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BRAIN MAGNETIC RESONANCE IMAGING FINDINGS IN CHILDREN WITH CEREBRAL PALSY AND TO CORRELATE IT WITH TYPE OF CEREBRAL PALSY

Paediatrics

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ABSTRACT

AIMS AND OBJECTIVES: The aim of study is to evaluate brain magnetic resonance imaging findings in children with cerebral palsy and to correlate it with type of cerebral pals with gross motor functional classification system (GMFCS) of cerebral palsy.

MATERIAL AND METHODS: 75 children diagnosed as cerebral palsy in the age group 2-18 years attending Pediatrics, Orthopedics and Physiotherapy OPD and admitted in the inpatient unit of Pediatrics, Orthopedics wards at a Tertiary Care Center were included in the study. The children were then examined in detail and classified according to the clinical type and by age appropriate GMFCS. Magnetic resonance imaging brain was done with GE 1.5 Tesla 16 channel HDXT version 23.0. GE MAGNETIC RESONANCE IMAGING MACHINE and images were read with help from a single qualified staff of Department of Radiology.

RESULTS: 67 out of 75 children with cerebral palsy had abnormal MRI. Commonest type of cerebral palsy in the study group was spastic diplegia followed by quadriplegia, hemiplegia and dystonia. Commonest area of brain involvement was periventricular white matter followed by cerebral cortex, ventricles and corpus callosum. Commonest MRI findings were periventricular leukomalacia followed by cystic degeneration, infarct and cortical atrophy. The difference in the proportion of MRI abnormality across GMFCS levels was statistically insignificant as indicated by p-value of 0.589. Furthermore, MRI findings correlated well with clinical diagnosis of cerebral palsy.

KEYWORDS

Cerebral palsy, magnetic resonance imaging

INTRODUCTION

Cerebral palsy (CP) is diagnostic term used to describe a group of permanent disorders of movement and posture causing activity limitation, that are attributed to non progressive disturbances in the developing fetal or infant brain.[1] It is the most common childhood physical disability that represents a group of conditions with heterogeneous symptoms which are characterized by deficient motor control, spasticity, paralysis and other neurological disturbances that emerge before, during, or in a short time after birth.[2] It continues unabated despite advances in investigation methods, maternal and neonatal care and development of interventional techniques and treatment. Majority of studies for prevalence and incidence of cerebral palsy have been performed in western countries.

Worldwide cerebral palsy occurs in every 2 to 2.5 per 1000 children but in developed countries like United States the prevalence is 3.6 per 1000 children and around 1200 to 1500 children are diagnosed per year with cerebral palsy.[3] In developing countries like India cerebral palsy is the second most prevalent neurological disorder in rural population.[4] An improper medical facility increases this incidence in all regions especially in rural or remote villages.

Due to abnormal biomechanics, children with cerebral palsy develop progressive muscle and orthopaedic problems in spite of a non progressive brain damage. It is a developmental impairment which causes functional limitations. There are no curative solutions in the traditional health model of disease, but early diagnosis & interventions can lessen their limitations & improve the quality of life of persons with cerebral palsy and their families.[5]

Cerebral palsy has been the subject of numerous clinical, neuropathological, and neuroradiologic studies to assess the relationship of prenatal, perinatal and postnatal events to CP.[6-14] Clinical studies have been limited by the availability of historical information regarding prenatal care and possible prenatal insults. Neuropathological studies have been limited in their usefulness, primarily because of the limited capabilities of neuroimaging in the era before computed tomography (CT) and magnetic resonance imaging (MRI).

The use of cranial ultrasound (US) for diagnosing periventricular leukomalacia (PVL) was established in the early 1980's, since then this modality of imaging has been in the forefront in the diagnosis and follow up of PVL.[15] Although cranial ultrasonography is convenient and readily available, it also has its limitations, it can depict only 28 to 80 % of histologically proved PVL.[16] One of the difficulties is in differentiating between a normal periventricular halo and early PVL. Moreover, it may be difficult to assess the severity of echogenicity and finally there is substantial intra- and inter observer variability.[17]

With development of CT, radiographic correlation with clinical data regarding prenatal, perinatal, and postnatal asphyxia became possible, particularly with respect to morphologic changes of the cerebral white matter.[6, 12, 18] The sensitivity of CT brain, however, is limited in many cases of cerebral palsy. In particular, CT brain is sensitive to dramatic anomalies of brain development, such as schizencephaly. Magnetic resonance (MR) brain is more sensitive than CT brain in the detection of both subtle brain malformations, such as callosalhypogenesis, polymicrogyria, and mild degrees of white matter damage. Therefore, we studied MR images of brains of patients suffering from cerebral palsy.

Various studies have reported findings on children with selected types of CP, including spastic CP[19] and hemiplegia,[20] and types of MRI pattern, such as periventricular leukomalacia (PVL).[21] However, there are limited studies reporting MRI brain findings in a large CP population including all of the clinical subtypes. Cranial MRI is a standard diagnostic procedure safe to use in children.

Fewer than 10% of children with cerebral palsy had evidence of intrapartum asphyxia.[1]In many cases definite history suggestive of brain insult is not available. Neuroimaging, especially magnetic resonance imaging (MRI), plays an important role in the diagnosis of brain lesion in children suffering from cerebral palsy.[22]It has the potential to visualize physiological, pathological morphological changes during brain development. Also an understanding of the development and structure of myelin is helpful in explaining the changing MR signals observed during brain development.[23] Positive findings on magnetic resonance imaging brain will aide in diagnosis of cerebral palsy. This study is designed to evaluate brain magnetic resonance imaging findings in children suffering from cerebral palsy

and to correlate it with clinical diagnosis according to type of cerebral palsy.

AIM AND OBJECTIVES

Aim and Objectives

- The aim of study is to evaluate brain magnetic resonance imaging findings in children with cerebral palsy and to correlate it with type of cerebral palsy according to clinical diagnosis.
- To correlate brain magnetic resonance imaging findings with gross motor functional classification system (GMFCS) of cerebral palsy.

MATERIALS AND METHOD

STUDY DESIGN - Cross sectional descriptive study

STUDY PERIOD - This study was conducted from 1st October 2015 to 30th September 2017 in a Tertiary care hospital in central India.

STUDY SAMPLE

As the prevalence of cerebral palsy is low and that this study being time bound for 24 months only, all cerebral palsy patients of age group 2-18 years attending Pediatrics, Orthopedics and Physiotherapy OPD and inpatient of Pediatrics, Orthopedics wards at a Tertiary Care Center were included in the study.

INCLUSION CRITERIA: -

All clinically diagnosed cerebral palsy patients of age group 2-18 years attending Pediatrics, Orthopedics and Physiotherapy OPD and inpatient of Pediatrics, Orthopedic wards at a Tertiary Care Center were included in the study

EXCLUSIVE CRITERIA

1. Children with history of regression of milestones.
2. Neuroimaging suggestive of metabolic disorders.
3. Children with inflammatory brain diseases such as meningitis, encephalitis and intracranial space occupying lesions (i.e., brain abscess, tuberculoma, neurocysticercosis and neoplastic lesions of cerebral cortex).

ETHICAL REQUIREMENT:

Institutional Ethic Committee clearance was obtained. Informed and written consent was taken from parents and assent was taken wherever suitable. Privacy and confidentiality was maintained.

METHODOLOGY

After clearance from Institutional Ethic Committee, children with cerebral palsy between the ages of 2 to 18 years who came to a Tertiary Care hospital in Central India in Pediatrics, Orthopedics and Physiotherapy OPD and inpatient of Pediatrics, Orthopedics wards at a Tertiary Care Center during the period of 1st October 2015 to 30th September 2017 were enrolled in the study with their due consent. The children were then examined in detail and classified according to the clinical type and by age appropriate GMFCS (Annexure II). Magnetic resonance imaging brain was done with GE 1.5 Tesla 16 channel HDXT version 23.0. GE MAGNETIC RESONANCE IMAGING MACHINE and images were read with help from a single qualified staff of Department of Radiology. For children who already had magnetic resonance imaging brain images their films were read again at the institute and findings noted. These findings were noted on a predesigned proforma.

Picture 1- MRI MACHINE:

HDXT 1.5 Tesla 16 channel- MRI machine

The tests were performed using following parameters. Sequences: T1, T2, FLAIR and diffusion weighted axial images; Coronal T2, Sagittal T1 sequences. Children who were not co-operative were sedated using Syrup Pedicloryl (20 mg/kg/dose). Those children who were difficult to sedate they were given short sedation under the supervision of a trained anesthesiologist. Plain images were acquired in the above mentioned sequence.

STATASTICAL ANALYSIS

The data obtained was coded and entered into Microsoft Excel Worksheet. The categorical data was expressed as rates, ratios, proportions and percentages whichever was applicable and the continuous data were expressed as mean ± standard deviation (SD). The analysis was performed using Microsoft Excel 2013.

OBSERVATION AND RESULTS-

Table 1: Distribution of children according to gender

SEX	NUMBER	PERCENTAGE
Male	52	69.33
Female	23	30.67
Total	75	100

Table 1 shows the distribution of children according to gender. In the present study, 52 children were males (69.33%) and 23 children were females (31.67%). The male to female ratio is 2.26:1.

Table 2: Table 1: Distribution of children according to various age group

AGE GROUP (YEARS)	NUMBER	PERCENTAGE
2 to 6	64	85.33
7 to 10	4	5.33
11 to14	2	2.67
15 to 18	5	6.67
Total	75	100

Table 2 shows the distribution of children in various age groups in years. In the present study, maximum children were in the age group of 2 to 6 years 64 in number (85.33%) followed by 5 in the age group of 15 to 18 years (6.67%), then 4 in the age group 7 to 10 years (5.33%) and lastly 2 in the age group 11 to 14 years (2.67%). The mean age was 4.45±3.67 years.

Table 3: Distribution of children according to MRI abnormality

MRI Abnormality	NUMBER	PERCENTAGE
Normal	8	10.67
Abnormal	67	89.33
Total	75	100

Table 3 shows the distribution of children with cerebral palsy having brain MRI abnormality. Abnormal brain MRI was present in 67 out of 75 (89.33%) children while 8 out of 75 (10.67%) children with cerebral palsy had normal brain MRI.

Table 4: Distribution of children according to type of cerebral palsy according to clinical diagnosis

Type of Cerebral Palsy	NUMBER	PERCENTAGE
Spastic Quadriplegia	14	18.67
Spastic Diplegia	27	36.00
Spastic Hemiplegia	12	16.00
Dystonic	8	10.67
Choreoathetoid	1	1.33
Ataxic	1	1.33
Hypotonic	7	9.33
Mixed	5	6.67
Total	75	100

Table 4 shows distribution of children according to type of cerebral palsy according to clinical diagnosis. In the present study majority of the children were of spastic diplegia 27 (36%) followed by spastic quadriplegia 14 (18.67%), spastic hemiplegia 12 (16%), dystonic 8 (10.67%), hypotonic 7 (9.33%), mixed 5 (6.67%), choreoathetoid and ataxic 1 (1.33%) each.

Table 5: Distribution of various areas of the brain involvement in brain MRI scan

Areas of Brain Involvement	NUMBER	PERCENTAGE
Periventricular White Matter	46	61.33
Cerebral Cortex	36	48
Corpus Callosum	19	25.33

Thalamus	6	8
Globus Pallidus	6	8
Putamen	6	8
Caudate Nucleus	4	5.33
Internal Capsule	7	9.33
Ventricular Enlargement	33	44
Cerebellar Atrophy	1	1.33
Encephalomalacia	10	13.33

Table 5 shows distribution of various area of brain involvement in brain MRI scans. Many MRI scans had involvement of more than one area of brain. In this study the commonest area of brain involvement in brain MRI scan was involvement of periventricular white matter (61.33%) followed by cerebral cortex (48%), ventricular enlargement (44%), corpus callosum (25.33%). Other findings include encephalomalacia (13.33%), internal capsule (9.33), thalamus, globus pallidus and putamen (8%) each, caudate nucleus (5.33%) and cerebellar atrophy (1.33).

Table 6: Distribution of children according to pattern of brain involvement on MRI scan

MRI Diagnosis	NUMBER	PERCENTAGE
Periventricular Leukomalacia	30	40
Cystic Degeneration	9	12
Basal Ganglia Lesions	6	8
Cortical Atrophy	8	10.67
Infract	9	12
Focal Gliosis	1	1.32
Malformation	2	2.67
Demyelination	2	2.67
Normal	8	10.67
Total	75	100

Table 6 shows distribution of children with pattern of brain involvement on MRI brain scan. In the present study, the commonest MRI diagnosis was periventricular leukomalacia 30 (40%). The next common diagnosis was cystic degeneration and infract 9 (12%) each. This was followed by cortical atrophy 8 (10.67%), basal ganglia lesions 6 (8%). Less common diagnosis includes malformation and demyelination 2 (2.67%) each and focal gliosis 1 (1.32%). 8 out of 75 children with cerebral palsy (10.67%) had normal brain MRI findings.

Table 7: Distribution of children according to GMFCS level

GMFCS LEVEL	NUMBER	PERCENTAGE
I	7	9.33
II	38	50.67
III	5	6.67
IV	22	29.33
V	3	4
Total	75	100

Table 7 shows distribution of children according to GMFCS level. Maximum number of children in the GMFCS level II were 38 (50.67%) followed by 22 (29.33%) in level IV, 7 (9.33%) in level I, 5 (6.67%) in level III and lastly 3 (4%) in level V.

Table 8: Distribution of children according to GMFCS Level with brain MRI abnormality

	MRI ABNORMALITY	
GMFCS LEVEL	Normal (Number of Cases)	Abnormal (Number of Cases)
I	0	7
II	6	32
III	1	4
IV	1	21
V	0	3
Total	8	67

P-value: 0.589 using Fisher's exact test

Table 8 shows that the difference in the proportion of MRI abnormality across GMFCS levels was statistically insignificant as indicated by p-value of 0.589 using Fisher's exact test. The proportion of abnormality in group I-III was 0.86 (86%), while that in group IV was 0.95 (95%) and in group V was 1 (100%).

Table 9: The correlation of MRI diagnosis and Clinical diagnosis

Type of cerebral palsy	MRI Diagnosis												
	Periventricular leukomalacia	Cystic degeneration	Basal ganglia	Cortical atrophy	Infract	Demyelination	Focal Gliosis	Malformation	Normal	Total	Number of Cases correlated	Number of cases not correlated	Overall correlation in percentage
Spastic Quadriplegia	2	8	1	2	0	0	0	1	0	14	10	4	71.42
Spastic Diplegia	22	0	0	0	0	1	0	1	3	27	22	5	81.48
Spastic Hemiplegia	1	1	0	0	9	0	1	0	0	12	10	2	83.33
Choreoathetoid	0	0	0	0	0	0	0	0	1	1	0	1	0
Dystonic	1	0	5	2	0	0	0	0	0	8	5	3	63
Ataxic	0	0	0	1	0	0	0	0	0	1	1	0	100
Hypotonic	1	0	0	3	0	1	0	0	2	7	5	2	71.42
Mixed	3	0	0	0	0	0	0	0	2	5	3	2	60
Total	30	9	6	8	9	2	1	2	8	75	56	19	74.66

Table 9 shows the correlation of MRI diagnosis with type of cerebral palsy according to clinical diagnosis. The maximum correlation of brain MRI diagnosis with clinical diagnosis was noted with ataxic (100%) followed by spastic hemiplegia (83.33%), spastic diplegia (81.48%), spastic quadriplegia and hypotonic (71.42%) each. Least correlation was noted with choreoathetoid cerebral palsy (0%) and dystonic (63%). Overall the percent agreement between brain MRI diagnosis and clinical diagnosis was 74.66%.

DISCUSSION

In past two decades improved NICU resulted in reducing neonatal mortality but not matched by success in reducing the risk of cerebral palsy. Understanding the time of onset of a brain lesion in a child with CP and the potential preventability of the neurological injury is important for parents and medical professionals.[24] Neuroimaging in children with CP may help determine the etiology and make better prognosis of CP.[25,26]

The contemporary diagnostics of children with CP, apart from the neurological examination, psychological and neurophysiologic evaluation like EEG, also uses neuroimaging such as magnetic resonance imaging (MRI) and computed tomography (CT).[27,28,29] Reports of recent years indicate the potential to differentiate changes in the various forms of CP by the technique of MRI.[30,31]

Not only does MRI scan help reveal the pathologic basis of the condition, but also, the findings have strong correlations with clinical findings. This may be useful in helping parents, clinicians, and others involved in the care of children with CP to understand the nature of the children's condition and to predict their needs in the future. Therefore, all children with CP should have an MRI scan.[32]

The present two years cross sectional descriptive study was undertaken in the Department of Paediatrics at a Tertiary Care Centre. In the present study during 1st October2015 to 30th September 2017 was performed in 75 children with clinical diagnosis of cerebral palsy. In the present study slight male preponderance was noted as 69.33% of the children were males and 30.67% were females and the male to female ratio was 2.26:1. These findings were consistent with a study done by Najar BA et al.[33] from Srinagar, where 64.91% of the children were males and 35.09% were females and similar study by Kulak W. et al.[27] who reported 67.27% of males. In European cerebral palsy study79 61.9% of the children were males.

In contrast to our findings Yamada K et al.[31] in 1993 noted female preponderance with 60.52% of the children being females out of 38 cases. The present study included children between ages 2 to 18 years. The maximum numbers of children with CP were in the age group two to six years which comprised of 85.33% of study population and followed by in age group between 15 to 18 years (6.67%). The mean age noted was 4.45±3.67 years.

In European Cerebral Palsy study[32], the age at the time of examination ranged from 12 to 91 months, with a mean age of 3.83 years which was almost similar to the present study. In contrast, a recent study by Dobhal M. et al.[34] in Delhi 2014 reported the mean age as 5.08 years. In another study by Najar BA et al.[33] from Srinagar, India, the commonest age group involved was 2-5 years which accounted for 78.94% and the least involved group was 11-16 years (3.50%). The differences observed in the age distribution of pattern of the present study and the other Indian studies[33,34] can be explained by the varying sample size of the study population and inclusion of difference age groups in latter studies.

MRI was normal in 10.67% of studied subjects in our study. 89.33% CP children had abnormal MRI which is almost similar to Bax et al[32] study who had normal MRI in 11.76% of children with CP and abnormal MRI in 88.24% cases. Observations were made by Kulak W et al[27] who reported only 4.7% normal MRI. Slightly higher percentages of normal MRI scans of CP patients have been reported by MN Robinson et al[35] (16%) in 2009 and Krageloh Mann et al.[36] (14%) in 2007. Higher percentage of normal MRI scans has also been reported by Kwong K et al.[37] (25%) and Saginoya T et al.[38] (20%) in 1996 in contrast to our study.

In this study, based on clinical evaluation most of the children had spastic diplegia (36%) followed by quadriplegia (18.67%), hemiplegia (16%), dystonic (10.67%), hypotonic (9.33%), mixed (6.67%) and choreoathtoid and ataxic (1.33%) each. Similar observations have been made by Bax et al[32] in European cerebral palsy study reported maximum children with diplegia (34.4%) followed by hemiplegia (26.2%), spastic quadriplegia (18.6%) and dyskinesia (14.4%). In a similar, the study done by Najar BA et al[33] from Srinagar, India, most common type of CP observed was spastic diplegia contributing to 49.10% of all cases. Similarly Kwong K et al.[37] observed spastic diplegia contributing to 50% of all cases. However, MN Robinson et al.[35] have reported slightly lower (28.5%) spastic diplegia cases as against other forms of CP.

In the present study various area of brain involvement as seen in brain MRI were studied. Commonest area involved was periventricular white matter (61.33%) followed by cerebral cortex (48%), corpus callosum (25.33%), thalamus (8%) and globus pallidus (8%). The other common findings noted were ventricular enlargement (44%). Based on these findings the commonest MRI diagnosis was periventricular leukomalacia (40%), cystic degeneration (12%), infarct (12%), cortical atrophy (10.67%), basal ganglia lesions (8%), malformation (2.67%), demyelination (2.67%), focal gliosis (1.32%).These MRI findings observed in the present study were consistent with several other studies. The European Cerebral Palsy study[32] , showed that white matter damage of immaturity (WMDI, including PVL) was the most common finding (42.5%), followed by basal ganglia lesions (12.8%), cortical/subcortical lesions (9.4%), malformations (9.1%), focal infarcts (7.4%), and miscellaneous lesions (7.1%). In other studies, a study by Najar BA et al[33] reported the commonest MRI abnormality as PVL in 38.59% of the children, while Kwong K et al.[37] and Gururaj et al.[39] in 2002 reported very high rate of PVL that is 66% and 57% respectively.

In present study 8 out of 75 children had normal brain MRI but they were in the category level II, III, IV according to GMFCS with highest number was found in children functioning at GMFCS level II (6/38). In similar study by Ruba Benini et al.[40] in 2013 illustrated that children with CP can present with either normal-appearing or abnormal MRI findings irrespective of their GMFCS level. In contrast to our study, MN Robinson et al.[35] studied that normal MRI were found at each GMFCS level, with the highest number in children functioning at GMFCS Level I (8/25). Contrary Ruba Benini et al.[40] observed in GMFSC IV (50%; 7 of 14) to have normal brain MRI.

In the present study MRI findings correlated well with clinical diagnosis of children with ataxic cerebral palsy (100%), spastic hemiplegia (83.33%) and spastic quadriplegia (81.48%). The least correlation was noted with choreoathetid (0%), mixed (60%). Similar to our study Avanji SH et al[41] in 2008 found radiological findings closely related to type of CP. In contrast to our study, A. Aggarwal et al[42] reported that neuroimaging findings did not relate to type of CP. In present study, the overall correlation of MRI findings with clinical diagnosis was found to be 74.66%.

CONCLUSION

In the present study titled ―Brain magnetic resonance imaging findings in children with cerebral palsy and to correlate it with type of cerebral palsy, we conclude that

1. Neuroimaging, especially brain magnetic resonance imaging, plays an important role in the diagnosis of brain lesion in children suffering from cerebral palsy.
2. In this study, total 75 children in the age between 2 to 18 years during the period 1st October 2015 to 30st September 2017 were studied.
3. Amongst these 75 children, 67 had abnormal brain MRI which accounts to 89.33%.
4. Majority of the children were of spastic diplegia (36%) followed by spastic quadriplegia (18.67%), spastic hemiplegia (16%), dystonic (10.67%), hypotonic (9.33%) and mixed (6.67%). Less number of children had choreoathetoid and ataxic CP (1.33%) each.
5. The commonest area of the brain involvement was periventricular white matter (61.33%), cerebral cortex (48%), ventricular enlargement (44%) and corpus callosum (25.33%). Involvement of thalamus, globus pallidus (8%) each and cerebellar atrophy (1.33%) to a lesser extent.
6. The commonest MRI diagnosis noted was periventricular leukomalacia (40%) followed by cystic degeneration (12%), infarct (12%), cortical atrophy (10.67%) and basal ganglia lesions (8%). However, few patients were diagnosed with malformation, demyelination (2.67%) each and focal gliosis (1.32%). 8 out of 75 children with cerebral palsy (10.67%) had normal brain MRI findings.
7. The difference in the proportion of MRI abnormality across GMFCS levels was statistically insignificant as indicated by p-value of 0.589.
8. Furthermore, MRI findings correlated well with clinical diagnosis. The maximum correlation of MRI diagnosis with clinical diagnosis was noted in ataxic CP (100%) followed by spastic hemiplegia (83.33%), spastic diplegia (81.48%). While least correlation was noted with choreoathetoid cerebral palsy (0%).
9. Overall, MRI is a better diagnostic modality which helps to detect abnormalities in patients with cerebral palsy which helps in understanding the causal pathways in CP.

LIMITATION OF THE RESEARCH

- Limited sample size
- Areas based research

Future prospect study should be developed in cooperating large sample size and mass study with appropriate methodology to capture the frequency and prevalence of brain magnetic resonance imaging findings in children with cerebral palsy.

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Conflict of Interest- The authors declare that they have no conflict of interest.

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