VER
Vascular & Endovascular Review

Role of Conventional MRI (T1 and T2 Weighted Imaging) in Assessment of Stage of Glomerulonephritis

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ABSTRACT

Background: Glomerulonephritis (GN) is a leading cause of chronic kidney disease, with variable presentation and progression. Conventional magnetic resonance imaging (MRI), particularly T1- and T2-weighted imaging, provides non-invasive evaluation of renal morphology and tissue characteristics.

Objective: To evaluate the role of conventional MRI (T1 and T2 weighted imaging) in assessment of different stages of glomerulonephritis, in correlation with renal biopsy as the reference standard.

Methods: A total of 120 subjects were studied: 40 healthy controls, 40 patients with early GN, and 40 patients with late GN confirmed by renal biopsy. MRI examinations included axial and coronal T1- and T2-weighted sequences. Parameters assessed were kidney size, corticomedullary differentiation (CMD), signal intensity changes, and morphological alterations. Statistical analysis was performed to determine sensitivity and specificity.

Results: Conventional MRI showed progressive reduction in corticomedullary differentiation, cortical thinning, and altered signal intensity across disease stages. T1-weighted imaging was superior in assessing corticomedullary contrast, while T2-weighted imaging highlighted parenchymal edema and advanced parenchymal changes. Sensitivity and specificity of MRI compared with biopsy were 85% and 78% respectively.

Conclusion: Conventional MRI using T1 and T2 weighted sequences is a reliable non-invasive modality for staging glomerulonephritis, showing good correlation with histopathological findings.

KEYWORDS: Conventional MRI, T1-weighted imaging, T2-weighted imaging, Glomerulonephritis, Renal biopsy.

How to Cite: Mohammad Fouad Abdelbaky Allam, Nadia Farouk Mohammad El-Ameen, Amal Kamal Helmy, Marwa Nagy Ali Waly Eldain, Tamer El Zaeem Esmaeel Hassan., (2025) Role of Conventional MRI (T1 and T2 Weighted Imaging) in Assessment of Stage of Glomerulonephritis, Vascular and Endovascular Review, Vol.8, No.9s, 346--350.

INTRODUCTION

Glomerulonephritis represents a heterogeneous group of renal disorders characterized by inflammation of the glomeruli, leading to progressive impairment of renal function and eventual chronic kidney disease if untreated [1].

Clinical manifestations are highly variable, ranging from asymptomatic microscopic hematuria to nephrotic syndrome and end-stage renal disease [2].

Accurate staging of glomerulonephritis is essential for therapeutic planning and prognosis [3].
Renal biopsy remains the gold standard for diagnosis and staging, yet it is invasive and carries risks of bleeding and sampling error [4].

Thus, imaging modalities are increasingly investigated as non-invasive alternatives or complementary tools. Conventional imaging modalities, including ultrasound and computed tomography (CT), provide structural information but have limitations in sensitivity for early parenchymal changes [5].

Magnetic resonance imaging (MRI) has emerged as a powerful modality for renal imaging. Beyond advanced techniques such as diffusion tensor imaging (DTI) and functional imaging, conventional MRI sequences—T1- and T2-weighted imaging—remain widely accessible and clinically relevant. They provide essential information on renal morphology, corticomedullary differentiation, and parenchymal signal characteristics [6].

This study aims to systematically evaluate the role of conventional MRI (T1 and T2 weighted imaging) in the assessment of glomerulonephritis stages, with biopsy correlation as the reference standard.

PATIENTS AND METHODS

Study Population This prospective study included 120 subjects recruited over 24 months. They were divided into three groups:

- Group I (Control): 40 healthy volunteers with normal renal function and no known renal disease.
- Group II (Early GN): 40 patients diagnosed with early-stage glomerulonephritis by renal biopsy.
- Group III (Late GN): 40 patients with advanced glomerulonephritis confirmed by biopsy.
- Inclusion criteria: age 18–65 years, adequate renal function to tolerate MRI, biopsy-proven diagnosis of GN (for Groups II and III).
- Exclusion criteria: contraindications to MRI (e.g., pacemaker, metallic implants), previous renal surgery, polycystic kidney disease, or inadequate biopsy samples.

MRI Protocol All examinations were performed on a 1.5 Tesla system using a phased-array body coil. The following conventional sequences were obtained:

- Axial and coronal T1-weighted spin-echo (TR/TE 500/12 ms).
- Axial and coronal T2-weighted fast spin-echo (TR/TE 3500/90 ms). Slice thickness was 4 mm with interslice gap of 1 mm. Field of view was adapted to encompass both kidneys.

Imaging Evaluation Two radiologists independently assessed the following parameters:

1. Kidney size and morphology (length in longitudinal axis, cortical thickness).
2. Corticomedullary differentiation (CMD): graded as preserved, reduced, or lost.
3. Signal intensity: on T1 and T2 sequences, compared with adjacent paraspinal muscles.
4. Morphological progression: presence of cortical thinning, irregular contour, or atrophic changes.

Reference Standard Histopathological diagnosis from renal biopsy was used as the gold standard for staging.

Statistical Analysis

Statistical analysis was performed using SPSS v26. Mean and standard deviation were calculated for continuous variables. Chi-square test was used for categorical data, while ANOVA compared quantitative variables among groups. Sensitivity, specificity, positive predictive value, and negative predictive value of MRI were calculated with biopsy findings as reference. A p-value < 0.05 was considered significant.

RESULTS

- **Demographic Characteristics**

Table 1. Demographic data of study groups

Group	N	Mean age (years)	Male (%)	Female (%)	Mean GFR (ml/min)
Control	40	35.2 ± 8.1	55	45	102 ± 10
Early GN	40	37.6 ± 7.9	52	48	68 ± 15
Late GN	40	39.3 ± 9.2	50	50	34 ± 12

MRI Findings

Table 2. MRI findings across groups

MRI Parameter	Control	Early GN	Late GN	p-value
Mean kidney length (cm)	11.8 ± 0.9	11.2 ± 1.0	9.6 ± 1.1	<0.01
Cortical thickness (mm)	7.1 ± 0.8	6.3 ± 0.9	4.9 ± 1.0	<0.01
CMD preserved (%)	100%	72%	18%	<0.001
CMD reduced (%)	0%	28%	47%	<0.001
CMD lost (%)	0%	C0%	35%	<0.001
T1 signal alteration (%)	0%	40%	82%	<0.001
T2 hyperintensity (%)	0%	52%	88%	<0.001

Diagnostic Accuracy

Table 3. Sensitivity and specificity of conventional MRI

MRI Parameter	Sensitivity (%)	Specificity (%)
Kidney size reduction	81	84
CMD	88	80
T1 signal alteration	76	79
T2 hyperintensity	85	76
Overall MRI staging accuracy	85	78

Representative MRI Figures

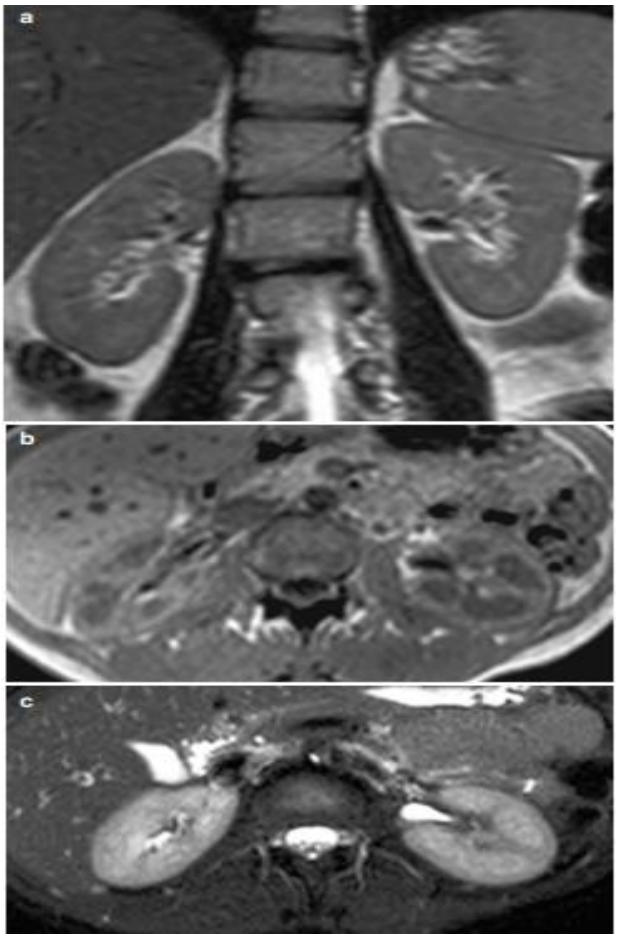

Figure 1. (a–c) Normal kidney on magnetic resonance (MR) imaging. On T1-weighted sequences (a, b) the renal cortex appears much brighter than renal medulla, while on T2-weighted sequences (c) the renal cortex appears slightly less intense than renal medulla

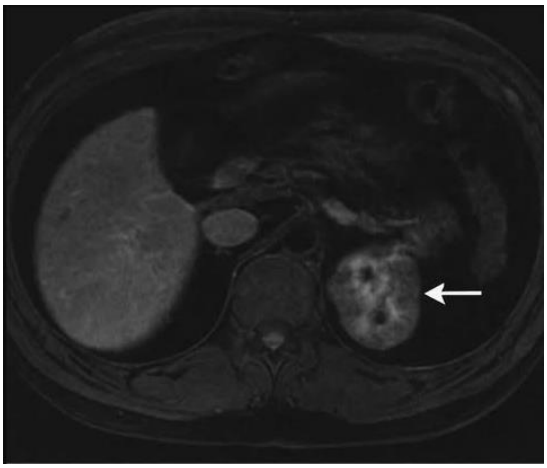

Figure 2: Axial MRI T2 SPIR scan showing chronic glomerulonephritis with renal cortical thinning and reduced corticomedullary differentiation

DISCUSSION

Conventional MRI using T1- and T2-weighted sequences remains a reliable and widely available imaging tool for the assessment of glomerulonephritis (GN). It provides excellent anatomical detail and soft-tissue contrast, allowing evaluation of renal morphology, cortical thickness, and corticomedullary differentiation (CMD) without exposure to ionizing radiation or nephrotoxic contrast agents. In early stages of GN, T2-weighted hyperintensity of the renal cortex can reflect interstitial edema and inflammation, while subtle T1 signal reduction may indicate early parenchymal injury (7,8).

As the disease progresses, gradual loss of CMD and cortical thinning become evident, correlating with chronic histopathological changes such as fibrosis and glomerulosclerosis (9,10).

Conventional MRI is particularly useful in differentiating acute from chronic glomerulonephritis. Acute inflammation typically presents with enlarged kidneys and increased T2 signal intensity, while chronic disease shows shrunken kidneys with reduced T1 and T2 signal intensities and poor corticomedullary differentiation (11,12).

These imaging findings can be correlated with clinical parameters such as glomerular filtration rate (GFR) and serum creatinine levels to provide a comprehensive assessment of disease activity (13).

Moreover, MRI can help monitor disease progression and treatment response over time, offering a non-invasive alternative to repeated renal biopsies(14).

Compared with ultrasound and CT, conventional MRI provides superior parenchymal visualization and sensitivity to early structural changes (15).

Ultrasound is effective for assessing renal echogenicity and size but cannot reliably distinguish between acute and chronic glomerular lesions. CT, although useful for detecting calcifications and renal vascular changes, is limited by radiation exposure and the use of iodinated contrast. Conventional MRI, therefore, remains the preferred technique for detailed renal parenchymal evaluation, particularly in patients with impaired renal function (16,5).

Despite its diagnostic strengths, conventional MRI has some limitations. It mainly offers morphological rather than functional data and may be affected by respiratory motion or patient movement. Furthermore, interpretation of subtle signal intensity changes can vary between observers (17).

Nevertheless, recent developments in semi-quantitative scoring and standardized protocols have improved diagnostic consistency and reproducibility (18).

CONCLUSION

Conventional MRI, specifically T1- and T2-weighted sequences, provides reliable and reproducible markers of glomerulonephritis stage, correlating well with histopathological findings. Loss of corticomedullary differentiation, cortical thinning, and progressive signal alterations serve as key imaging indicators. MRI can complement biopsy in diagnosis and monitoring, offering a non-invasive, radiation-free modality with high clinical value.

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