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RESEARCH ARTICLE

DIAGNOSTIC VALUE OF MRI IN CEREBRAL PALSY CHILDREN WITH ETIOLOGICAL CORRELATION & CLINICAL PROFILE

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ABSTRACT

Aims and Objective

1. To correlate MRI (Magnetic Resonance Imaging) brain findings with etiology, clinical types and severity of children with CP (Cerebral Palsy).
2. To identify the associated risk factors in children with CP.

Materials & Methods

This is a cross sectional descriptive and analytical study done at Government Kilpauk Medical College, Chennai, India. The study population includes 55 patients between 2 and 15 years of age with cerebral palsy attending the outpatient department (OPD) and admitted to the paediatric wards. A detailed demographic data, clinical history was taken, clinical examination was done and MRI images were reviewed by a radiologist with knowledge of the preceding clinical diagnosis of cerebral palsy.

Results

The most common MRI lesion in children with CP are cortical lesions followed by PVL (Periventricular leukomalacia)**.** MRI increases the diagnostic yield and improves the understanding of the neuroanatomical basis for functional limitations in the CP.

INTRODUCTION

Cerebral palsy (CP) is a static encephalopathy and may be defined as a non-progressive disorder of posture and movement, often associated with epilepsy and other abnormalities of vision, speech and intellect due to defect or lesion in the developing brain[(1)] Cerebral palsy is the most common cause of severe physical disability in childhood, occurring in approximately 1.5-2.5 children per 1,000 live births [(2)]. CP is not a single entity rather it is a syndrome with many etiologies. While a variety of antenatal and perinatal risk factors have been identified for CP, in many cases the precise etiology may be difficult to establish [(3)].

Growing literature rejects this past perception and have shown that prenatal and post natal factors are more implicated in the etiology of the disease rather than natal factors in developed countries[(4)]. In low-income countries, birth asphyxia is much more common than in high-income countries[(5)] which may influence the subtype distribution in the CP population. However birth asphyxia has been highly associated with CP in developing countries[(6)]. Hence we wanted to elicit the etiology for CP in a developing country like India.

Neuroimaging studies especially Magnetic Resonance Imaging (MRI) are helpful in identifying abnormal neuroanatomic findings, which are found in most affected children. MRI plays an increasing role in the diagnosis of CP[(7)]. Neuropathology identified by MRI correlate well with clinical descriptions of motor impairment in children who have CP.

Considering these facts the study was designed to find out the relationship between the abnormalities in MRI brain and the etiologies of CP, its clinical spectrum, classification and severity.

METHODS AND MATERIALS

The objectives of the study were to correlate MRI brain findings with etiology, clinical types, risk factors and severity in CP children. This is a cross-sectional descriptive and analytical study done at Government Kilpauk Medical College hospital, Chennai, India. The study population includes 55 patients between 2 and 15 years of age with CP attending the OPD and admitted to the paediatric ward. The study was conducted for a duration of one year from January 2016 to December 2016.

Inclusion criteria

Children aged 2 to 15 years with a diagnosis of cerebral palsy were included in this study. A definite diagnosis of CP in infant and younger child may be difficult because of the transitory and changing nature of early neurological signs, hence minimum cut-off age of 2 years was fixed[8, 9].

Exclusion criteria

Progressive neurological diseases and neurodegenerative disorders.

A detailed history of the basic demographic data including age, sex, antenatal, natal, postnatal history, developmental milestones, history of seizures, and other co-morbidities were obtained.

Complete physical examination of the children was done. Children with CP were classified based on the motor and topographical involvement. They were further classified into 5 grades (I - V) based on the best observed self-initiated movements, according to their age as per the Gross Motor Function Classification System (GMFCS). MRI brain of the children which have been done previously was noted. The MR studies were reviewed by a Radiologist with knowledge of the preceding clinical diagnosis of CP, but without knowledge of the specific clinical manifestations of each case. Thus, the MR review was partially blinded, since the diagnosis of CP was known.

APGAR scores when available were considered. In the absence of these, the following alternate criteria[6] was used –

1. History of delayed cry >5 min after birth
2. Baby turning blue and requiring oxygen therapy with baby having difficulty in respiration, lethargy and/or seizures within 72 hours of birth.

Classification of CP: Children with CP were categorized according to Hagberg *et al*[10] into Spastic (Quadriplegia, Diplegia, Hemiplegia), Ataxic/ Hypotonic, Dyskinetic/ Athetoid and Mixed CP.

Microcephaly was considered when the measured head circumference was less than 3 Standard Deviation below the mean for the age and sex.

Developmental age was assessed by history given by the caregiver.

Development Quotient (DQ) was calculated and classified as follows

- DQ ≥ 85 - Normal
- DQ 71-85 - Mild to moderate development delay
- DQ ≤ 70 - Severe development delay

The MRI findings of the CP patients were categorized as Periventicular Leukomalacia (PVL)(Fig. 1), Basal Ganglia lesion (Fig. 2), Cortical lesion(Fig. 3 & 4), Brain Malformation (Fig. 5), Corpus Callosal lesion (Fig. 6), miscellaneous lesion and normal MRI. The PVL lesions were divided into four subtypes. They were Posterior PVL, Middle PVL, Posterior & Middle PVL (Fig. 1) and Posterior, Middle & Anterior PVL

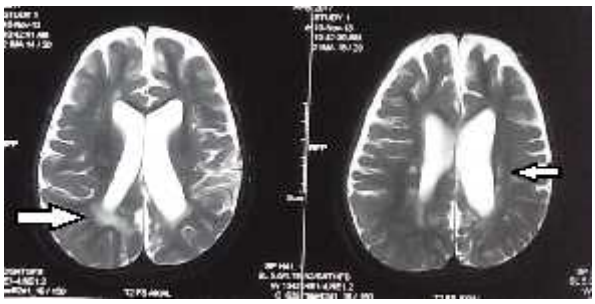

Fig 1 Posterior and Middle PVL lesion,Axial T2 show periventricular hyperintensity(arrow)

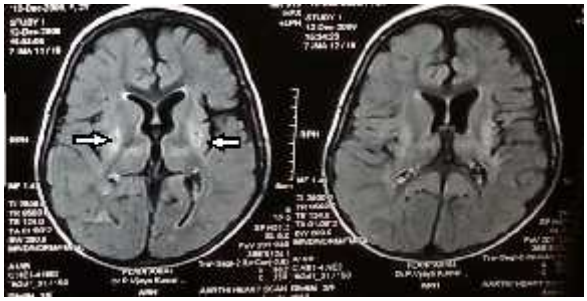

Fig 2 Bilateral Basal ganglia lesions – Axial FLAIR show hyperintensity in bilateral lentiform nucleus.

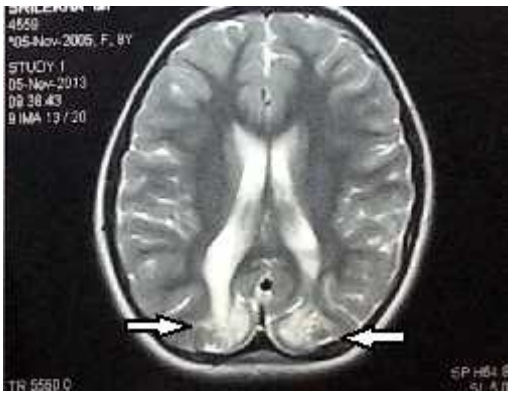

Fig 3 Bilateral occipital infarcts – Axial T2 shows bilateral occipital symmetrical hyperintensity

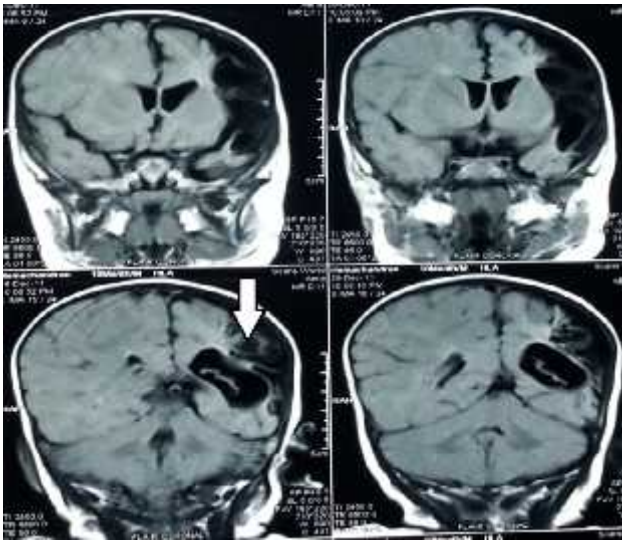

Fig 4 Porencephaly – Coronal FLAIR show old infarct with gliotic change in the left temporo-occipital region

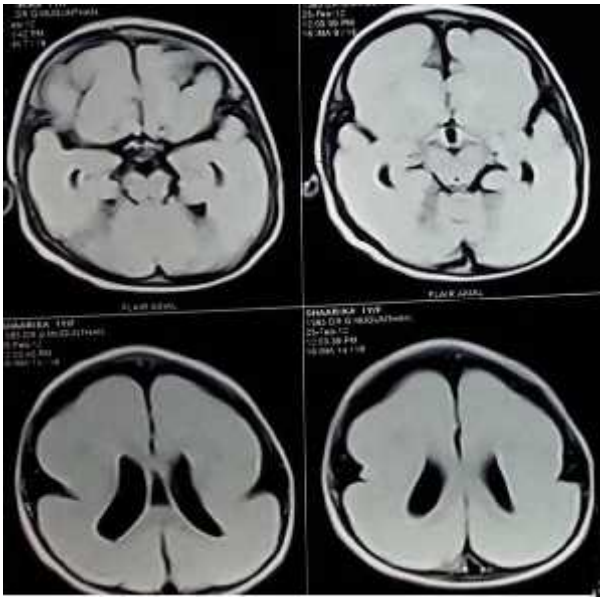

Fig 5 Malformation (Lissencephaly) – Axial FLAIR show smooth brain with absence of sulcogyral differentiation

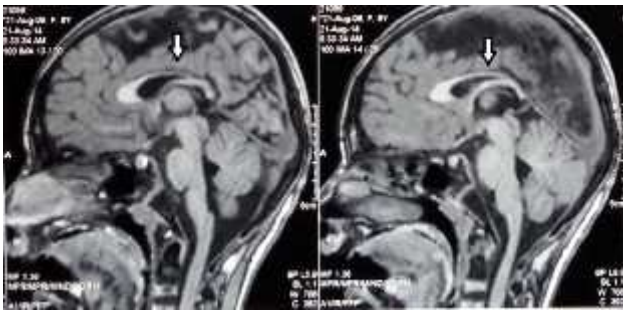

Fig 6 Sagittal T1 show Focal corpus callosal thinning in the body of corpus callosum

Statistical Analysis

The data regarding the general information of CP patients, factors influencing CP, clinical features, types, severity of CP and MRI brain findings were recorded. The Data was analyzed using Statistical Package for Social Scientists (SPSS) version 19.0 software. Statistical analysis was done using Chi square test/Fisher's exact test (when expected value was<5) and Pearson's correlation test. P value < 0.05 was considered statistically significant.

RESULTS

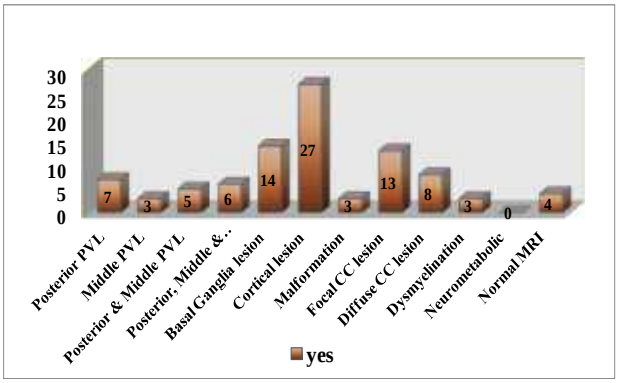

Figure 7 Mri Findings

Table .1 Characteristics of Study Population

S. NO.	Variables	Number	Percentage
	Sex		
1.	1) Male	35	64%%
	2) Female	20	36%
	Age:		
2.	1) 2-5	29	53%
	2) 6-10	3	5%
	3) >10	23	42%
	Order of birth		
3.	1) 1st	38	69%
	2) 2nd	12	22%
	3) 3rd	4	7%
	4) 4th	1	2%
	Maternal age at the time of delivery		
5.	1) <20	6	11%
	2) 20-25	19	34%
	3) 25-30	24	44%
	4) >30	6	11%
	Marriage Pattern		
6.	1) Non consanguinous	37	67%
	2) 1st degree consanguinous	0	0%
	3) 2nd degree consanguinous	5	9%
	4) 3rd degree consanguinous	13	24%
	Age of presentation		
7.	1) Day ½ of life	3	6%
	2) <6 months	12	22%
	3) 6-12 months	26	47%
	4) >12 months	14	25%
	Presenting illness :		
8.	1) motor delay	36	65%
	2) seizures	9	16%
	3) difficulty in using hand	7	13%
	4) tip-toe walking	3	6%

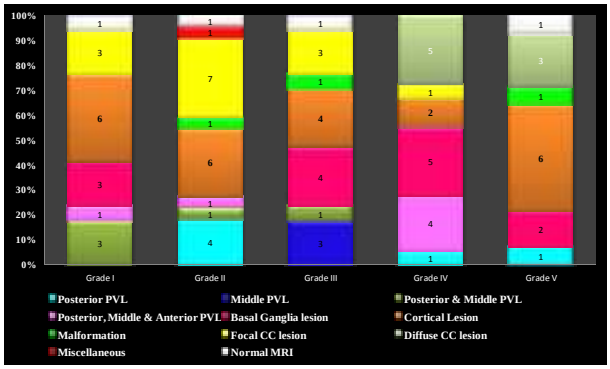

Figure 8 Comparison of Gmfcs With Mri Lesions

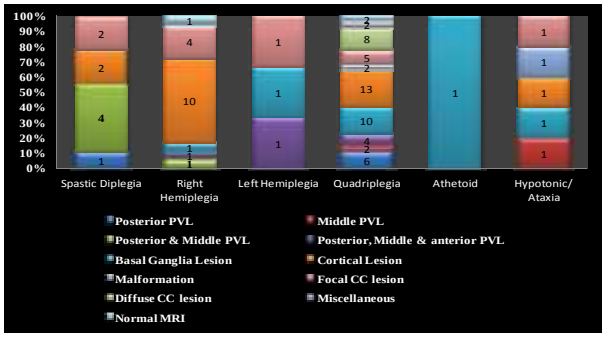

Figure 9 Comparison of Types of Cp With Mri Lesions

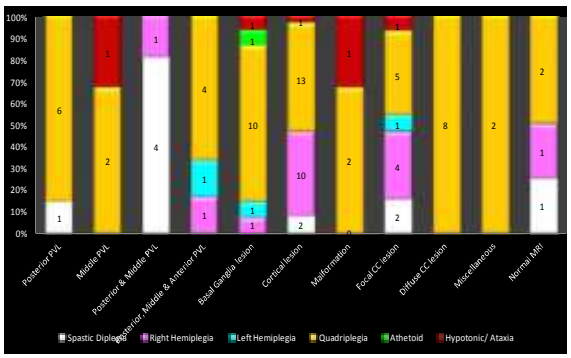

Figure 10 Comparison Of Mri Lesions With Types Of Cp

The characteristics of the study population are shown in Table 1. Male children contribute 64% of the study population and majority of the children are 2-5 years of age (53%). The most common order of birth is the first order seen in 69% and the maternal age at delivery is most commonly between 25-30 years of age (44%). The most common age of presentation is 6-12 months of age (47%) and the most common clinical presentation is motor delay seen in 65%.

Tables 2 and 3 show correlation between the factors influencing CP and clinical profile with the MRI findings.

Tables 4 and 5 show correlation between the types of CP and GMFCS with the MRI findings.

Table 2 Correlation between factors influencing Cp and Mri findings

S.NO	MRI findings / Factors influencing CP	Post PVL	Middle PVL	Post & middle PVL	Post, middle & ante PVL	Basal Ganglia lesion	Cortical lesion	Malforation	Corpus Callosal – focal	Corpus Callosal-diffuse	Dysmyeli-nation	Normal MRI
1.	Antenatal factors											
1a.	Maternal fever	.189	-.058	-.076	-.084	-.136	.245	-.084	.055	-.099	-.068	.173
1b.	Teratogenic drugs	-.055	-.072	-.068	-.232	.039	.090	-.127	.108	.131	-.103	.067
1c.	APH	-.052	-.033	.430	-.048	-.077	-.134	-.058	-.076	-.056	-.047	-.058
1d.	PIH	-.134	-.089	.092	-.122	-.198	.240	.076	-.057	.186	.191	-.084
1e.	Maternal seizures	-.074	-.047	-.061	-.068	-.110	-.191	-.033	-.108	-.080	-.026	-.033
1f.	Multiple birth	.039	.171	.090	.250	-.059	.131	.023	.077	.184	-.061	-.076
1g.	Others	.004	.218	-.110	.245	.251	-.023	-.058	-.087	-.014	-.061	-.052
2.	Gestation age at delivery	.084	-.055	-.122	-.345*	.192	-.053	-.072	.108	-.135	.090	.103
3..	Birth asphyxia	.165	.318*	.024	.099	.373*	.014	-.033	-.065	.331*	-.110	-.179
4.	Postnatal factors											
4a.	Postnatal convulsion	-.076	.306*	-.118	.205	-.058	-.023	-.089	.003	.207	-.122	-.052
4b.	Septicemia	.216	-.084	-.111	.252	-.024	.123	-.047	-.057	.186	.024	-.092
4c.	Meningitis	-.052	-.033	-.043	-.048	-.077	-.134	.171	-.076	-.056	-.043	.041
4d.	Neonatal encephalopathy	.103	-.067	-.089	-.098	.013	.005	-.089	.009	.282	-.089	-.052
4e.	Hyperbilirubinemia- kernictus	-.179	-.113	.103	.067	.046	-.244	-.047	-.091	-.091	.103	.103
4f.	Hypoglycemia	.041	-.084	.092	-.122	-.198	.356*	.171	-.080	-.021	.092	-.179
4g.	Vascular episode	-.052	-.033	-.043	-.048	.256	-.134	-.084	-.076	-.056	-.043	.041
4h.	Intracranial haemorrhage	-.092	-.058	-.076	.430*	-.110	-.076	-.033	.055	.128	-.076	-.052
4i.	Prolonged ventilation	.041	-.084	-.111	.065	-.055	-.110	-.058	-.057	.021	.041	-.092

Table 3 Correlation between clinical profile of Cp and Mri findings

S.NO	MRI findings / Clinical profile of CP	Post PVL	Middle PVL	Post & middle PVL	Post, middle & ante PVL	Basal Ganglia lesion	Cortical lesion	Malforation	Corpus Callosal - focal	Corpus Callosal-diffuse	Dysmyeli-nation	Normal MRI
1.	Speech disorder	.195	.053	-.572*	-.041	.305	-.004	-.084	-.137	.091	.033	-.084
2.	Ocular defect	.032	-.049	.081	-.021	-.197	.174	-.127	.158	.257	.067	-.127
3.	Convulsion	.001	.081	-.192	.059	.177	.184	-.058	.043	.157	.080	-.058
4.	Hearing disorder	.018	.149	-.121	-.041	.185	.171	.076	-.084	.307*	-.084	.076
5.	GMFCS	.029	.042	-.247	.100	.154	.022	-.033	-.283	.458*	.120	-.033
6.	Developmental age	.089	-.131	.258	-.071	-.362*	-.015	-.084	.267	-.400*	.033	.203
7.	Behavior problem	-.084	-.134	-.176	.080	-.192	.224	-.127	.194	.013	.067	-.084
8.	Others	-.114	-.078	.142	.273	-.010	.049	-.058	.127	.323	.080	-.127

Table 4 Correlation between type of Cp and Mri findings

S.NO	MRI findings / Types of CP	Post PVL	Middle PVL	Post & middle PVL	Post, middle & ante PVL	Basal Ganglia lesion	Cortical lesion	Malfor-ation	Corpus Callosal - focal	Corpus Callosal-diffuse	Dysmyel-ination	Normal MRI
1.	Spastic Diplegia	-.041	-.084	.701*	-.122	-.204	-.098	-.084	.080	-.144	-.068	.173
2.	Right Hemiplegia	-.202	-.127	-.014	-.044	-.208	.393*	-.127	.121	-.218	-.103	.067
3.	Left Hemiplegia	-.092	-.058	-.076	.173	.043	-.227	-.058	.055	-.099	-.047	-.058
4.	Quadriplegia	.266	.076	.062	.322*	.240	-.017	.076	-.139	.405*	.191	-.084
5.	Athetoid	-.052	-.033	-.043	-.048	.233	-.129	-.033	-.076	-.056	-.026	-.033
6.	Hypotonic/ Ataxia	-.121	.203	-.100	.092	-.040	-.046	.203	-.027	-.130	-.061	-.076

Table 5 Correlation between GMFCS and MRI findings

S. NO	MRI findings / Types of CP	Post PVL	Middle PVL	Post & middle PVL	Post, middle & ante PVL	Basal Ganglia lesion	Cortical lesion	Malformation	Corpus Callosal - focal	Corpus Callosal - diffuse	Dysmyelination	Normal MRI
1.	Grade I	-.234	-.147	.232	-.083	-.077	-.007	-.147	-.052	-.253	-.119	.033
2.	Grade II	.327*	-.127	-.014	-.044	-.209	.029	.067	.431*	-.218	.133	.067
3.	Grade III	-.191	.480*	.000	.117	.230	-.109	.080	.043	-.077	-.097	.080
4.	Grade IV	.041	-.084	-.111	.439*	.465*	-.098	-.084	-.195	.683*	-.068	-.084
5.	Grade V	-.055	-.120	-.158	-.175	-.083	.164	.080	-.278	.180	.146	.120

Table 6 MRI Correlation summary

S.NO.	Features	MRI Lesions	P Values
		Factors influencing CP	
1.	Preterm gestation	Posterior,middle and anterior PVL	0.009
		Middle PVL	0.018
2.	Birth asphyxia	Basal Ganglia	0.049
		Diffuse corpus callosal lesion	0.014
3.	Postnatal convulsion	Middle PVL	0.023
4.	Hypoglycemia	Parieto-occipital cortical lesion	0.008
5.	Intracranial hemorrhage	Posterior,middle and anterior PVL	0.029
		Clinical Profile	
6.	Speech problem	Posterior,middle PVL	0.001
7.	Hearing problem	Diffuse corpus callosal lesion	0.023
8.	Development delay	Basal ganglia lesion	0.007
		Diffuse corpus callosal lesion	0.003
		Type of CP	
9.	Spastic diplegia	Posterior,middle PVL	0.001
10.	Spastic hemiplegia	Unilateral cortical lesion	0.048
11.	Spastic Quadriplegia	Posterior,middle and anterior PVL	0.023
		Diffuse corpus callosal lesion	0.004
		GMFCS	
12.	Grade II	Posterior PVL	0.034
		Focal corpus callosal lesion	0.004
13.	Grade III	Middle PVL	0.006
		Posterior,middle and anterior PVL	0.013
14.	Grade IV	Basal ganglia lesion	0.003
		Diffuse corpus callosal lesion	0.001

Table 6 shows the overall correlation summary of the MRI findings.

Figure 7 shows most common MRI findings in CP. Cortical lesions are most common seen in 27 cases and basal ganglia lesion the second most common seen in 14 cases.

Figures 8 and 9 show comparison between GMFCS and the type of CP with MRI findings. Cortical lesions are seen in all grades of GMFCS. Basal ganglia lesions were seen in all except grade II GMFCS. And middle periventricular leukomalacia was seen in only those with grade III GMFCS. Figure 10 shows the comparison between the MRI findings and type of CP. Children with quadriplegic CP show all types of MRI lesions except posterior and middle periventricular leukomalcia. Athetoid type was seen in only those with basal ganglia lesion. 80% of cases with spastic diplegia showed posterior and middle periventricular leukomalacia.

DISCUSSION

Cerebral palsy even though first described in 19thcentury, strong evidences for the etiology have not been made till date. The clinical types of CP vary between developed and developing countries. Studies from South India are sparse. In this study we have tried to describe the MRI findings of CP children and find out whether MRI is really useful in these children to find the etiology, pathogenesis for CP, whether the clinical manifestations and comorbidities correlate with the MRI findings and whether its severity can be predicted by MRI.

In our study the most common lesion in term born children were cortical lesions, deep grey matter lesions (basal ganglia lesion) and in preterm children was PVL lesion, the relation has been well documented in literature[11] . Diffuse cortical atrophy was present in 6 patients all of who were quadriplegics with GMFCS grade V. In our study children with diffuse corpus callosal involvement and basal ganglia lesion were found to have severe motor impairment with grade V GMFCS. This was similar to the finding by Himmelmann *et al*[12]

In children with posterior and middle PVL lesion, spastic diplegia is the most common topography. This was evident also in the review done by Ryan *et al*[13]

When there is predominantly unilateral cortical involvement, it results in hemiplegia. When the lesion is bilateral posterior PVL with basal ganglia involvement quadriplegia is likely. Quadriplegics also have cortical lesions combined with diffuse corpus callosal and basal ganglia lesions. Athetoid CP goes in-hand with isolated basal ganglia lesion. Malformation resulted in quadriplegia most often in our study. This is in contrast to the association of hemiplegic children in the study by Korzeniewski *et al*.[14]

Normal imaging in our study was seen in two quadriplegics,one hemiplegic and diplegic CP children.

CONCLUSION

MRI is an important tool in the evaluation of CP children.MRI improves the understanding of the neuroanatomical basis for function in CP. In order to establish an etiology and prognosis in children with CP, neuroimaging with MRI is recommended in all cases.

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