(International Print/Online Journal)

SJIF IMPACT FACTOR: 6.829
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 9, Issue 3, Page No: 431-438
May-June 2026

IJMSCR

Decoding Cerebral Palsy: Magnetic Resonance Imaging Spectrum Of Brain With Clinical Correlation In Paediatric Age Group

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Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

Background: Cerebral palsy (CP) is mostly a neuromotor condition that impacts the development of movement, muscle tone and posture.

Methodology: The Descriptive cross-sectional study was conducted in the department of Radio-diagnosis, J.J.M. Medical College Davangere (Bapuji Hospital), Karnataka over a period of 18 months, 50 cases were included in the study.

Results: The MRI patterns observed included disorders of cortical formation and maldevelopments 8(16%), Predominant white matter injury 12(24%), Predominant grey matter injury 20(40%), Cerebellar atrophy, cerebral atrophy, delayed myelination, brainstem lesions, calcifications 10(20%). Higher MRICS grades were predominantly observed in children aged 1–2 years. Male children constituted the majority across all MRICS grades. we observed MRI findings significant correlation with the prediction of functional outcomes($p=0.016$). Nonetheless, its function in assisting in prognosis ($p=0.37$) and treatment planning($p=0.29$), although practically valuable, does not exhibit a statistically significant correlation across MRICS grades in this study.

Conclusion: This study confirms that cerebral palsy, despite its clinical diversity, frequently exhibits specific and identifiable patterns on MRI. The incorporation of neuroimaging into the diagnostic paradigm enhances the comprehension of pathophysiology, facilitates more precise classification, and provides enhanced prognostic clarity. MRI functions as an essential link between clinical observation and anatomical data, facilitating more accurate, effective, and individualized treatment for children with Cerebral Palsy.

Keywords: Brain, cerebral palsy, magnetic resonance imaging spectrum

Introduction

Cerebral palsy (CP) is mostly a neuromotor condition that impacts the development of movement, muscle tone, and posture. This refers to a collection of chronic mobility and postural abnormalities that result in activity limitations, linked to nonprogressive disturbances in the developing fetal or immature brain.[1,2]

While the primary neuropathologic lesion is non-progressive, children with cerebral palsy may subsequently acquire several secondary diseases that might differentially impact their functional capabilities.[3,4] Shevell et al., has reported that cerebral palsy can be studied as a spectrum disorder rather than a discrete clinical entity.[5]

Prenatal factors account for around 80% of cerebral palsy instances, whereas postnatal factors contribute to about 10% of cases.[6]

The aggregated prevalence of cerebral palsy in India was 2.95 per 1000 surveyed children.[7]

Neuroimaging is crucial for assessing the location, timing, and severity of brain injuries; hence, cranial magnetic resonance imaging (MRI) has been endorsed by the American Academy of Neurology since 2004, as an investigation after a comprehensive history, neurological examination, and assessment of supplementary deficits. Various studies indicated that neuroimaging patterns were associated with the illness subtype and clinical manifestations, including motor function.[8,9]

The MRI classification system (MRICS) consists of five main groups: maldevelopments, predominant white matter injury, predominant grey matter injury, miscellaneous, and normal findings.[10,11]

A research by Kumar BK et al. indicated that the majority of cerebral palsy patients have neuroimaging findings on MRI, with relatively few lacking such findings. A association existed between motor function and the kind of cerebral palsy, as well as the degree and type of brain lesions shown in MRI scans.[12]

Objectives

1. Identifying and characterizing structural abnormalities in the brain through MRI, such as malformations, lesions, or white matter abnormalities.
2. Explore the potential of specific MRI findings as predictive markers for functional outcomes in cerebral palsy, assisting in prognosis and treatment planning.
3. To categories the patients into different subgroups based on MRICS grading which broadly includes maldevelopments, predominantly white and gray matter lesions and miscellaneous.
4. To correlate MRI findings with perinatal history, developmental history and Clinical features.

Mateials And Methods

1. The study is descriptive cross-sectional study done on 50 cases over a period of 18 months in the department of Radiodiagnosis, J.J.M. Medical College, Davangere
2. Imaging techniques: MRI scans are performed by Phillips (Archiva), 1.5Tesla machine
3. Qualitative variables were expressed as frequencies(percentages). Chi square test and Fisher exact test were applied for categorical variables as applicable. P-value<0.05 was considered to be statistically significant and p-value<0.01 was considered as highly statistically significant.
4. Categorize the cases based on MRI findings as mentioned below
    a. Disorders of cortical malformation like proliferation, organization and migration disorders and other maldevelopments like corpus callosum agenesis, pachygyria.
    b. Predominant white matter injury like periventricular leukomalacia and Sequelae intraventricular hemorrhage or periventricular hemorrhagic infarction or both combined.
    c. Predominant grey matter injury like thalamus and basal ganglia lesions and others like Cortico-subcortical lesions only (watershed lesions in parasagittal distribution / multicystic encephalomalacia).
    d. Arterial infarctions (MCA and others)
    e. Miscellaneous like cerebellar atrophy, cerebral atrophy, delayed myelination, ventriculomegaly, brain stem lesions and calcifications.

1.Distribution of Types of Cerebral Palsy

Type of cerebral palsy	Number of patients	%
Spastic	32	64
Dyskinetic	2	4
Spastic dyskinetic	6	12

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Spastic hemiplegia	**10**	**20**

Spastic cerebral palsy was the most prevalent type (64%), followed by spastic hemiplegia (20%). Dyskinetic and spastic dyskinetic types were less common.

2.Distribution of MRICS Grading

MRI patterns observed	Number of patients	%
Disorders of cortical formation and maldevelopments -(MRICS grade A)	8	16
Predominant white matter injury- (MRICS grade B)	12	24
Predominant grey matter injury- (MRICS grade C)	20	40
Cerebellar atrophy, cerebral atrophy, delayed myelination, brainstem lesions, calcifications- (MRICS grade D)	10	20
Normal- (MRICS grade E)	0	0

MRICS grade ‘c’ was the most common (40%), followed by grade ‘b’ (24%) and grade ‘d’ (20%).

3. Association of Clinical Variables with MRICS Grading

Variables	**MRICS grading**					**p-value**
	a(n=8)	**b(n=12)**	**c(n=20)**	**d(n=10)**	**e(n=0)**	
Developmental delay						
• **Present**	**8(100)**	**12(100)**	**13(65)**	**0(0)**	**0(0)**	**<0.01****
• **Absent**	**0(0)**	**0(0)**	**7(35)**	**10(100)**	**0(0)**	
Trouble with motor skills						
• **Present**	**0(0)**	**8(66.67)**	**0(0)**	**0(0)**	**0(0)**	**<0.01****
• **Absent**	**8(100)**	**4(33.33)**	**20(100)**	**10(100)**	**0(0)**	
Abnormal body and muscle tone						
• **Present**	**2(25)**	**8(66.67)**	**20(100)**	**10(100)**	**0(0)**	**<0.01****
• **Absent**	**6(75)**	**4(33.33)**	**0(0)**	**0(0)**	**0(0)**	
Spasticity						
• **Present**	**8(100)**	**12(100)**	**20(100)**	**5(50)**	**0(0)**	**<0.01****
• **Absent**	**0(0)**	**0(0)**	**0(0)**	**5(50)**	**0(0)**	

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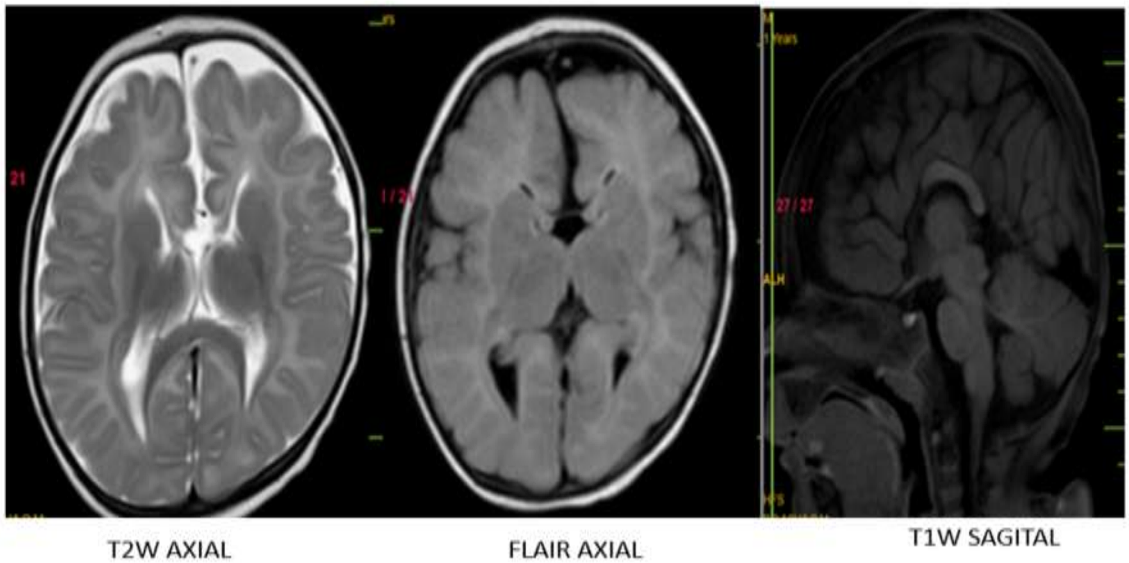
Hypotonia						
• **Present**	**0(0)**	**0(0)**	**0(0)**	**5(50)**	**0(0)**	**<0.01****
• **Absent**	**8(100)**	**12(100)**	**20(100)**	**5(50)**	**0(0)**	
Trouble with speech						
• **Yes**	**0(0)**	**4(33.33)**	**0(0)**	**0(0)**	**0(0)**	
• **Mild**	**0(0)**	**5(41.67)**	**0(0)**	**0(0)**	**0(0)**	**<0.01****
• **No**	**8(100)**	**3(25)**	**20(100)**	**10(100)**	**0(0)**	
Difficulty in eating						
• **Present**	**0(0)**	**0(0)**	**0(0)**	**5(50)**	**0(0)**	**<0.01***
• **Absent**	**8(100)**	**12(100)**	**20(100)**	**5(50)**	**0(0)**	
Difficulty in coordination and balance while walking						
• **Present**	**0(0)**	**0(0)**	**0(0)**	**10(100)**	**0(0)**	**<0.01****
• **Absent**	**8(100)**	**12(100)**	**20(100)**	**0(0)**	**0(0)**	
Difficulty in fine motor skills like grasping						**<0.01****
• **Present**	**8(100)**	**12(100)**	**14(70)**	**0(0)**	**0(0)**	
• **Absent**	**0(0)**	**0(0)**	**6(30)**	**10(100)**	**0(0)**	
Past history						
• **Negative**	**8(100)**	**12(100)**	**13(65)**	**10(100)**	**0(0)**	**0.007****
• **Similar complications in siblings**	**0(0)**	**0(0)**	**7(25)**	**0(0)**	**0(0)**	

A statistically significant association was observed between MRICS grading and developmental delay, motor difficulties, muscle tone abnormalities, spasticity, hypotonia, speech difficulty, feeding difficulty, coordination issues, fine motor impairment, and past history ($p < 0.01$).

Figure 1: 1.5yr/old – male baby - H/o global developmental delay. Absence of genu and rostrum with cingulate gyrus in the anterior half with thinning of splenium of corpus callosum and normal appearing body. Thinning and parallelly placed frontal horns with dilatation of occipital horns of bilateral lateral ventricle- MRICS grade A- partial agenesis of corpus callosum



Case 2

Figure 2: 14month baby with seizures and delayed mile stones. Asymmetric right cerebral hemisphere involving predominantly parietal and occipital lobes with prominent posterior horn of right lateral ventricle - Features in favor of right sided partial megalencephaly.

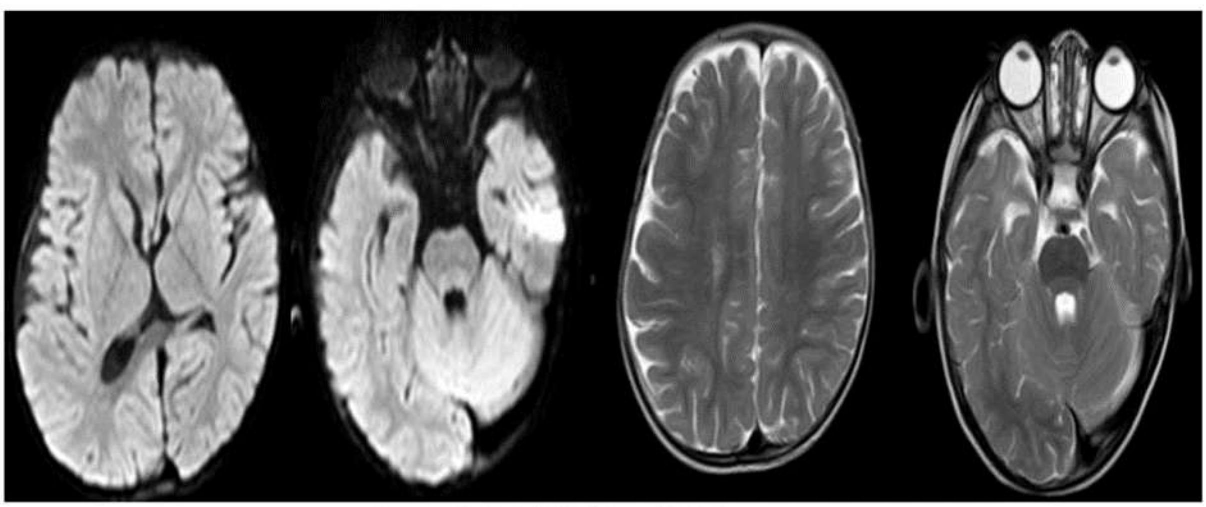


Figure 2: Axial FLAIR and T2W

Case 3

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Figure 3: 9month old term baby with history of birth asphyxia and developmental delay. Imaging-Symmetric diffuse areas of FLAIR hyperintensities showing true diffusion restriction in bilateral peri Rolandic area, basal ganglia, splenium of corpus callosum, hippocampi and mesial temporal lobes PREDOMINANT GRAY MATTER INJURY-- S/O MRICS GRADE C gray matter injury

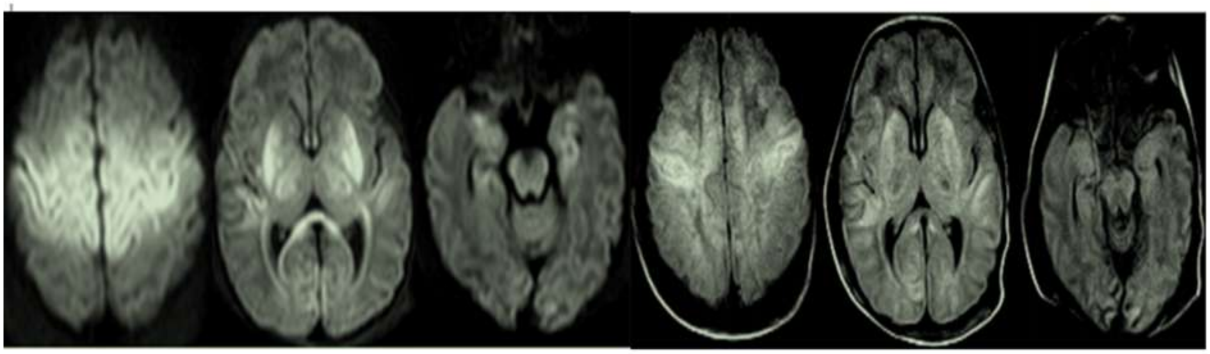

Figure 3a. DWI axial Figure 3b. FLAIR axial

Case 4.

Figure 4: 1 year old female with left hemiparesisAcute non-haemorrhagic infarct involving right cerebral hemisphere with occlusion of distal M1, M2, M3 and M4 branches of right MCA- MRICS GRADE C gray matter injury (arterial infarction)

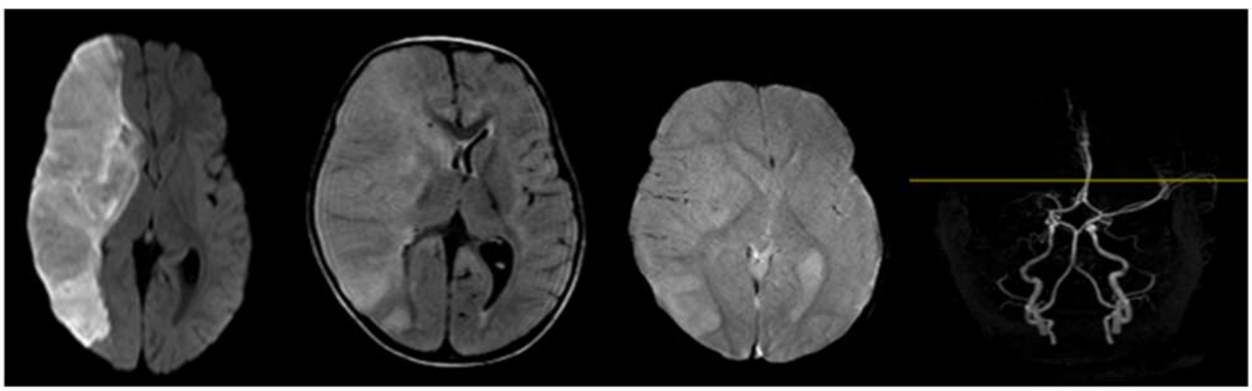

Figure4: Axial DWI Axial FLAIR Axial GRE MRA reformatted

Case 5.

Figure 5: 5month old male baby with preterm delivery and birth asphyxia. Multiple cysts of varying sizes and shapes diffusely involving the bilateral cerebral hemispheres and basal ganglia with thinning of cerebral cortex Multicystic encephalomalacia- Sequele of chronic hypoxic ischemic Encephalopathy-MRICS GRADE C

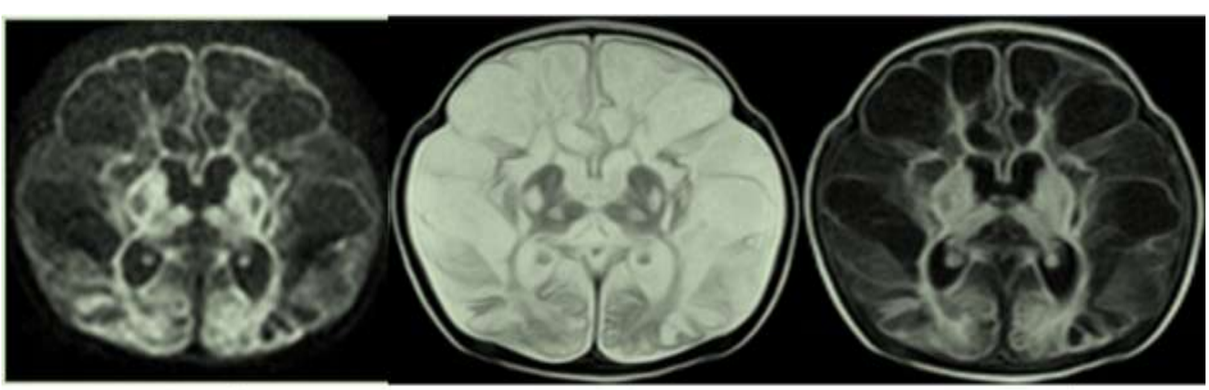

Figure 5: DWI axial T2 axial FLAIR axial

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Figure 6: 9month old male preterm baby with birth asphyxia, microcephaly and developmental delay. Imaging shows Simplified gyral pattern involving anterior fronto-temporal lobes- Pachygyria -MRICS GRADE A

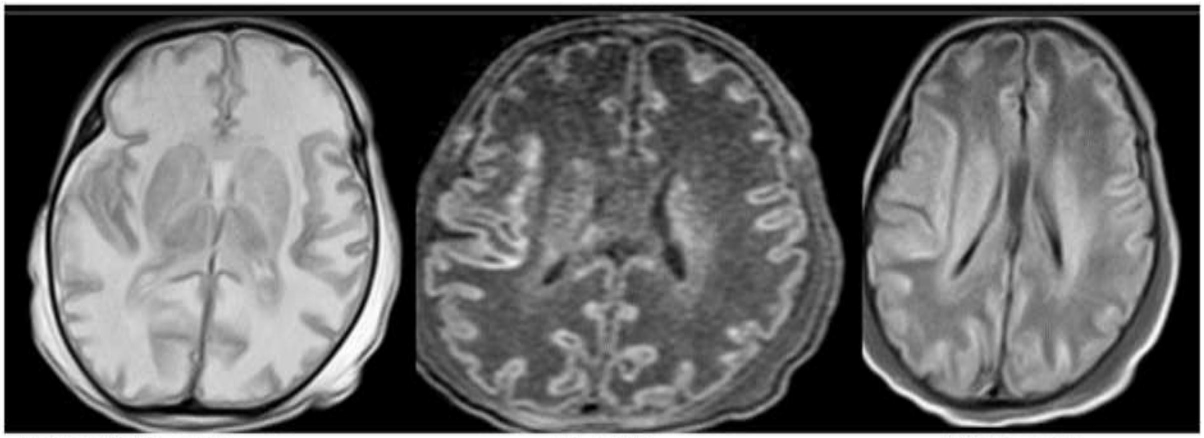

Figure 6: T2 axial T1 axial FLAIR axial

Discussion

The Classification system was based on pathologic patterns manifesting throughout various stages of brain development. The MRI classification system (MRICS) has five primary categories: maldevelopments, primarily white matter damage, predominant grey matter injury, miscellaneous, and normal results.

In this study, the MRI patterns observed included disorders of cortical formation and maldevelopments 6(16%), Predominant white matter injury 12(24%), Predominant grey matter injury 20(40%), cerebral atrophy, delayed myelination, 10(20%).

A similar study conducted by Kate Himmelmann, et al., conducted a study on MRI classification (MRICS) for children with CP, this classification includes five main groups, results showed that MRI abnormal findings were seen in 86% of CP cases and indicated pathogenesis in 83%, most frequent finding was periventricular white matter injury(56%) followed by deep gray matter injury (18%) and maldevelopment of brain (9%).11

Conclusion

1. We observed MRI findings significant correlation with the prediction of functional outcomes. Nonetheless, its function in assisting in prognosis and treatment planning, although practically valuable, does not exhibit a statistically significant correlation across MRICS grades in this study.
2. This study confirms that cerebral palsy, despite its clinical diversity, frequently exhibits specific and identifiable patterns on MRI. The incorporation of neuroimaging into the diagnostic paradigm enhances the comprehension of pathophysiology, facilitates more precise classification, and provides enhanced prognostic clarity.
3. MRI functions as an essential link between clinical observation and anatomical data, facilitating more accurate, effective, and individualized treatment for children with Cerebral palsy.

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