Biomedical and Biopharmaceutical Research
Abbreviation: Biomed. Biopharm. Res.
Volume: 22: Issue: 01 |Year: 2025
Page Number: 252-259

Study of histological spectrum of renal biopsy specimens at a tertiary care center

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Article Received:21-02-2025

Article Accepted:5-04-2025

Abstract

Introduction: Renal biopsy remains the gold standard for diagnosing renal parenchymal diseases and is essential in guiding treatment and predicting outcomes. This study aimed to evaluate the histopathological spectrum of renal biopsy specimens at a tertiary care center over an 18-month period and correlate findings with clinical parameters.

Materials and Methods: A prospective, cross-sectional observational study was conducted on 78 patients advised to undergo native kidney biopsy. Inclusion criteria encompassed patients with suspected renal pathology who consented to biopsy. Exclusion criteria included renal malignancies, bleeding disorders, and transplanted kidneys. Biopsies were performed using a spring-loaded Tru-Cut needle under real-time ultrasound guidance. Histopathological evaluation included light microscopy, immunofluorescence, and electron microscopy where indicated. Clinical, demographic, and laboratory data were recorded, and descriptive statistical analysis was performed.

Results: The mean patient age was 37 years, with the majority (53.85%) aged 21–40 years. Males constituted 61.54% of the study population. Nephrotic syndrome (32.05%) was the most common indication, followed by nephritic syndrome (21.79%) and rapidly progressive renal failure (16.67%). Among glomerular diseases, focal segmental glomerulosclerosis (16.67%) and membranous nephropathy (8.97%) were predominant. Diabetic nephropathy (7.69%) was the most common cause of chronic kidney disease. Histologically, glomerular obsolescence (47.44%) and interstitial fibrosis/tubular atrophy (15.38%) were prominent findings. Crescent formation (2.56%) and arteriolar hyalinosis (16.67%) reflected progressive and vascular pathologies.

Conclusion: Renal biopsy continues to be indispensable in evaluating kidney diseases. This study highlights a predominance of glomerular pathologies such as FSGS and membranous nephropathy in the Indian population, with diabetic nephropathy and hypertensive vascular changes contributing significantly to chronic kidney disease. Early diagnosis through biopsy can optimize management and improve renal outcomes.

Keywords: Renal biopsy, glomerular disease, nephrotic syndrome, focal segmental glomerulosclerosis, diabetic nephropathy, histopathology, chronic kidney disease.

INTRODUCTION

Renal biopsy is a crucial diagnostic tool in nephrology, offering essential insights into kidney diseases.[1] It remains the gold standard for diagnosing renal parenchymal disorders, guiding treatment decisions, and assessing prognostic outcomes. Despite advancements in non-invasive diagnostic techniques, renal biopsy continues to be indispensable in confirming clinical diagnoses and determining disease severity.[1–4]

Kidney diseases are a growing public health concern, particularly in developing countries like India, where chronic kidney disease (CKD) is rising due to increasing incidences of diabetes, hypertension, and environmental factors. Renal biopsy helps identify the underlying etiology of renal dysfunction, distinguishing between different glomerular and tubulointerstitial pathologies. Histopathological findings provide valuable information about disease progression and treatment response.[5–8]

The advent of real-time ultrasound-guided biopsy techniques has significantly improved the safety and accuracy of the procedure. Initially introduced by Alwall in 1944 and later refined by Iversen and Brun in 1951, percutaneous renal biopsy has revolutionized nephropathology. Immunofluorescence and electron microscopy further enhance diagnostic capabilities, allowing for a comprehensive assessment of glomerular, tubular, and vascular abnormalities.[5,8,9]

Clinically, renal diseases present with various manifestations, including nephrotic syndrome, nephritic syndrome, acute kidney injury (AKI), and rapidly progressive glomerulonephritis (RPGN). The histological spectrum of these conditions varies, and accurate categorization is vital for determining the appropriate therapeutic approach. Epidemiological studies suggest regional variations in biopsy-proven renal diseases, with focal segmental glomerulosclerosis (FSGS) being the most common in India.[7,8,10,11]

Despite its significance, renal biopsy carries potential risks such as bleeding and infection. However, advancements in technique and post-procedure care have improved its safety profile. This study aims to evaluate the histological spectrum of renal biopsy specimens in a tertiary care center, contributing valuable insights to nephropathology.

MATERIALS AND METHODS

This study was conducted after obtaining approval from the Institutional Ethics Committee at a tertiary care hospital. The research was carried out in the Department of Pathology in collaboration with the Department of Nephrology. The study aimed to analyze the histopathological spectrum of renal biopsy specimens and their correlation with clinical and laboratory findings. A prospective cross-sectional observational study design was chosen to ensure accurate data collection and analysis.

The study was conducted over a period of 18 months, allowing sufficient time for patient recruitment and assessment. The sample size was determined based on the prevalence of glomerulonephritis in India (15.2%), at a 95% confidence interval, with an 8% margin of error. Using the standard statistical formula, the estimated sample size was 78 patients, which was considered adequate for the study's objectives. Patients were recruited from the Department of Nephrology, and informed written consent was obtained before their participation.[7]

Patients included in the study met specific inclusion criteria, which required them to be clinically diagnosed with renal disease and advised to undergo native renal biopsy. Only those who provided written informed consent were enrolled. However, several exclusion criteria were applied to maintain the accuracy and relevance of the findings. Patients who refused to provide consent, had self-limiting kidney diseases, or had contraindications for renal biopsy were excluded. Absolute contraindications included uncontrolled hypertension, bleeding disorders, renal malignancy, widespread cystic disease, hydronephrosis, and uncooperative behavior. Meanwhile, relative contraindications involved a single kidney, antiplatelet or anticoagulant therapy, anatomical abnormalities (such as small kidneys), and active urinary or skin infections. Additionally, transplanted renal biopsies were not included in the study.

The study involved a detailed clinical assessment of each patient. A thorough medical history was obtained, including age, gender, chief complaints, past medical history, family history, and associated comorbidities such as diabetes, hypertension, and coronary artery disease. A systemic examination was conducted to assess general health status and any signs of renal impairment. Laboratory investigations played a crucial role in establishing baseline parameters before the biopsy procedure. These included complete blood count (CBC), erythrocyte sedimentation rate (ESR), renal function tests, liver function tests, blood glucose levels, ECG, coagulation tests (bleeding time, clotting time, APTT, PT), urine microscopy, 24-hour urinary protein, and ultrasonography (USG) of the abdomen.

Renal biopsy was the primary investigative tool in this study. Before the procedure, written informed consent was obtained from all patients, and they were positioned according to the type of biopsy. For native kidney biopsies, patients were placed in the prone position, whereas for transplanted kidney biopsies, they were positioned in the supine position. The biopsy was performed using a posterolateral approach under sterile conditions with real-time ultrasound guidance. The lower pole of the left kidney was selected as the biopsy site due to its accessibility. A spring-loaded Tru-Cut biopsy needle (14G-18G) was used to obtain samples. The procedure was performed under local anesthesia (lidocaine) with light sedation to minimize discomfort.[3,5]

The biopsy procedure was carried out meticulously to ensure accuracy and safety. Three adequate core biopsy specimens were collected, and in high-risk patients, needle track plugging with Gelfoam was performed to reduce post-procedural bleeding risks. Post-biopsy monitoring was critical to detect complications early. Patients were kept on supine rest for at least six hours, and their vital signs were closely monitored for 24 hours. Blood pressure (BP) was checked every 30 minutes for three hours, then hourly for five hours, and subsequently every four hours for 16 hours. Hemoglobin levels were assessed at 24 hours post-biopsy to identify any occult bleeding. Patients were advised to return for a one-week follow-up OPD visit, where an ultrasound abdomen was performed to rule out complications such as arteriovenous fistula formation.[5]

Following collection, biopsy specimens underwent histopathological examination. Light microscopy was performed on tissues fixed in 10% buffered formalin. The samples were processed and stained with Hematoxylin and Eosin (H&E), Periodic Acid-Schiff (PAS), Jones' Methenamine Silver Stain, and Masson's Trichrome Stain. Each biopsy was evaluated for glomerular, tubular, and interstitial abnormalities to establish the histopathological diagnosis. Additionally, immunofluorescence microscopy was conducted on frozen sections using antibodies against IgA, IgG, IgM, C3c, C1q, κ, and λ light chains. The results were graded subjectively (0 to 3+) and analyzed under ultraviolet light.

Electron microscopy was performed in selected cases where additional structural evaluation was necessary. This technique was particularly useful in diagnosing minimal change disease, membranous nephropathy, diabetic

glomerulopathy, and immune-complex diseases. Electron microscopy provided valuable insights into ultrastructural changes within the glomeruli, aiding in diagnostic precision.
For statistical analysis, the collected data was compiled using MS Excel 2019. Qualitative data was analyzed using frequency and percentage distribution. Descriptive statistics were used to summarize the findings, while visual representations such as bar charts and pie charts were generated to enhance clarity and presentation. These methods ensured an objective and structured analysis of renal biopsy findings.

RESULTS

Table 1: Demographics Particulars of the present study

Demographics	Number of Cases (N)	Percentage (%)
Age Group		
≤ 20	12	15.38%
21 to 40	42	53.85%
41 to 60	20	25.64%
> 60	4	5.13%
Gender		
Male	48	61.54%
Female	30	38.46%

The Demographics Table presents the distribution of cases in the present study based on age group and gender. Among the 78 total cases, the majority (53.85%) were in the 21 to 40 years age group, followed by 41 to 60 years (25.64%), ≤ 20 years (15.38%), and the least representation was from those over 60 years (5.13%). In terms of gender distribution, males constituted 61.54% of the cases, while females accounted for 38.46%. This data highlights that the highest proportion of cases falls within the younger and middle-aged adult population, with a higher prevalence among males.

Chart 1: Pie chart displaying the eGFR distribution of the present sample

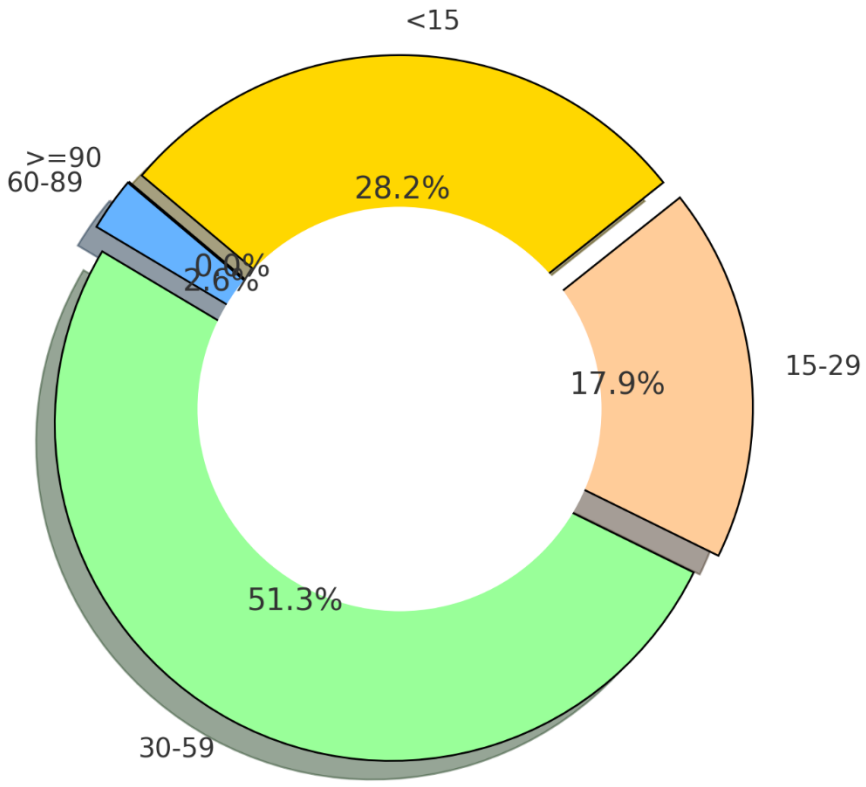

Table 2: Distribution based on diagnosis

Diagnosis	Number of Cases (N)	Percentage (%)
Nephrotic Syndrome	**25**	**32.05%**
a. Focal Segmental Glomerulosclerosis	13	16.67%
b. Minimal Change Disease	3	3.85%
c. Membranous Nephropathy	7	8.97%
d. Amyloidosis	2	2.56%
Nephritic Syndrome	**17**	**21.79%**
a. IgA Nephropathy	2	2.56%
b. Lupus Nephritis	12	15.38%
c. Membranoproliferative Glomerulonephritis	3	3.85%
Chronic Kidney Disease	**12**	**15.38%**
a. Chronic Tubulointerstitial Nephritis	1	1.28%
b. Diabetic Nephropathy	6	7.69%
c. Diffuse Global Glomerulosclerosis	1	1.28%
d. Hypertensive Nephropathy	3	3.85%
e. Idiopathic Nodular Glomerulosclerosis	1	1.28%
Rapid Progressive Renal Failure	**13**	**16.67%**
a. Thrombotic Microangiopathy	2	2.56%
b. Myeloma Cast Nephropathy	2	2.56%
c. Crescentic Glomerulonephritis	9	11.54%
Acute Kidney Injury	**9**	**11.54%**
a. Acute Interstitial Nephritis	6	7.69%
b. Acute Tubular Necrosis	3	3.85%
Rapid Progressive Glomerulonephritis	**2**	**2.56%**
a. Anti-GBM	1	1.28%
b. ANCA-disease	1	1.28%

The distribution of cases based on diagnosis in this study reveals that Nephrotic Syndrome is the most prevalent condition, affecting 32.05% of the cases. Among its subtypes, Focal Segmental Glomerulosclerosis (16.67%) is the most common, followed by Membranous Nephropathy (8.97%), Minimal Change Disease (3.85%), and Amyloidosis (2.56%). Nephritic Syndrome accounts for 21.79% of the cases, with IgA Nephropathy (2.56%) and Membranoproliferative Glomerulonephritis (3.85%) being notable contributors.

Chronic Kidney Disease (CKD) constitutes 15.38% of the cases, with Diabetic Nephropathy (7.69%) as the most frequent underlying cause. Other CKD subtypes include Hypertensive Nephropathy (3.85%), Chronic Tubulointerstitial Nephritis (1.28%), Diffuse Global Glomerulosclerosis (1.28%), and Idiopathic Nodular Glomerulosclerosis (1.28%). Rapid Progressive Renal Failure (RPRF) accounts for 16.67% of cases, with Crescentic Glomerulonephritis (11.54%) being the predominant subtype, followed by Thrombotic Microangiopathy (2.56%) and Myeloma Cast Nephropathy (2.56%).

Acute Kidney Injury (AKI) is observed in 11.54% of the cases, with Acute Interstitial Nephritis (7.69%) being more common than Acute Tubular Necrosis (3.85%). Lastly, Rapid Progressive Glomerulonephritis (2.56%) is the least common diagnosis, with Anti-GBM disease (1.28%) and ANCA-associated disease (1.28%) each contributing a small proportion of cases. These findings highlight the diversity of renal pathologies encountered in the study population,

emphasizing the significant burden of glomerular and progressive kidney diseases. Histopathological Findings Table with Accurate Percentages

Table 3: Distribution based on histopathological findings

Histopathological Findings	Number of Cases (N)	Percentage (%)
Glomerular Obsolescence	37	47.44%
Interstitial Fibrosis / Tubular Atrophy	12	15.38%
a. Mild	7	8.97%
b. Moderate	3	3.85%
c. Severe	2	2.56%
Arteriolar Hyalinosis	13	16.67%
a. Mild	8	10.26%
b. Moderate	4	5.13%
c. Severe	1	1.28%
Nodular Mesangial Sclerosis	4	5.13%
Crescent	2	2.56%

The distribution of histopathological findings in the study highlights Glomerular Obsolescence as the most prevalent abnormality, affecting 47.44% of the cases. This finding suggests a high occurrence of glomerular structural deterioration, which is commonly associated with chronic kidney diseases and aging-related renal changes.

Interstitial Fibrosis and Tubular Atrophy (IFTA) was observed in 15.38% of cases, with varying severity. Among them, mild fibrosis was the most frequent (8.97%), while moderate (3.85%) and severe (2.56%) cases were relatively less common. The presence of IFTA indicates progressive kidney damage and is a critical factor in predicting renal function decline.

Arteriolar Hyalinosis, a marker of vascular damage often linked to hypertension and diabetic nephropathy, was found in 16.67% of cases. Within this category, mild arteriolar hyalinosis (10.26%) was more frequent compared to moderate (5.13%) and severe (1.28%) forms. These findings emphasize the role of systemic vascular diseases in renal pathology.

Nodular Mesangial Sclerosis, a condition commonly associated with diabetic nephropathy and certain glomerular diseases, was detected in 5.13% of cases. Additionally, Crescent formation, which is a hallmark of severe glomerular injury often seen in rapidly progressive glomerulonephritis, was present in 2.56% of cases. This low occurrence suggests that aggressive glomerular diseases were less frequent in the study population.

Overall, the histopathological spectrum reveals a predominance of glomerular and vascular abnormalities, with glomerular obsolescence, interstitial fibrosis, and arteriolar hyalinosis being the most commonly encountered findings. These results highlight the importance of early detection and management of chronic kidney diseases to prevent progressive renal damage.

Table 4: Biopsy findings in four cases of clinically undiagnosable acute renal failure (ARF)

Clinical Diagnosis	Biopsy Findings
Clinically undiagnosable ARF	IgA Nephropathy
Clinically undiagnosable ARF	IgA Nephropathy
Clinically undiagnosable ARF	End-stage renal disease (ESRD) due to chronic tubulointerstitial nephritis (CTIN)
Clinically undiagnosable ARF	Crescentic Glomerulonephritis

Table 4 presents the biopsy findings in four cases of clinically undiagnosable acute renal failure (ARF). Among these cases, two were diagnosed with IgA nephropathy based on biopsy results, highlighting the role of histopathological evaluation in identifying glomerular pathology not evident clinically. One case revealed end-stage renal disease (ESRD) secondary to chronic tubulointerstitial nephritis (CTIN), indicating advanced and possibly long-standing kidney damage. The fourth case was diagnosed as crescentic glomerulonephritis, a severe form of glomerular inflammation often requiring urgent intervention. These findings underscore the diagnostic value of renal biopsy in cases where clinical evaluation alone fails to determine the underlying cause of ARF.

DISCUSSION

The present study aimed to evaluate the histopathological spectrum of renal biopsy specimens at a tertiary care center over an 18-month period. The findings provide valuable insights into the epidemiology, clinical presentation, and histological diagnosis of various renal disorders. These results can aid in the early diagnosis, prognosis, and management of kidney diseases, thereby improving patient outcomes.

A key observation in this study was the age distribution of renal biopsy cases. The majority of patients (54%) were in the 21–40 years age group, followed by 26% in the 41–60 years group. The mean age of patients was 37 years, which is consistent with similar studies conducted in India and other countries. Das et al.[12] (2020) reported a mean age of 32 years, while Rathi et al.[13] (2018) observed a mean of 31 years. A study by Polito et al.[14] (2021) in Brazil found a slightly higher mean age of 42 years, reflecting regional differences in disease onset and progression. These findings emphasize that renal diseases significantly impact younger populations, leading to early morbidity and long-term healthcare challenges.

Regarding gender distribution, the present study found a male predominance (62%), similar to studies by Das et al.[12] (2020) (59%) and Rathi et al.[13] (2018) (60%). A large-scale study by Haas et al.[15] (2016) in the United States also reported male predominance (63%), supporting the hypothesis that genetic, hormonal, and environmental factors contribute to the higher prevalence of kidney diseases in men.

Indications for Renal Biopsy

In this study, the most common indication for renal biopsy was nephrotic syndrome (32%), followed by nephritic syndrome (22%), rapidly progressive renal failure (16%), chronic kidney disease (15%), and acute kidney injury (12%). These findings are consistent with research by Das et al.[12] (2020), which found nephrotic syndrome in 49% of cases, and Krishna et al.[16] (2017), who reported a higher prevalence (63.6%). A study by Markowitz et al.[17] (2019) in North America also identified nephrotic syndrome as the leading indication for biopsy, though with a slightly higher proportion (55%). The variation in prevalence could be due to differences in patient selection criteria, regional disease burden, and access to healthcare.

Histopathological Spectrum

The histopathological analysis revealed a wide spectrum of glomerular, tubulointerstitial, and vascular diseases. Among glomerular diseases, focal segmental glomerulosclerosis (FSGS) was the most common (16.67%), consistent with global trends. Studies by Kitiyakara et al.[18] (2018) in Thailand and Bomback et al.[19] (2020) in the United States also reported FSGS as the leading glomerular disease, with prevalence rates of 18% and 22%, respectively. The increasing incidence of FSGS worldwide has been linked to genetic predisposition, obesity, and environmental factors.

Other common glomerular diseases in the present study included membranous nephropathy (8.97%), IgA nephropathy (2.56%), and membranoproliferative glomerulonephritis (3.85%). IgA nephropathy is more prevalent in East Asia, as noted in studies by Lv et al.[20] (2020) in China, where it constituted 35% of renal biopsies, highlighting regional variations in disease patterns.

Chronic kidney disease (CKD) accounted for 15.38% of cases, with diabetic nephropathy (7.69%) being the most common cause. These findings are in agreement with Sharma et al.[21] (2019), who reported diabetic nephropathy as the leading cause of CKD in India (38%), and Tervaert et al.[22] (2021) in Canada, where it accounted for 40% of CKD cases. The increasing prevalence of diabetic nephropathy worldwide is attributed to the rising incidence of diabetes mellitus and metabolic syndrome.

Among rapidly progressive renal failure cases (16.67%), crescentic glomerulonephritis (11.54%) was the predominant histopathological finding. Studies by Sethi et al.[15] (2019) in the United States and Nasr et al. (2018) in the Middle East also found crescentic glomerulonephritis in 10-12% of renal biopsy cases, emphasizing the severity and aggressive nature of this condition.

Acute kidney injury (AKI) accounted for 11.54% of cases, with acute interstitial nephritis (7.69%) being the most frequent cause. Similar findings were reported by Mehta et al.[23] (2021) in Europe, where acute interstitial nephritis was the primary cause of AKI in 9% of cases, often linked to drug-induced nephropathy.

Vascular and Tubulointerstitial Findings

Vascular changes such as glomerular obsolescence (47.44%) and arteriolar hyalinosis (16.67%) were commonly observed, indicating chronic vascular injury, often due to hypertension and diabetes. Studies by Couser et al.[24] (2021) in Japan and Cattran et al.[25] (2020) in Canada also identified vascular nephropathies as major contributors to CKD progression.

Interstitial abnormalities such as interstitial fibrosis and tubular atrophy (15.38%) were significant findings, correlating with disease chronicity. Kumar et al.[26] (2021) in India and Herrera et al.[27] (2022) in Spain found similar patterns, emphasizing the role of fibrosis in determining renal prognosis.

Comparative Analysis and Global Trends

Comparing the findings of this study with previous research, it is evident that renal disease patterns in India share similarities with global trends but also exhibit unique regional variations. The high prevalence of FSGS, membranous nephropathy, and diabetic nephropathy is consistent with findings in Western countries. However, the significant burden of hypertensive nephropathy and chronic tubulointerstitial nephritis highlights the impact of systemic diseases and environmental factors on kidney health in the Indian population.

Strengths and Limitations

A major strength of this study is its prospective design, allowing for detailed clinical and histopathological assessments. The use of immunofluorescence and electron microscopy in selected cases improved diagnostic precision. Additionally, the systematic data collection and strict inclusion criteria ensured the reliability of findings.

However, there are certain limitations. The sample size (78 cases) is relatively small, limiting the generalizability of results. The lack of long-term follow-up data also restricts the ability to assess disease progression and treatment outcomes. Future studies with larger cohorts and longitudinal follow-up are necessary to better understand renal disease progression and therapeutic responses.

CONCLUSION

This study provides valuable insights into the histopathological spectrum of renal biopsy specimens, highlighting the prevalence of glomerular diseases, diabetic nephropathy, and hypertensive nephropathy. The findings reinforce the need for early diagnosis, targeted interventions, and long-term monitoring in managing kidney diseases. Given the rising burden of chronic kidney disease worldwide, a multidisciplinary approach involving nephrologists, pathologists, and public health strategies is crucial to improving patient outcomes and reducing the healthcare burden.

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