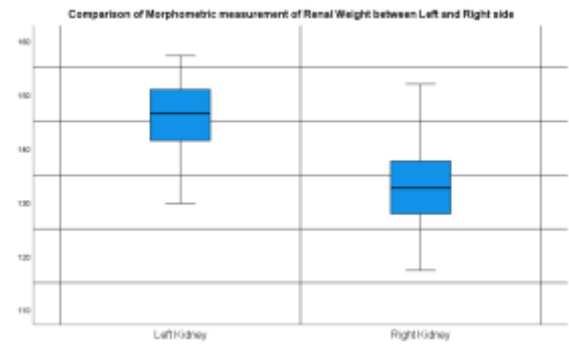
Correlation	r value	p value	Significance
Left Kidney length vs Left Ureter length	0.144	0.320	Not significant
Right Kidney length vs Right Ureter length	0.126	0.384	Not significant

**Table 8: List of congenital anomalies**

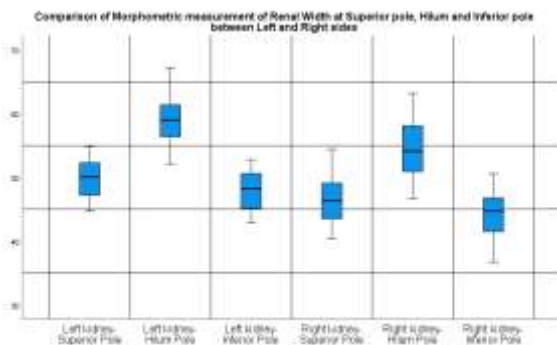
Congenital anomaly	Side	Occurrence (%)
Horseshoe kidney	Bilateral	1 (2%)
Persistent foetal lobulation	Left	2 (4%)
Renal agenesis	Right	1 (2%)
Duplicated ureter	Left	2 (4%)
Bifid ureter	Left	1 (2%)



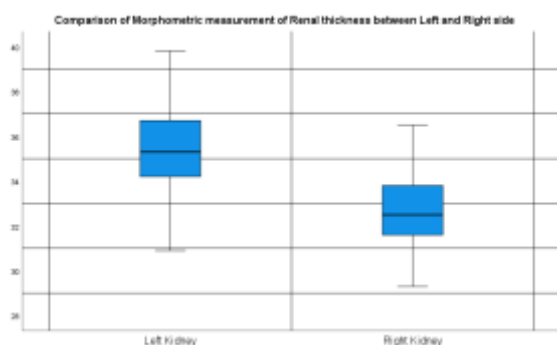
**Graph 1: Graphical representation of Comparison of Renal length on left and right side**



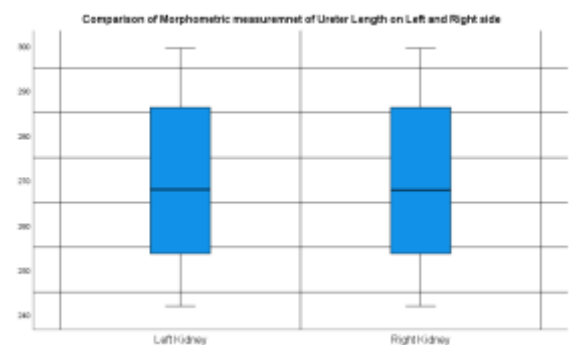
**Graph 4: Graphical representation of Comparison of Renal Weight at left and right side**



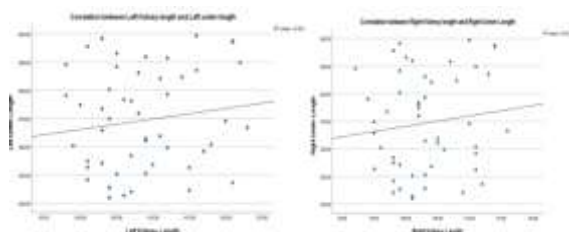
**Graph 2: Graphical representation of Comparison of Renal Width at three levels on left and right side**



**Graph 3: Graphical representation of Comparison of Renal thickness at left and right side**



**Graph 5: Graphical representation of Comparison of Ureter length on right and left side**



**Graph 7: Graphical representation of correlation analysis between kidney and ureter length**

A total of 50 pair of cadaver kidney were examined, from which left kidney demonstrated significantly greater length, width at all three levels, thickness, and weight compared to the right kidney ( $p < 0.0001$ ). However, no statistically significant difference was observed in ureteric length between the two sides ( $p = 0.949$ ). [Table No. 1]

## DISCUSSION

The present cadaveric study provides detailed morphometric measurements essential for establishing baseline reference values, left kidney was significantly longer, wider, thicker, and heavier

than the right kidney. This left side predominance has been consistently described in previous literature as well and is attributed to the presence of the liver on the right side, which limits right renal growth.<sup>[1]</sup> The mean left renal length is 109.11 mm while on right side is 103.94 mm in the present study which is comparable to finding of Dharmadas et al,<sup>[6]</sup> which suggests that present study has a normal anatomical variation rather than a pathological deviation.

Renal width was greatest at the level of the hilum on both sides, corresponding to the anatomical location of the renal sinus and vascular structures. The mean ureter length had no statistically significant difference between right and left sides, aligning with study by Novaes et al,<sup>[7]</sup> they also observed that, ureteral length does not correlate strongly with anthropometric parameters, which was consistent with present study's Pearson's correlation analysis revealing weak and statistically non-significant relationship ( $r = 0.144$  on the left;  $r = 0.126$  on the right) between kidney length and ipsilateral ureter length. This suggests that ureteric length is largely independent of renal dimensions.

Congenital anomalies were observed in 14% of cadavers, with Persistent foetal lobulation to be most common anomaly in present study. Horseshoe kidney was observed in one specimen, which results from abnormal fusion of the metanephricblastema during embryogenesis.<sup>[4,8]</sup> A case of unilateral renal agenesis was also identified, which may occur due to failure of interaction between the ureteric bud and metanephric mesenchyme during renal development.<sup>[5]</sup>

Ureteric anomalies such as duplicated ureter and bifid ureter arise due to early splitting or duplication of the ureteric bud, which was documented in present study, consistent with cadaveric study of Arumugam et al,<sup>[9]</sup> and Chakravarthi and Reghunadhan.<sup>[10]</sup> Awareness of such variations is clinically significant during urological procedures, renal transplantation, and radiological interpretation. The morphometric values obtained in the present study provide baseline anatomical data for adult

kidneys and ureters, which will assist clinicians and surgeons in distinguishing normal anatomical asymmetry from pathological enlargement, atrophy, or congenital abnormalities.

#### **Limitations**

The present study was limited to cadavers available in a single institution, restricting its generalizability. Demographic parameters such as age and body height were not correlated with morphometric findings.

## **CONCLUSION**

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