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MRI In White Matter Diseases -Clinico Radiological Correleation

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ABSTRACT
Background: Demyelinating disorders are a heterogeneous group of diseases described as ―centralwhite matter disease, in which myelin loss exceeds axonal loss. The result of demyelinating diseasesis the thinning or even focal disappearance of the myelin sheath of axons. Such changes will affectsignal propagation in affected axons; depending on their location, this can lead to a host of neurologicandpsychiatric symptoms.
Aim of the study: To analyze the practical approach of MRI in white matter diseases of adult brain.**Objectivesofthestudy:**Tostudythedistribution andnatureofMRIfindingsinwhitematterdiseasesofadultbrainandtoestablishanaccuratediagnosisandtonarrowdownthedifferentialdiagnosisinvarious whitematterdiseases.
Materials and methods: The present study was conducted in the **Department of Radiology, Great Eastern Medical College Srikakulam for a period of 12 months from August 2020 toJuly2021.** It was an observationalstudy involving 50 cases, who were above 14 years of age with clinical suspicion / diagnosis of whitematter lesion, referred to the Department of Radiology for MRI irrespective of sex. Patients withclinical suspicion / diagnosis of white matter lesion referred to MRI with age more than 14 years andof both sexes, both out patients and in patients were included in the study. Exclusion criteria werepatientswithMRInon-compatibleimplantsintheirbodyinanyform(pacemaker,orthopedicimplants etc., patients with claustrophobia, unstable patients on life support mechanism, patients notwilling to give the consent and all the patients with age related vascular causes were not included inthestudy.
Results: The present study had been carried out for a period of 12 months among 50 adult patientsaged15yearsandabovewhowerereferredfor MRItothedepartmentofRadiodiagnosis,with clinical suspicion or diagnosis of white matterdisease. 62% of the study population belonged to the age group of 15 to 34 years. There after adecreasingtrendofthewhitematterlesionswasobservedwithincreaseinage.Outof50,only2cases (4%) belonged to age 65 years and above. Out of 50 cases studied, 27 (54%) were females and23 (46%) were males. Out of the total 50 cases studied, majority of the cases were of ADEM (28%)followed by PRES (20%). 5 cases each of ODM, MS and DAI were seen (10% each). 3 cases (6%) ofCADASIL,2 cases (4%) eachofTDM, PML, CTXand MBDwereobserved.
Conclusion: MRI due to its excellent gray-white matter resolution is very sensitive in detecting subtlewhite matter changes. The present study concludes that MRI, in correlation with DWI, MRS, MRcontrast in required cases is an ideal modality in early diagnosis of white matter diseases and aids intheearlyinstitutionof therapyso that the curable conditionsamongthemcan betreated.
KEYWORDS-MRI,White matter,Brain.

I. INTRODUCTION

Demyelinatingdisordersareaheterogeneous group of diseases described as ―central whitematterdisease‖,inwhichmyelinlossexceedsaxonal loss. The result of demyelinating diseasesis the thinning or even focal disappearance of themyelin sheath of axons. Such changes will affectsignal propagation in affectedaxons;dependingontheirlocation,thiscanleadtoahostofneurologicandpsychiatricsymptoms[1].Primarydemyelinatingdisorders,infectious,neoplastic, post-traumaticandmetabolicdisordersarethemostcommon.Whenwhitematterdiseaseisencounteredonanimagingstudy, it is useful to first characterize the whitematterinvolvementasmultifocal,confluent/diffuse, or selective (geographic). This approach,combined with the clinical information regardingpatientdemographics,clinicalhistoryandphysicalfindings,helpstheimagerlimitthedifferentialdiagnosis.Ifthewhitematterabnormalities are confluent, the next most helpfulMRIdiscriminatorconcernswiththeidentification of predominant localization of theabnormalities.Themajorpreferentiallocalizations

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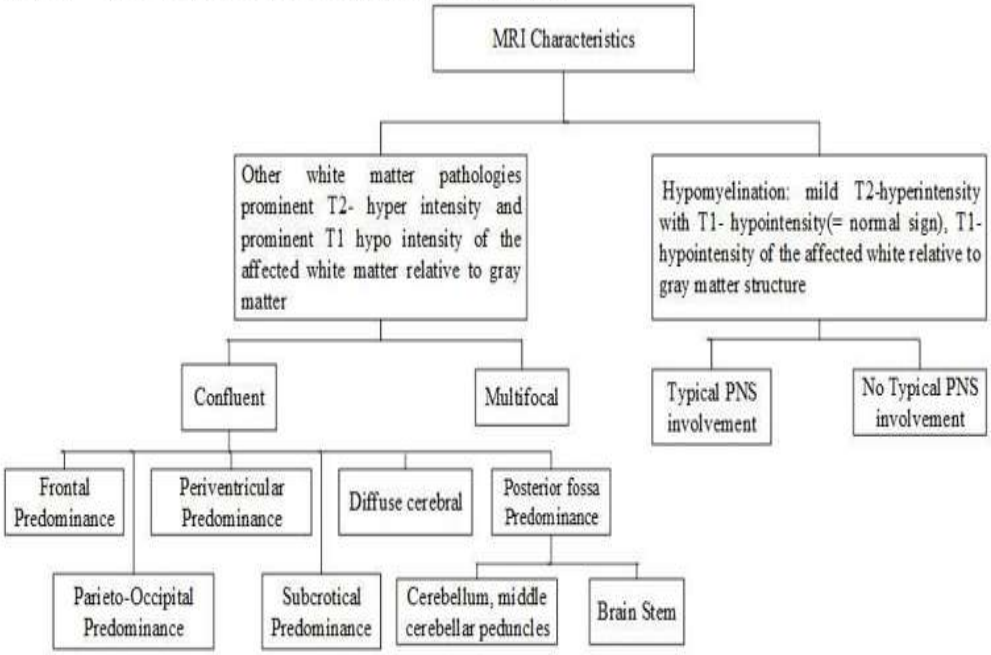
arefrontal,parieto-occipital,temporal,periventricular,subcortical,diffusecerebral,andposteriorfossa.SpecialMRIfeatures are typically seen in a number of specificdisorders and have a significant diagnostic value[2].MR characteristicsareas per **Figure–1**.

The advent of MR has revolutionized the conceptof understanding of white matter diseases. MRI isconsidered far superior to CT and is the imagingmodalityofchoiceinwhitematterdiseases.Further, with the advent of multi-echo sequencesof MR, even subtle lesions of demyelination canbe detected. A correct diagnosis could be made inmajority ofthepatientsbasedon MR findingsandclinicalhistoryalone.MR,inconjunction with clinical findings, plays a significant role inestablishingthediagnosisandinthefurtherfollow up of patients with white matter diseases[3].

Figure – 1: MRI Characteristics of White matter diseases.



Materials and methods

Thepresentstudywasconducted**fromAugustr2020to July2021**.It was an observational study involving 50 caseswho were above 14 years of age with clinicalsuspicion/diagnosisofwhitematterlesion,referredtotheDepartmentofRadiologyforMRI,irrespective ofsex.

Inclusioncriteria

- Patientswithclinicalsuspicion/diagnosis of white matter lesion referredto MRI with age more than 14 years andofbothsexes.
- Bothoutpatientsandin patientswereincludedinthestudy.

Exclusioncriteria

- PatientswithMRInon-compatibleimplants in their body in any form (pacemaker,orthopedicimplantsetc.
- Patientswithclaustrophobia.
- Unstablepatientsonlifesupportmechanism.
- Patientsnot willingtogivetheconsent
- All the patients with age related vascularcauseswere not includedinthe study.

Examination technique

AlltheMRIsequenceswereobtainedon1.5TeslaMRI machine_GESigna‘1.5TSignaExcitesystem(GeneralElectricMedicalSystems, Milwaukee, USA). A dedicated eightchannel high resolutionhead coilwasused.

Method

After obtaining informed consent, general dataregarding age, sex, symptoms, history of presentillness, past and personal history, smoking habit,alcoholconsumption,etc.werenoted.Axialsections of T1, T2 and FLAIR images of MRIwereobtainedfromallthepatients.Diffusionweighted MR sequence was also performed in allthepatients.Postcontrast T1imagesandMRspectroscopy were obtained in required patientsonly. MR imaging data of each patient regardingdistributionandnatureofthewhitematterlesi

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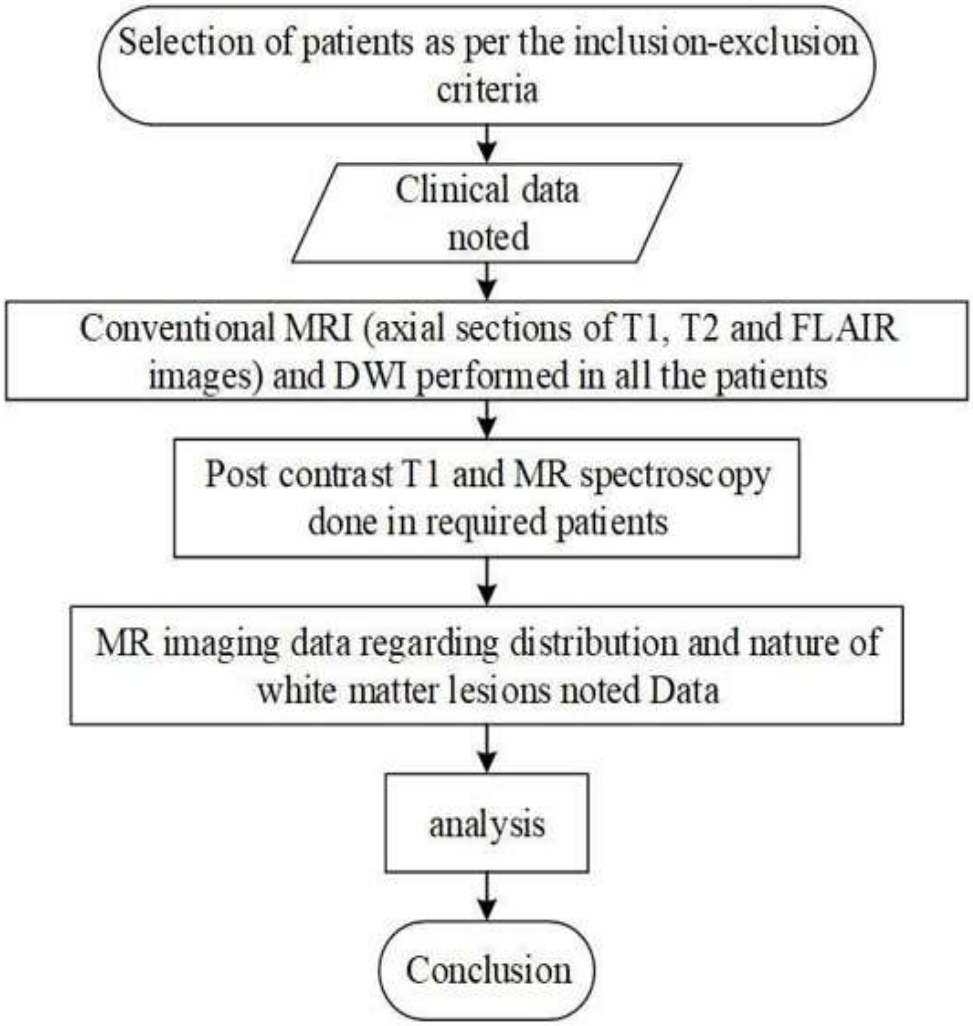
onsviz.,regionofinvolvement,signalcharacterization, presence or absence of diffusionrestriction,presenceorabsenceofcontrasten hancement,levelsofmetabolitesinMRspectroscopy,e tc. werenoted.

Dataanalysis

Statistical analysis of the data was performed byusing MicrosoftExcel.Datawasrepresentedintheformoffre quenciesandpercentages with the help of tables, bar diagrams.

Figure – 2: Brief procedure.



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II. RESULTS:

Thepresentstudyhadbeencarriedoutforaperiodof12 months among50adultpatientsaged 15 years and above who were referred forMRI to the department of Radiodiagnosis, withclinical suspicion or diagnosis ofwhite matterdisease. 62% of the study population belonged tothe age group of 15 to 34 years. Thereafter, atrend of the white matter lesions was observedwithincreaseinage.Out of50,only 2cases(4%) belonged to the age range of 65 years andabove.Outof50casesstudied,27(54%)werefemalesand23(46%)weremales.Out of the total 50 cases studied, majority of thecaseswereofADEM(28%)followedbyPRES(20%). 5 cases each of ODM, MS and DAI wereseen (10% each). 3 cases (6%) of CADASIL, 2cases (4%) each of TDM, PML, CTX and MBDwereobserved.Inmostofthewhitematterdiseases,youngeragegroupiscommonlyinvolvedexceptinODMandCTX.Allthe5cases in ODM belonged to the age group of 45years and above. Both the cases of observed CTXbelongedtomiddleage(45to54years).Therewas notmuchofadifferenceinsexdistributionof overall white matter lesions in the consideredstudy population, 27 females (54%) and 23 males(46%).Amongindividualdiseases,femalepreponderance was observed in PRES (M:F = 1:9) and MS (M:F=1:4), while male preponderancewas observed in DAI (all the 5 cases were males)as per **Table -1**.

Table - 1: Prevalence of white matter lesions (n=50).

Disease	No. of cases	Percentage
ADEM	14	28%
PRES	10	20%
ODM	5	10%
MS	5	10%
DAI	5	10%
CADASIL	3	6%
TDM	2	4%
PML	2	4%
CTX	2	4%
MBD	2	4%
TOTAL	50	100

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Table - 2: Age and Sex Distribution of ADEM Lesions (n=14).

Age in years	Female	Male	Total
15 to 24	2 (50.0%)	2 (50%)	4 (28.6%)
25 to 34	3 (60%)	2 (40%)	5 (35.7%)
35 to 44	1 (50%)	1 (50%)	2 (14.3%)
45 to 54		2 100%)	2 (14.3%)
55 to 64		1 100%)	1 (7.1%)
≥ 65		0	0
TOTAL	6 (42.9%)	8 (57.1%)	14 (100%)

Table - 3: Site of Lesions in ADEM.

Site of lesions	No. of cases	Percentage (%)
Cerebral White matter (predominantly subcrotical)	12	85.7%
Brain stem	5	35.7%
Basal ganglia	5	35.7%
Thalamus	4	28.5%
Periventricular white matter	4	28.5%
Cerebellum	2	14.3%

Table - 4: Site of Lesions in PRES.

Site of lesion	No. of cases	Percentage (%)
Occipital/parietal	8	80%
Frontal lobe	4	40%
Inferior temporal	4	40%
Cerebellum	4	40%
Brain stem	2	20%

Outof14casesofADEM,9cases(64%)belonged to 15 to 34 years age group. Thereafterwith increase in age, there was a decrease in thenumber of cases of ADEM. Out of 14 cases ofADEM,6werefemales(42.9%)and8weremales(57. 1%)as per**Table-2**.

On MR imaging of brain T1 hypointense, T2 andFLAIRhyperintenselesionswerenotedinADEMp atients.Predominantsiteofinvolvementwassubcortic alwhitematter(85.7%)followedbybrainstem(35.7%) andbasalganglia(35.7%).Thalamusandperiventricul arwhitematterwereinvolvedin28.5%ofcaseseach.Ce rebellum involvementwasseenin14.3%ofcases.Oncontrastad ministration 4 out of 14 cases (28.5%) showeddiscrete enhancing lesions. All the 10 cases ofPRESwereofbelow35yearsage.9outof10caseswer efemales.These9femaleswereknown preeclampsia patients and presented withhighbloodpressures.Onemalewhowasaknown case of hypertension presented with headache,high B.P and visionloss(**Table–3**).

MR imaging showed T1 (4cases-isointense, 6cases-hypointense), T2 and FLAIR hyperintenselesions. The common site involved in PRES wasoccipital or parietal region (80%). Frontal lobe,inferiortemporalregionandcerebellumwereinvo lved in 40% cases each. In 20% of the cases,brain stem was involved. On DWI 2 cases, (20%)showeda fewareasofrestricteddiffusioninsubcortical regions of both cerebral hemispheres,whichappearedisointenseonADCmap. Allthe5 cases of ODM observed were of 45 years andabove, 2 females and 3 males. All these caseswereendstagerenaldiseasepatientsonhemodialy sis. Pons was involved in 100% of thecasesofODM.Thalamusandmidbrainwereinvolve din40%ofthecaseseach.Allthecases

(5)ofmultiplesclerosisinourstudyshowedlesions in corpu callosum. Periventricular regionwas involved in 80% (4) of the cases. Corticalwhite matter, brain stem, spinal cord and opticnerve involvement was seen in one case (20%)each.In4cases(80%)lesionshaveovoidconfiguration with the major axes perpendiculartotheventricularsurface(Dawson'sfingers)whichareassociatedwiththeinflammatorychanges around the long axis of the medullaryveinthatcreatethedilatedperivenularspace(**Table– 4**).

Diffuseaxonalinjury

Out of 5 cases of DAI, two cases were grade III,two were grade II and one case was grade I. Allwere males of 25-34 years age group with meanageof29.2years.Allthese5casespresentedwithhistoryofpolytrauma.Involvementofcorpus callosum was seen in 4 out of 5 cases(80%).Brainstemwasinvolvedintwocases(40%).Thalamusandbasalgangliawereinvolvedin one case(20%)each.

CADASIL

Allthe3casesofCADASILbelongedto35to44 years age group. 2 were females, 1 male. OnMR Imaging T2 and FLAIR hyperintense areaswereobservedinexternalcapsuleandanterotemporal white matter in all the 3 (100%)cases. Periventricular and subcortical region wasalso involved in all the 3 cases (100%). Coranaradiatawasinvolvedin2cases(66.7%),brainstem in 2 cases (66.7%). All the three casesshowedsubcorticalinfarcts.

Tumefactivedemyelination

Two cases of Tumefactive demyelination werereported in our study. Both were females (28 and50 years). Both patients presented with gradualprogressive loss of vision with one case havingcomplete vision loss at the time of presentation.MRinbothpatientsshowedsymmetrical T1hypointense,T2FLAIRhyperintenselesioninvolvingtheperiventricularandsubcorticalwhitematterofbilateralposteriortemporal,occipital,parietallobesextendingacrossthesplenium of corpus callosum. The lesions wereshowingnomasseffectovertheadjacentventricularhorns.Oncontrastadministration,both the cases showed irregular incomplete ringenhancement with open side of the ring towardsthecortex.MRSinboththecasesshowedelevatedlactate,reducedNAA,increasedcholine,elevatedglutamate,reducedNAA/Chratio.DWIshowedrestricteddiffusionintheperiphery of the lesion with hypointense signal incenterwhichappearedashyperintensecenterwithisotohypointenseperipheryonADCmaps.

Progressive multifocal leukoencephalopathy

The 2 cases of PML were HIV positive males (32and27years).MRIshowedwelldefinedlesionsappearing hypointense on T1, hyperintense on T2andFLAIRinvolvingthesubcorticalwhitematterofbilateralfrontalandrightparietallobeswithnomasseffect.Basalgangliaandthalamuswere involved in one case.

Oncontrastadministrationnoobviousenhancinglesionsandnoevidenceofcorticalatrophywerenoted.MRSshowedreducedNAA,elevatedcholine,normalcreatinine and reducedNAA/Chratio. Inaddition,ourpatient'sCSFwaspositiveforJCvirus which supported ourdiagnosis.

Cerebellartendonxanthomatosis

BoththecasesofCTXwerefemalesbelonging to45to54yearsagegroup.Bothofthemshowedsymmetrical T2hyperintensitiesinbilateralcerebellarhemispheresinvolvingdentate nucleus. Cerebellar foliae are prominentwith dilated fourth ventricle. Both the patientspresentedwithcataractandachillistendonxanthomas.

Marchiafavabignamidisease

The two cases of MBD observed in our studywerechronicalcoholicmalesofage36yearsand 22yearsold.T2andFLAIRhyperintensitieswithdiffusionrestrictionnotedinbodyandsplenium of corpus callosum in both the cases.With the administration of thiamine, both casesshowedimprovementin clinicalsymptoms.

II. DISCUSSION:

Thepresentstudyhasbeencarriedoutforaperiod of 12 Months among 50 adult patients aged15 years with clinical suspicion or diagnosis ofwhitematterdisease.62%ofthestudypopulation belonged to the age group of 15 to 34years. There after a decreasing trend of the whitematter lesions was observed with increase in age.Out of 50, only 2 cases (4%) belonged to age 65yearsandabove.Outof50casesstudied,27(54%) were females and 23 (46%) were males.Out of the total 50 cases studied, majority of thecases were of ADEM (28%) followed by PRES(20%). 5 cases each of ODM, MS and DAI wereseen (10% each). 3 cases (6%) of CADASIL, 2cases (4%) each of TDM, PML, CTX and MBDwereobserved.

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Acutedisseminatedencephalomyelitis(ADEM)

14 cases (8 males, 6 females) werediagnosed with ADEM. Allthe 14 cases havehistoryoffeverpriortotheonsetofclinicalsymptoms. In addition, 4 patients presented withalteredsensorium,2patientswithdoublevision,2 patients with 3 episodes of seizures. The agegroup varied through a wide range of 19 to 52yearswith male:femaleratio of2:1.5.However, Kesselring J, et al. [4] in their studyhad noted a male female ratio of 1.4:1. In ourseries, all the cases were adults with mean age of31 yrs. According to literature, ADEM can occurin all ages, although most reported cases are inchildren and young adults. However, study doneby Schwartz S et al on occurrence of ADEM inadult patients consisting of 40 cases showed themean age as 33.5 years which is comparable withourresult.InourstudyonMRimaging,T1hypointense, T2 and FLAIR hyperintense lesionswere noted, of which majority were located insubcorticalwhitematterofbothcerebralhemispheres (12/14cases-85.7%),followedbybrain stem (5/14 cases- 35.7%), cerebellar whitematter(2/14 cases-14.3%). Brain stem and/orcerebelluminvolvementin 43%of cases

On comparison, R.C. Dale, et al. [5] showed thatinvolvement of the deep and subcortical whitematterwasnearlyuniversal(91%),brainstemand /orcerebellumwereinvolvedin87%ofcases.Thethalamiand/orbasalgangliawereinvolved in 69% of cases. Periventricular regionwasinvolvedin44%Noneofthepatientsshowed involvementofspinalcord.InMikealoff, et al. [6] study, cerebellum and /orbrain stem were involved in 68%, thalamus and/orbasalgangliawereinvolvedin63%,juxtacortical regionwasinvolvedin66%ofcases. In Linn, et al. [7] study, cerebellum andbrain stem were involved in 77%, thalamus andbasalgangliawereinvolvedin62%,periventricular regionwasinvolvedin60%,cortical region was involved in 43% of cases. Inour study, Thalamic involvement was seen in 4out of 14 cases (28.5%) and basal ganglia wasinvolved in 5 out of 14 cases (35.7%), thalamusand/orbasalgangliain50%ofcases.Ourfindings were consistent with the study done byBaum PA, et al. [8] which showed that thalamicinvolvementisreportedtoberareinmultiplesclerosis, and may prove useful in distinguishingbetween ADEM and the initial presentation ofmultiplesclerosis.Oncontrastadministration,out of 14 cases, 4 cases (28.5%) showed discreteenhancinglesionswithonecaseshowinginco mpleteringtypeofconfiguration.Thesefindings were comparable with the observationsdone by Van der Knapp, et al. [9] and Nathan PYoung, et al. [10] which showed the white and/orgray matter lesions may enhance, but usually notalllesionsenhance,andcontrarytowhatisusually stated, their experience is that in manycasesenhancementisatmostsubtleorisnotpresentatall(**Table– 5**).

Posterior reversible encephalopathy syndrome(hypertensiveencephalopathy)

10 cases of PRES ofwhich 9 were female and 1 male with a sex ratioof male to female 1: 9. Of the 10 cases, 9 wereknown case of preeclampsia and presented withhighbloodpressures.Onemalewhowasaknown case of hypertensive presented with headache,highB.Pandvisionloss.MRimagingshowedT1(4cases-isointense,6cases-hypointense)T2FLAIRhyperintenselesionsaffecting the subcortical white matter of bilateralparietooccipitallobes(8/10casesi.e.80%),temporallobes(4/10casesi.e.40%),frontallobes(4/10casesi.e.40%),brainstem(2/10casesi.e. 20%) and cerebellum (4/10 cases i.e. 40%).These findings were comparable with study donebyDonmezFY,etal.[11]whoreportedthatthemost commonly involved localizations in PRESwereparietallobein84.8%,occipitallobein72.7 %, frontal lobe in 51.5%, temporal lobe in33.3%, and cerebellum in 33.3%. Chou MC et al[19]alsosuggestedthatinvolvementofanteriorcirculationregion,brainstem,cerebellum,deepcerebral white matter, and thalamus are commoninPRES(**Table – 6**).

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Table - 5: ADEM - Comparison of Present Study with Existing Studies.

FINDING	RC dale, et al. [5]	Mikealoff, et al. [6]	Linn, et al. [7]	Prevalence in present study
Sub cortical white matter	91%	66%	43%	85.3%
T and /or BG	69%	63%	62%	50%
BS and /or CB	87%	68%	77%	43%
Periventricular	44%	-	60%	28.5%

***T-Thalamus, BG-Basal ganglia, BS-Brain stem, CB –Cerebellum.**

Table - 6: Posterior Reversible Encephalopathy Syndrome Comparison of Present Study with Existing Studies.

FINDING	Donmez FY, et al. study [11]	W.S. Bartynski, et al. [18]	Prevalence in present study
Sub cortical white matter of bilateral parieto occipital regions	Parietal (84.8%) & occipital (72.7%)	98%	80%
Temporal lobes	33.3%	40%	40%
Frontal	51%	68%	40%
Cerebellum	33.3%	32%	40%

Table - 7: Osmotic demyelination syndrome: Comparison of present study with existing studies.

FINDING	Jonathan Graff-Radford, et al. [14]	Ramesha Nekkare Kallakatta, et al. [15]	Prevalence in present study
Pons	100%	76%	100%
Thalamus	36%	20%	40%
Mid brain	27%	16%	40%
Diffusion restriction	53%		60%

findings are also comparable with the studydone by W.S. Bartynski, et al. [18], in which outof136patients,Vasogenicedemawasconsistently present in the parietal oroccipitalregions (98%), but other locations were commonincludingthefrontallobes(68%),inferiortemporallobes(40%),andcerebellarhemispheres(30%).Involvementofthebasalganglia(14%),brainstem (13%),anddeepwhitematter (18%) including the splenium (10%) wasnot rare. On DWI usually PRES does not showrestricted diffusion, however in our series 2 case,20% showed few areas of restricted diffusion insubcortical regions of both cerebral hemisphereswhich appeared isointense on ADC map. This atypical finding is comparable with study done byMcKinneyAM,etal.[12]whoreportedthatrestricted diffusionwasthesecondmostcommon atypicalpresentationofPRESintheirstudy,accounting for17.3%.Thefindingswerealsoconsistent with C J Stevens et al who stated thatrestricted diffusion as an associated finding hasbeen described in PRESandhasbeen shown tobepotentiallyreversible(**Table-6**).

Osmoticdemyelinationsyndrome

Inthepresentstudy,5casesofosmoticdemyelinationsyndromewereobserved.Allthesefivewereendstagerenaldiseasepatientson hemodialysis. All the 5 (100%) cases showedT1 hypo to isointense and FLAIR hyperintensityoncentralpons.Thisisinfavorofosmoticdemyelination syndrome with demyelination ortransientedemainpons.Oncomparison,N.CaglaTarhan,etal.[13]studyshowedhyperintensity in central pons in 65% (11 out of17)patients.

Thalamusandmidbrainwereinvolved in two cases (40%) each. Three cases(60%) show diffusion restriction on DWI. Thesefindings are almost comparable to the findings ofJonathan Graff-Radford, et al. [14] in which ponswas involved in all 22 patients (100%), followedbythethalamus(n=8[36%]),midbrain(n=6[27%]), cortical gray matter (n=3 [14%]), hippocampus (n=3 [14%]), caudate (n=2 [9%]),putamen(n=2[9%]),andmiddlecerebralpedun

cle(n=2[9%]).Of19casesinwhichdiffusion-weighted sequences were obtained, 10(53%)demonstratedevidenceofrestricteddiffusion .InRameshaNekkareKallakatta,etal. [15]studyof25patientswithosmoticdemyelination, Pons was involved in 19 patients(76%)Caudate18(72%)Putamen19(76%)Th alamus5 (20%)Midbrain 4(16%)Corticalgreymater(frontalandinsular)3(12%) Extratemporalcorticalwhitemater3(12%)Hippocam pus2(8%)Cerebellum2(8%),Medulla1(4%)andSubt halamicnuclei1(4%)as per **Table -7**.

Multiplesclerosis

Cases of multiple sclerosis noted,were between 21-44 years of age. Mean age ofonsetis31.4years.Adistinctfemalepreponderancew asnotedinourstudygroup,with 4 females and 1 male (male: female = 1:4).All the above results were comparable with thestudiesdonebyBNLakhkar,etal.andGangopadhya yG,etal.Inourstudy,MRimagingshowedmultipledisc retelesionsappearinghyperintenseonT2andFLAIRi mages. Corpus callosum was involved in all fivecases which was consistent with a prospectivestudy done by Yulin Ge, et al. [11], who foundthatmostofMSpatientsdemonstratedconfluent/ focallesionsinvolvingthecalloso-septalinterface and concluded that callosal involvementwas specific for MS and also useful in assessingthe relapse rates. But in BN Lakhkar, et al. study,out of 15 patients only one patient had callosalatrophy.Involvementofperiventricularwhite matter was seen in 4 out of 5 cases (80%). Brainstem, spinal cord and optic nerve were involvedinonecase(20%)each.Thesefindingsweresi milartotheresultsofstudydonebyBNLakhkar, et al. [3] which showed periventricularinvolvement in 80%, brain stem in 40%, spinalcordandoptic nerve in 20% each.In Joost C. J. Bot, et al. [17] study done on 25casesofmultiplesclerosis,allthe25casesshowed periventricular Involvement.Juxtacorticallesionswerepres entin80%ofpatients.Infratentoriallesionswerepresen tin84% of patients. Deep white matter lesions werepresentin96%ofpatients.Enhancingfocallesions were observed 32% ofpatients. While inourstudy,infourcases(80%),lesionshaveovoidconf igurationwiththemajoraxesperpendiculartotheventri cularsurface(Dawson‘s fingers) which are associated with theinflammatory changes around the long axis of themedullary vein that create the dilated perivenularspace which is consistent with the findings of BNLakhkar, et al. [3] and Yulin Ge, et al. [18] as per**Table–8**.

Diffuseaxonalinjury

5 cases of DAI were observed, ofwhich two cases weregrade III, two were gradeII and one case was grade I. All were males of25-34yearsagegroupwithmeanageof 29.2years.ThesefindingsarecomparabletoPamelaW. Schaefer,etal.,inwhichmeanageis 25.2 years with a male and female ratio of 2.25.In present study, involvement of corpus callosumwas seen in 4 out of 5 cases (80%). Brain stemwasinvolvedintwocases(40%).Thalamusand/or basal ganglia were involved in two cases(40%).ThesefindingsarecomparablewithPamel aW.Schaefer,etal.[19]inwhich12(46%) patients had lesions in the brainstem, 12(46%) had lesions within the basal ganglia and/orthalamus,and16(61%)hadinjuriesofthe corpuscallosum.ComparedtoEzakiY,etal. [20] study done, among the 21 patients of DAI,greywhitematterinterfaceandcentralwhitematte rinvolvementin50%,Thalamus/basalgangliainvolve mentin12%corpuscallosuminvolvement in 9% and brainstem involvement in18%. Compared to M Takaoka, et al. [21] studydone, among 21 patients of DAI, involvement ofcorpus callosum is seen in all patients and brainstem is involved in 8 cases (38%) as per **Table -9**.

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Table - 8: Multiple sclerosis comparison of present study with existing studies.

FINDING	BN Lakhkar, et al. [3] study	Joost C. J. Bot, et al. [17]	Prevalence in present study
Periventricular white matter (with Dawsons fingers)	80	100	80
Deep white matter (Brain stem)	40	96	20
Spinal cord	20	-	20
Optic nerve	20	-	20
Juxtracortical lesions	-	80	20

Table - 9: Diffuse axonal injury comparison of present study with existing studies.

FINDING	Pamela W. Schaefer, et al. [19]	Ezaki Y, et al. [20]	M Takaoka, et al. [21] study	Prevalence in present study
Corpus callosum	61	9%	100%	80%
Brain stem	46	-	38%	40%
Thalamus and/or basal ganglia	46	12%	-	40%
Grey white matter interface	-	50%	-	80%

Table - 10: CADASIL: Comparison of present study with existing studies.

FINDING	Dorothee P. Auer, et al. [22] Study	Vandenboom, et al. [23] study	Prevalence in present study
Bilateral anterior temporal white matter	100%	95%	100%
External capsule	-	58	100%
Brain stem	89.3%	-	66%
Subcortical lacunar infarcts	-	37%	100%

CADASIL

In the present study, 3 cases (one male and 2females) of CADASIL belonged to the age groupof35to44yearswereobserved.OnMRImaging, T2andFlairhyperintenseareaswere observed in external capsule and anterotemporalwhitematterinallthe3(100%)cases.Periventricular and subcortical region was alsoinvolved in all the 3 cases (100%). Other regionsinvolvedwerecoranaradiatain2cases(66.7%), brainstem in 2 cases (66.7%). All the three casesshowedsubcorticalinfarcts.On comparison, in Dorothee P. Auer, et al. [22]study, out of 28 patients on MR Imaging, all buttwo of the 28 patients showed involvement oftemporopolar WM. Further, lesions were seen inthe basal ganglia in 24 patients (85.7%), in thebrainstemin25(89.3%),inthethalamusin25(89.3%), in the cerebellum in 13 (46.4%), and inthecortexintwo(7.1%).ComparedtoVandenboom, etal.[23]studydoneon24patientsofCADASIL,Subcorticallacunarinfarctsin9patients(37%),Lacunarinfarcts15(62.5%),Microbleeds(n)4,Anteriortemporallobe 23(95%),Externalcapsule (n) 14(58%)andInternalcapsule (n) 15(**Table– 10**).

Tumefactivedemyelination

Two casesofTumefactivedemyelinationinourstudyseries. Bothcaseswere females (28 and 50 years) with average ageof onset being 39 years which was comparablewith D. Shah, et al. [24] who stated that theselesions occur more frequently in women in thesecondandthirddecadesoflife,withanaverage age of onset of at least 37 years. Bothpatients presented with gradual progressive lossof vision with one case having complete visionlossatthetimeofpresentation.MRinbothpatients showed symmetrical T1 hypointense, T2FLAIRhyperintenselesioninvolvingtheperiventricularandsubcorticalwhitematterofbilateralposteriortemporal,occipital,parietallobes extending across thesplenium ofcorpuscallosum.Thelesionswereshowingnomasse

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ffectovertheadjacentventricularhorns.Oncontrast administration, 2 cases showed irregularincomplete ring enhancement with open side oftheringtowardsthecortex.InastudybyCurtisAGive n,etal.[25],approximately half of tumefactive demyelinatinglesionshavepathologiccontrastenhanc ement,usuallyintheformofringenhancementandcom monly the enhancement pattern will be in theform of an open ring, with the incomplete portionoftheringonthegraymattersideofthelesion ComparedtoDaeSikKim,etal.[26]whostudiedtheenh ancementpatternsinthe15patientswithTDLreportedi ncompleterimenhancement was noted in 83%, Mixed T2 isoand hyper intensity of enhancing components in83%, Absence of mass effect was noted in 79%,absenceofcorticalinvolvementwasnotedin76% MRSinboththecasesshowedelevatedlactate,reduced NAA,increasedcholine,elevatedglutamate,reduced NAA/Chratio.Thesefindingswereconsistentwiththes tudydonebyCurtisAGiven,etal.[25]whoreporteda characteristic spectrum consisting of elevatedcholinewithsuppressedlevelsofN-acetylaspartate. Additionally, there may be detectablelevelsoflipidsandlactatecorrespondington ecrosis and anaerobic metabolism mimicking aneoplastic process, However these lesions can bedifferentiatedfromneoplasticlesionswithdemonsta rion of glutamate peak which was notedin our cases consistent with the findings of A.Cianfoni, et al. [27] study, who reported that anabnormalelevationoftheglutamate/glutamine(2.1–2.5ppm)peaksisthemorecriticalMRspectroscopyfind ingintumefactivelesionsinthe brain, a finding that is not usually seen in theconfoundingaggressiveintra-axial neoplasms.DWI in both cases showed restricted diffusion intheperipheryofthelesionwithhypointensesignal in center which appeared as hyperintensecenter with iso to hypointense periphery on ADCmaps. These findings were consistent with thestudy done by C.H Toh, et al. [28] who reportedrestricted diffusion in the lesion periphery waspresentin7of8tumefactivedemyelinatinglesions (87.5%)in their study group(**Table–11**).

Progressive multifocal leukoencephalopathy

ThepresentstudyincludedcasesofPMLwhoareHIVp ositivemales(32and27years).KruppLB,etal.[29]repo rtedthatPMLhasastrongerassociation with AIDS than With any immune suppressuvediseaseand55%to85%ofrecent PMLcasesareattributabletoAIDS.

Table - 11: Tumefactive Demyelination - Comparison with Existing Studies.

FINDING	Curtis A Given, et al. [25] study	C.H Toh, et al. [28] study	Dae Sik Kim, et al. [26]	Prevalence in present study
Incomplete rim enhancement	50	-	83%	100
Absence of Mass effect	-	-	83%	100
Diffusion	-	87.5%	-	100

The younger age of onset was consistent with thestudy done by Giesen VHJ, et al. [30] on HIVpatientswithPMLwhichstatedthatthemeanage of onset was 29 years. They also opined thatthe mean age of onset in HIV positive cases weresignificantly lower than HIV sero negative PMLandmale patients prevailed.

MRshowedwelldefinedlesionsappearinghypointens eonT1,hyperintenseonT2andFLAIR involving the subcortical white matter ofbilateral frontal and right parietal lobes with nomasseffect.Oncontrastadministration,noobviouse nhancinglesionswerenotedandnoevidenceofcortical atrophy.Thesefindingscorrelatedwiththediagnosticc riteriaproposedbyGiesenVHJ, etal. [30].

MRSshowedreducedNAA,elevatedcholine,normalc reatinineandreducedNAA/Chratio.Thesefindingswe recomparablewithIranzoA,et al. [31] and Chang L, et al. [32] which showedPML lesions to be characterized by significantlyreducedNAA,significantlyincreasedCh ocomparedwithcontrolgroupvalues.DWIshowedrest ricteddiffusioninthelesioninvolvingsubcorticalwhite matterofrightfrontal lobe which appeared isointense on ADCmap. These findings are comparable with BerguiM, et al. [33] study which showed newer lesionsandtheadvancingedgeoflargelesionshadnorm al-to-lowADCandgavehighsignalonDWI. High signal on DWI and low ADC markthe regions of active infection and cell swelling,distinguishingthemfromareasofreparativeg liosis.TheMR,MRSandDWIfindingsincorrelationwi

thpatient‘sHIVstatusweresuggestiveofprogressivemultifocalleukoencephalopathy.Inaddition,ourpatient‘sCSF was positive for JC virus which supportedourdiagnosis.

Cerebrotendinoxanthomatosis

The present study includes 2 cases of CTX. BoththepatientsshowedsymmetricalT2hyperintensities inbilateralcerebellarhemispheresinvolving dentate nucleus. Cerebellar foliae areprominentwithdilatedfourthventricle.SymmetricalT2hyperintensitiesarenotedinparieto-occipitalsubcorticalwhitematter&internalcapsule.Boththepatientspresentedwithcataract and achillistendonxanthomas.Thesefindingsareconsistentwith FrederikBarkhof,etal.[34]studydoneon24CTXpatientsinwhichcerebellumwasaffectedinmostpatients(84%)Cerebellarinvolvementtypicallystartedinthedentatenucleus.TheAchilles tendons were affected in seven patients.63%casesshowedpyramidaltractinvolvement.

Marchiafavabignamidisease

Two cases of MBD were observed.Bothwerechronicalcoholicmalesofage36yearsand22yearsold.T2andFLAIRhyperintensitieswithdiffusionrestrictionisnoted in body and splenium ofcorpuscallosumin both the cases. These findings are consistentwithLeeSH, et al.[35];Ménégon,etal.[36].

III. CONCLUSION

MRIduetoitsexcellentgraywhitematterresolutionisverysensitiveindetectingsubtlewhitematterchanges.ThepresentstudyconcludesthatMRI,incorrelationwith DWI,MRS, MR contrast in required cases is an idealmodalityinearlydiagnosisofwhitematterdiseasesandaidsintheearlyinstitutionoftherapysothatthecurableconditionsamongthemcan betreated.

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