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Application of Magnetic Resonance Imaging in the Evaluation of Stroke: An Imaging Based Cross Sectional Analysis

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ABSTRACT

Background: Stroke continues to impose a substantial health burden worldwide, and its consequences are particularly pronounced in low and middle-income countries, where delayed presentation and limited availability of advanced imaging frequently complicate early diagnosis [3,4,10,11]. In emergency settings, separating ischemic from hemorrhagic injury and determining the temporal stage of infarction remain central to modern stroke management. While CT is indispensable for identifying acute haemorrhage, MRI,most notably diffusion imaging offers the capacity to depict ischemic injury long before structural changes are obvious on routine sequences [6,7].

Aim: To evaluate the diagnostic contribution of a focused MRI protocol in patients clinically suspected of stroke.

Methods: A cross-sectional observational study was conducted on 100 consecutive patients undergoing MRI of the brain for suspected stroke. Standard sequences (T1-, T2-, FLAIR), DWI with ADC, SWI, and TOF-MRA were acquired on 1.5-T systems. Imaging findings were correlated with clinical data to determine stroke subtype, estimate infarct age, and identify involved vascular territories.

Results:
Individuals aged 60–69 years formed the largest subgroup (24%). Males comprised 68%. Hypertension (58%) and diabetes (50%) were the leading risk factors. Ischemic stroke occurred in 86% of patients, hemorrhage in 13%, and stroke mimics in 1%. Acute infarcts (24 hours–7 days) predominated. The MCA territory was most frequently affected (50.6%). DWI identified 9.2% of ischemic lesions not visible on T2WI. Hemorrhagic strokes most often involved the basal ganglia and thalamus.

Conclusion: A concise MRI protocol centered on DWI/ADC, FLAIR, SWI, and TOF-MRA offers reliable characterization of stroke subtype and timing and provides critical information regarding vascular involvement. When logistically feasible, incorporating such protocols into early evaluation can enhance diagnostic confidence and improve clinical decision-making.

Keywords: Stroke, MRI, DWI, SWI, Ischemia, Hemorrhage, TOF-MRA.

I. INTRODUCTION

Stroke remains a major source of neurological disability, and its rising incidence in many low-resource settings has drawn renewed attention to the need for rapid and effective diagnostic pathways [3,4,10,11]. In these environments, delayed arrival to medical facilities and limited availability of advanced neuroimaging often impede early intervention. Consequently, imaging techniques capable of providing both sensitivity and specificity in the acute window are increasingly important.

Although non-contrast CT remains the first step in emergency assessment—primarily to exclude intracranial hemorrhage—its capacity to detect early ischemic injury is inherently limited [6,7]. MRI, by contrast, offers several complementary contrasts that allow clinicians to appreciate subtle parenchymal alterations well before overt structural change develops. Among these, diffusion-weighted imaging has transformed the evaluation of acute stroke by identifying the cytotoxic edema that emerges within minutes of vascular occlusion [6,8,19]. DWI can reveal abnormalities even when T2-weighted and FLAIR sequences remain unremarkable, and this property is especially valuable in patients with uncertain onset times, where mismatch patterns may assist in treatment decisions [8].

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Additional MRI sequences enhance diagnostic precision in other dimensions. SWI is particularly useful for detecting microbleeds, small foci of hemorrhagic transformation, and venous congestion [6,7]. TOF-MRA provides a non-contrast evaluation of major intracranial arteries and helps identify stenosis or occlusion in emergent settings. High-resolution vessel-wall imaging, though not part of the present protocol, has gained recognition for its ability to distinguish atherosclerotic plaque from vasculitis or dissection and is likely to contribute more broadly to stroke evaluation in coming years [1,25].

Given the sustained burden of stroke within India and the need for dependable imaging information early in the patient's clinical course [4,9,13,16], this study was undertaken to assess how a compact MRI stroke protocol performs in day-to-day clinical practice. The emphasis was placed on defining stroke subtype, gauging infarct age, determining vascular territory involvement, and evaluating the incremental utility that DWI provides relative to conventional imaging.

AIM
To evaluate the diagnostic role of MRI in the assessment of patients presenting with suspected stroke.

OBJECTIVES
• To determine the utility of MRI in distinguishing ischemic from hemorrhagic stroke.
• To classify infarcts by MRI-based age characteristics and explore their relevance to decisions regarding thrombolytic therapy.

II. MATERIALSAND METHODS
Study Design and Setting
The present **observational cross-sectional study** was conducted in the Department of Radiodiagnosis and Imaging co**nducted in the department of Radiodiagnosis at HI-TECH Medical College & Hospital, Bhubaneswar**for a period of **12 months**, from **December 2023 to December 2024**, following approval from the Institutional Ethics and Scientific Committee.

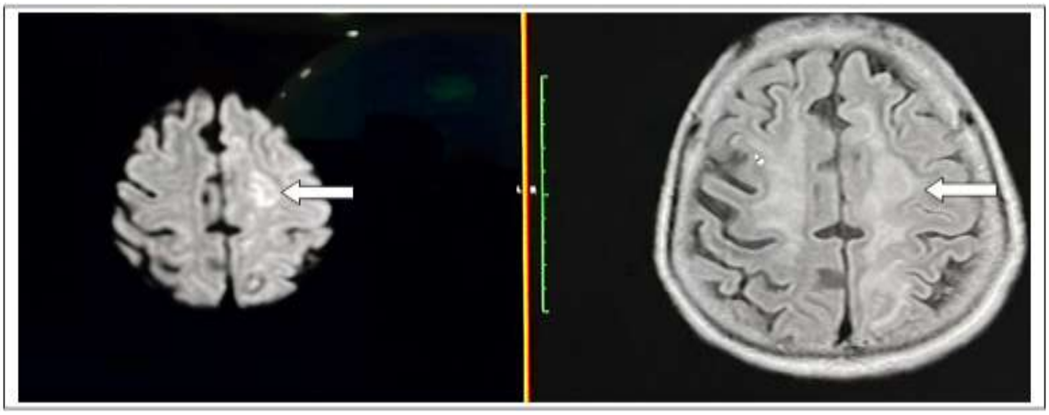
Participants
One hundred patients of all ages and both sexes with clinical suspicion of stroke and referred for MRI were enrolled following informed consent.

Inclusion Criteria
• Clinical suspicion of stroke
• Suitability for MRI

Exclusion Criteria
• Claustrophobia
• Standard contraindications to MRI (cardiac pacemaker, certain metallic implants, orbital metallic fragments)
• Refusal to participate

Imaging Protocol
Imaging was performed on 1.5-T Siemens Sempra and GE SIGNA systems, incorporating the following sequences:
• T1-weighted imaging
• T2-weighted imaging
• FLAIR
• DWI with ADC mapping
• SWI
• 3D TOF-MRA
Scans were acquired in multiple orthogonal planes, with a field of view approximating 230 mm.

Data Handling
Clinical details, vascular risk factors, and imaging results were recorded in a structured format. Statistical analysis was descriptive, using Microsoft Excel 16.0.



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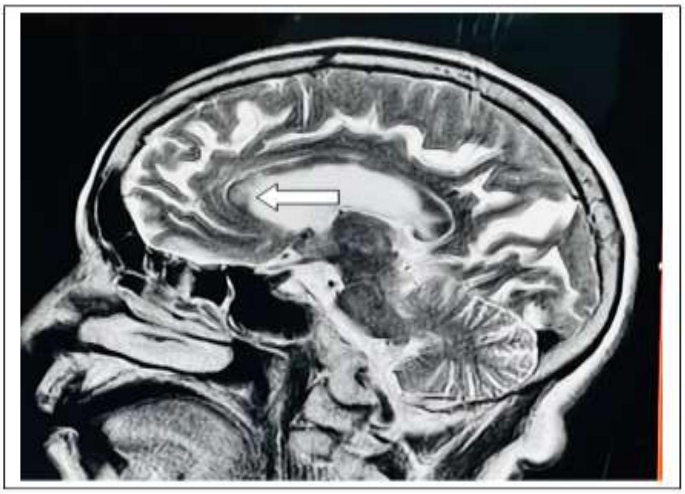

Figure 3.
Axial DWI (A) and T2 FLAIR (B) and T2 SAG showing hyperintensity with diffusion restriction in left frontopareital sub cortical & deep white matter, left genu and body of corpus callosum.

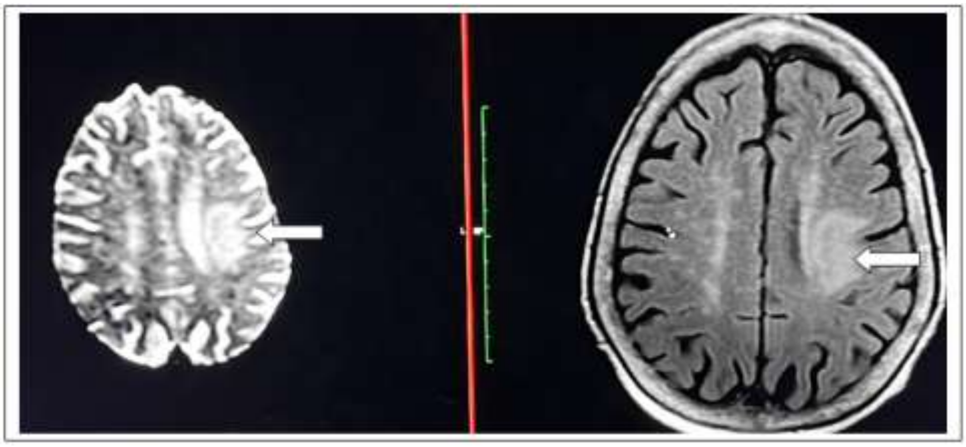

Figure 3.
Axial DWI (A) and T2 FLAIR (B) showing hyperintensity in left frontal region showing diffusion restriction in a 83-year-old female

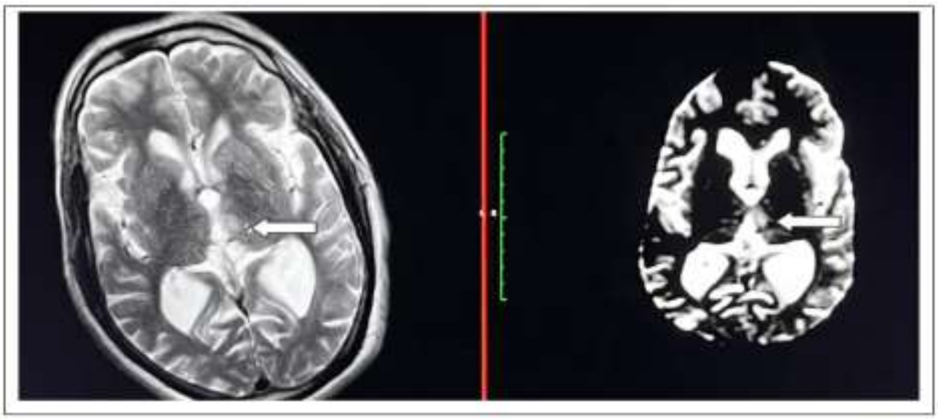

Figure 3.
Axial T2 and DWI showing hyperintense focus in left thalamus region showing diffusion restriction in a 55-year-old male

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III. OBSERVATIONS AND RESULTS

Table 1. Age-wise distribution of patients

Age Group (years)	Number of Cases	Percentage (%)
<20	4	4.0
20–29	6	6.0
30–39	8	8.0
40–49	14	14.0
50–59	21	21.0
60–69	24	24.0
70–79	18	18.0
≥80	5	5.0
Total	**100**	**100.0**

The largest proportion of cases fell within 60–69 years, mirroring global observations that stroke risk increases steadily with age.

Table 2. Gender distribution

Gender	Number of Patients	Percentage (%)
Male	68	68.0
Female	32	32.0
Total	**100**	**100.0**

Men represented 68%, reflecting a pattern documented in multiple stroke surveys worldwide

Table 3. Distribution of vascular risk factors

Risk Factor	No. of Patients	Percentage (%)
Hypertension	58	58
Diabetes Mellitus	50	50
Smoking	39	39
Hypercholesterolemia	34	34
Atrial Fibrillation	7	7
Cardiovascular Disease	12	12
Diabetes + Hypertension	33	33

Hypertension and diabetes were the predominant comorbidities, with smoking and hypercholesterolemia also frequently encountered

Table 4. Presenting clinical features

Clinical Feature	Cases
Hemiplegia	66
Gait Disturbance	25
Facial Palsy	22
Vertigo	24
Aphasia	19
Vomiting	15
Visual Disturbances	17
Headache	18

Hemiplegia was the leading symptom, supported by additional motor, sensory, and vestibular complaints across the cohort.

Table 5. Etiologic classification of stroke

Stroke Type	Cases	Percentage (%)
Ischemic (Infarcts)	86	86.0
Intracerebral Hemorrhage	13	13.0
Stroke Mimics	1	1.0
Total	**100**	**100.0**

Ischemic stroke accounted for 86% of cases, intracerebral haemorrhage for 13%, and stroke mimics for 1%.

Table 6. Infarct age categorization based on MRI

Infarct Stage	Cases	Percentage (%)
Hyperacute (0–24 hrs)	8	9.3
Acute (24 hrs–7 days)	67	77.0
Subacute (1–3 weeks)	7	8.0
Chronic (>3 weeks)	5	5.7
Total	**87**	**100.0**

Most ischemic lesions were acute (24 hours–7 days), while hyperacute, subacute, and chronic infarcts comprised the remainder

Table 7. Involved vascular territories

Vascular Territory	Cases	Percentage (%)
MCA	44	50.6
PCA	12	13.8
ACA	5	5.7
Watershed Zones	6	6.9
Lacunar Infarcts	4	4.6
Multiple Territories	10	11.5
Basilar Artery	6	6.9
Total	**87**	**100.0**

The MCA territory was involved most frequently (50.6%), with PCA, ACA, watershed, lacunar, and brainstem territories contributing smaller proportions.

Table 8. Detection rates in T2WI vs DWI

Pattern	No. of Patients	Percentage (%)
T2WI Positive + DWI Positive	79	90.8
T2WI Negative + DWI Positive	8	9.2
Total	**87**	**100.0**

DWI demonstrated clear superiority, identifying early lesions not yet apparent on T2-weighted imaging

Table 9. Distribution of intracerebral haemorrhage sites

Hemorrhage Location	Cases	Percentage (%)
Basal Ganglia	5	38.5
Thalamus	3	23.0
Intraventricular	1	7.5
Lobar	4	31.0
Total	**13**	**100.0**

Deep gray-matter sites including the basal ganglia and thalamuswere the most common locations for haemorrhage.

IV. DISCUSSION

The results of this study reaffirm MRI's central role in the diagnostic evaluation of suspected stroke. The predominance of ischemic pathology in this cohort aligns closely with national and global epidemiological patterns [3,4,16]. Age and risk-factor distributions similarly reflect well-documented trends in Indian populations, particularly the high burden of hypertension and diabetes [9,13,16,20].

DWI's contribution stands out prominently. Its ability to delineate acute ischemia even when conventional sequences appear unremarkable is well established, and the present findings are consistent with this principle [6,8,19]. Early detection is particularly relevant when the time of onset is unclear, since MRI-derived age characteristics help guide decisions regarding thrombolysis.

The strong representation of MCA-territory infarction was anticipated, as this vascular bed is both extensive and vulnerable to embolism or in situ thrombosis [21]. The presence of watershed and lacunar infarcts illustrates the range of ischemic mechanisms encountered, from systemic hypoperfusion to small-vessel pathology [18,21].

SWI contributed valuable information about hemorrhagic components and micro vascular changes, which carry important implications for antithrombotic management [6,7]. TOF MRA proved useful in assessing flow-limiting disease in intracranial vessels without contrast exposure-a notable benefit in emergency practice.

Although vessel wall imaging was not part of this protocol, current evidence strongly suggests that it can help resolve stroke aetiologies that remain uncertain after standard angiography [1,25]. Incorporating such advances may further improve etiological classification.

Hemorrhagic lesions in this study followed expected patterns, with basal ganglia and thalamic involvement suggesting longstanding hypertensive arteriopathy [18,24]. These findings reinforce the clinical necessity of aggressive cardiovascular risk-factor modification.

Overall, the study demonstrates that a focused MRI protocol offers comprehensive diagnostic information that extends beyond simple stroke confirmation. It characterizes lesion age, vascular involvement, and microvascular pathology, and thus serves as a highly informative tool in acute stroke evaluation.

V. CONCLUSION

A structured MRI protocol incorporating DWI/ADC, FLAIR, SWI, and TOF-MRA provides a multidimensional evaluation of suspected stroke, allowing accurate distinction between ischemic and hemorrhagic events, reliable estimation of infarct timing, and clear identification of implicated vascular territories. When used in the acute phase, it improves diagnostic precision and supports timely, evidence-based decision-making.

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Additional Information

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