ORIGINAL RESEARCH PAPER

Paediatric Radiology

KEY WORDS: Developmental delay; magnetic resonance imaging; pediatric patients; congenital brain malformations; hypoxic-ischemic encephalopathy.

THE ROLE OF MR IMAGING IN THE EVALUATION OF DEVELOPMENTAL DELAY IN PEDIATRIC PATIENTS

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ABSTRACT

Introduction: Developmental delay is defined by significant delay in one or more developmental domains. Brain MRI is an important imaging modality for identifying structural causes and supporting diagnosis, prognosis, and parental counseling. **Aim:** To evaluate brain MRI findings and identify underlying etiologies in pediatric patients presenting with developmental delay. Materials and Methods: This prospective descriptive study included 50 children aged 3 months to 12 years referred for brain MRI over 6 months. MRI was performed on a 1.5-T GE SIGNA Explorer system using standard T1-weighted, T2-weighted, FLAIR, diffusion-weighted, susceptibility-weighted, and inversion-recovery sequences. **Results:** Abnormal MRI findings were present in 42/50 children (84%). Among the 42 abnormal examinations, congenital brain malformations were most frequent (15/42, 35.71%), followed by hypoxic-ischemic encephalopathy (12/42, 28.57%), isolated cerebral atrophy (10/42, 23.81%), and white matter disorders (5/42, 11.90%). The congenital malformation group comprised corpus callosum dysgenesis (6), corpus callosum agenesis (4), Dyke-Davidoff-Masson syndrome (3), Dandy-Walker syndrome (1), and Joubert syndrome (1). **Conclusion:** Brain MRI demonstrated a high yield of abnormalities in children with developmental delay and helped characterize a broad spectrum of structural etiologies.

INTRODUCTION

Developmental delay refers to delayed acquisition of expected developmental skills in one or more functional domains, including gross motor, fine motor, language, cognitive, and social functions. Determining the underlying cause is clinically relevant, as it facilitates appropriate patient management, assessment of prognosis, counseling regarding recurrence risk, and selection of additional genetic or metabolic investigations [1-3].

Brain MRI provides detailed evaluation of cerebral structure and myelination in children with developmental delay. It aids in detecting developmental malformations, hypoxic-ischemic changes, cerebral atrophy, and white matter abnormalities, while avoiding ionizing radiation. The present study aims to evaluate the spectrum and frequency of brain MRI abnormalities in pediatric patients presenting with developmental delay, identify the predominant neuro-imaging findings, and determine the etiological distribution among patients with abnormal MRI examinations.

MATERIALS AND METHODS

A prospective descriptive study was conducted in the Department of Radio-diagnosis, Index Medical College Hospital and Research Centre, Indore. The study included 50 children, aged 3 months to 12 years, presenting with developmental delay and undergoing brain MRI for the first time during a 6-month study period.

Children aged 3 months to 12 years with developmental delay referred for their initial diagnostic brain MRI were included. Patients with known genetic syndromes, including Down and Turner syndromes, active infectious disease, or a history of head trauma were excluded.

MRI examinations were performed on a 1.5-T GE SIGNA Explorer using a dedicated head coil. Sedation was administered to younger children when required. The protocol included axial and sagittal T1-weighted, axial and coronal T2-weigh-ted, axial FLAIR, axial T1-weighted inversion recovery, diffusion weighted imaging (DWI), and susceptibility weighted imaging (SWI).

RESULTS

Of the 50 children, 32 were male and 18 were female. Abnormal MRI findings were identified in 42 (84%) patients, while 8 (16%) had normal examinations. The 2–5-year age group constituted the largest proportion (18/50), followed by 5–8 years (11/50), 1–2 years (10/50), <1 year (8/50), and 8–12 years (3/50).

Congenital brain malformations were the predominant abnormality, observed in 15/50 (30%) children and accounting for 35.71% (15/42) of abnormal MRIs. Hypoxic-ischemic encephalopathy was identified in 12/50 (24%; 28.57% of abnormal MRIs), isolated cerebral atrophy in 10/50 (20%; 23.81%), and white matter disorders in 5/50 (10%; 11.90%).

Table 1. Etiological Classification of Mri Findings

MRI finding	Cases (N=50)
Normal MRI	8
Abnormal MRI	42
Congenital brain malformations	15
Corpus callosum dysgenesis	6
Corpus callosum agenesis	4
Dyke-Davidoff-Masson syndrome	3
Dandy-Walker syndrome	1
Joubert syndrome	1
Hypoxic-ischemic encephalopathy	12
Isolated cerebral atrophy	10
White matter disorders	5

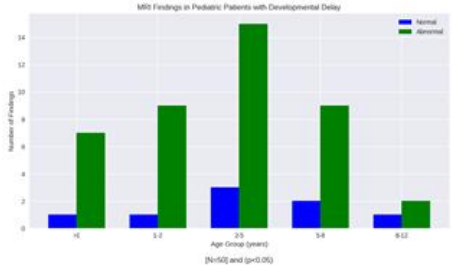

Figure 1. Age-wise Distribution of Normal and Abnormal Brain Mri Findings.

Representative Mri Findings

Case 1. Corpus Callosum Dysgenesis / Agenesis

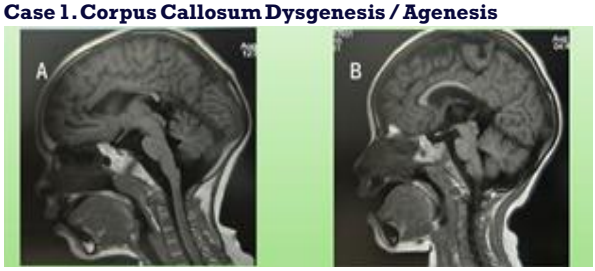

Figure 2. Corpus callosum abnormalities, retained in the

same A–B boxes as the PPT. (A) 8-year-old female child: sagittal T1-weighted image shows absence of the genu, rostrum and body of the corpus callosum, with a thinned-out splenium. (B) 4-year-old female child: sagittal T1-weighted image shows thinning of the body of the corpus callosum with absent visualization of the splenium.

Case 2. Dyke-davidoff-masson Syndrome with Dandy-walker Variant

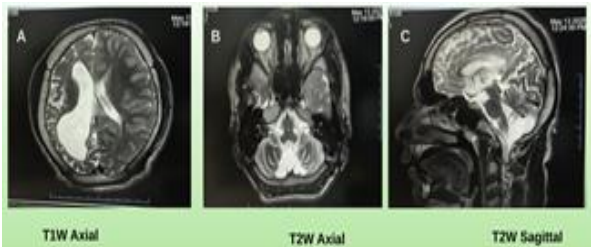

Figure 3. 10-year-old male child. The images remain in the same A–B–C boxes and sequence order as the PPT: (A) T1W axial, (B) T2W axial and (C) T2W sagittal. They show right cerebral hemispheric atrophy with enlargement of the ipsilateral lateral ventricle, with inferior vermian hypoplasia and an enlarged fourth ventricle communicating with the posterior cranial fossa.

Case 3. Joubert Syndrome

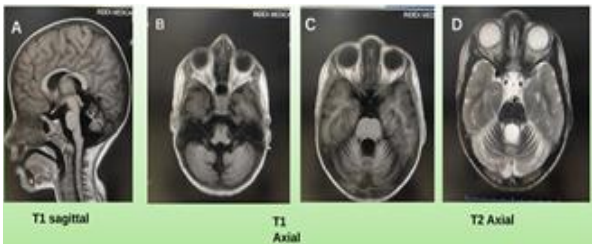

Figure 4. 6-year-old male child. The four images remain in the same A–B–C–D boxes as the PPT, with the displayed sequence labels preserved. Findings described in the PPT are vermian hypoplasia, dilated fourth ventricle with bat-wing appearance, thickened/prominent superior cerebellar peduncles producing the molar-tooth appearance, and age-disproportionate cerebellar atrophy.

Case 4. Hypoxic-ischemic Encephalopathy

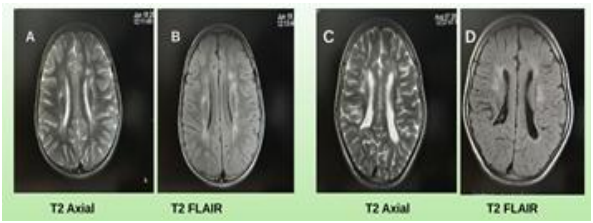

Figure 5. Two 8-year-old children, one male and one female. Images remain in the same A–B–C–D boxes as the PPT, preserving the T2 axial and T2 FLAIR pairs. T2/FLAIR hyperintensity is present in the bilateral periventricular white matter with mild dilatation of the lateral ventricles.

DISCUSSION

The present study demonstrated a high frequency of abnormal brain MRI findings (84%) among children with developmental delay. Developmental brain malformations were the predominant group, followed by hypoxic-ischemic encephalopathy, isolated cerebral atrophy, and white matter disorders.

The proportion of abnormal MRI examinations in our study is comparable to that reported in previous studies [1], [3–7]. Variations in diagnostic yield across studies may be related to differences in patient characteristics, age distribution, clinical presentation, imaging protocols, and criteria used for classification.

MRI enabled detailed characterization of structural brain abnormalities and helped narrow the etiological spectrum of developmental delay. The observed imaging patterns included corpus callosal abnormalities, Dyke-Davidoff-Masson syndrome, Dandy-Walker spectrum abnormality, Joubert syndrome, and sequelae of hypoxic-ischemic injury. These findings may assist in directing further clinical, genetic, and metabolic evaluation.

LIMITATIONS

The study was limited by its relatively small sample size and single-center design. Genetic and metabolic correlations were unavailable, and long-term developmental follow-up was not performed, limiting broader generalizability and definitive etiological correlation.

CONCLUSION

Brain MRI demonstrated a high diagnostic yield in children with developmental delay, with abnormalities detected in 84% of cases. Developmental brain malformations were the predominant finding. MRI enables accurate characterization of structural brain abnormalities and contributes to etiological assessment, further clinical evaluation, and appropriate counselling.

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