Original Article

Use of Jonkman *et al.* Score for Visual Quantification of Electroencephalography as a Tool to Assess Disease Severity in Cortical Dementias

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ABSTRACT

Objectives: To study electroencephalography (EEG) changes in patients with cortical dementias (Alzheimer's disease [AD] and frontotemporal dementia (FTD). (1) To correlate EEG changes with clinical severity of dementia as assessed by rating scales. (2) To correlate global gray matter volume (GGMV) with EEG scores and clinical severity rating scales. **Patients and Methods:** This is a prospective cross-sectional study involving patients fulfilling the criteria for Probable AD and FTD. A total of thirty patients (20 = FTD, 10 = AD) underwent detailed neuropsychological evaluation, dementia rating scales, EEG, and magnetic resonance imaging. Five EEG parameters were acquired and each parameter is scaled and the total score was compared with neuropsychological parameters and GGMV. **Results:** For FTD, the mean age of patients was 58.85 ± 6.87, mean mini-mental state examination score was 13.30 ± 6.33, Hindi mental state examination: 14.35 ± 6.28, mean grant total EEG score (GTES): 7.80 ± 5.39, and mean GGMV: 464580.76 ± 52127 mm^3 and for AD, the same were 69.50 ± 8.59, 12.90 ± 5.56, 14.20 ± 5.31, 9.80 ± 5.29, and 483208 ± 47371.5 mm^3, respectively. GTES for mild, moderate, and severe FTD are 2.33 ± 1.528, 6.00 ± 3.162, and 10.70 ± 5.677 and for AD it is 4, 7.50 ± 4.041, 15 ± 1.414, respectively. The GGMV for mild, moderate, and severe FTD was 511836 ± 45005, 492693.1 ± 50624, and 430725 ± 30744 and for AD it is 527217.3 ± 36171, 503598 ± 3006, and 440812 ± 33911. **Discussion:** The most common EEG abnormalities in cortical dementias are reduced frequency of rhythmic background activity. There is a significant correlation between GTES and dementia severity and global gray matter volume but the proportional correlation with GTES and volumetric scores is not significant. **Conclusion:** EEG is a cheap and sensitive and easily available tool to assess disease severity in patients with cortical dementias and thus helps in planning the type of rehabilitatory interventions and prognostication.

Key words: *Disease severity, global gray matter volume, Jonkman electroencephalography score*

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INTRODUCTION

Electroencephalography (EEG) represents the dynamic activity of cortical neurons their connectivity and synchrony and forms a voltage versus time graph which is the total of the postsynaptic excitatory and inhibitory potentials modified by the intralaminar nucleus of the thalamus and picked up from the cortex. The physiological basis for various rhythms includes alpha-rhythm which is an indicator of interconnectivity of cortical layers IV and V. Beta-rhythm is generated by cholinergic pedunculopontine tegmentum.[1] A small amount of theta activity may be recorded from temporal regions. Delta rhythm is not seen in normal awake EEG because of its suppression by the corticothalamic activating system. In dementia, there is a loss of neurons in the cerebral cortex, loss of connectivity, reduction in synapses, loss of cholinergic neurons, and damage to thalamocortical activating system. Hence, appropriate EEG abnormalities are likely to occur and this may serve as useful, simple tool to quantify brain volume loss and therefore useful in prognostication. EEG changes and degree of dementia were analyzed by Claus *et al*., Rae-Grant *et al*., Srinivas *et al*., Brenner *et al*., etc.[2-4] However, there is paucity of data comparing EEG data with gray matter volume.

Dementia represents one of the major public health problems affecting elderly in epidemic proportions. The prevalence of dementia is 3–11%[5] in people of 65 years and older and 20% in the age group of 80 years and older. By 2020, 70% of world's population aged 60 years and above will be located in developing countries and about 15% in India alone.[6] Staging the disease is important as it will help the physician to plan the use of disease-modifying treatment strategies, rehabilitory tools, versus end-stage symptom management and institutionalization. We tried to correlate clinical dementia rating (CDR) scale and EEG visual rating using Jonkman *et al*. in 1989 scale and global gray matter volume on magnetic resonance imaging (MRI).

PATIENTS AND METHODS

The study is a hospital-based prospective study. Patients were selected from outpatient/inpatients from the Department of Neurology and Geriatrics. Those who satisfied the diagnostic criteria for clinically probable Alzheimer's disease (AD) using National Institute of Neurological Disorders and Strokes- Alzheimer's Disease and Related Disorders, MCKhan *et al*. 1984 criteria and frontotemporal dementia (FTD) using McKhan *et al*. 2001 and Neary 1984 criteria were included sample size 30 (FTD 20, AD 10). Study period from February 2010 to December 2011.

Ethical issues

Informed consent taken from all the participants' protocol approved by the NIMHANS Ethics Committee.

EVALUATION WITH ELECTROENCEPHALOGRAPHY

EEG was carried out in EEG laboratory with GALLELIO EB Neuro Machine. Patients were advised to come for the test with thorough hair washing keeping it dry and not to be on fasting. The procedure was explained in detail. All the precautions to minimize the artifacts to the possible extent were taken. Electrode placement was according to the international 10–20 system. Additional electrodes included were electrocardiograph electrode, electromyography electrode, anterior temporal (T1 and T2), and F9 and F10 electrodes. Electrode impedance was measured before any EEG (between 100 and 5000 ohms). High-frequency filter was kept at 70 Hz. Recording was done in referential montage. At least 20 min recording was taken; the following activation procedures were used in all cases. Hyperventilation for 5 min and recording for 2–3 min following it. Photic stimulation at 3 Hz increment from 1 Hz followed by 3 Hz up to 27 Hz. Each of these frequencies of photic stimulation was given for 5 s and next higher frequency stimulus after another 5 s.

Visual assessment of the electroencephalogram was done and findings were documented as per the following subheadings; grades ranging from 0 to 5 (for reactivity of the background activity there was no Grade 2, Grade 1 not described for sharp wave activity, Grades 1 and 2 were not described for paroxysmal activity).

1. Frequency of rhythmic background activity:
   0= >9.0 Hz, 1 = 8–9 Hz, 2 = 7–8 Hz, 3 = 6–7 Hz, 4 = 4–6 Hz, and 5 = none.
2. Diffuse slow activity:
   0 = non, 1 = intermittent theta, 2 = intermittent theta + sporadic delta, 3 = continuous theta + intermittent delta, 4 = continuous theta + delta, and 5 = continuous delta.
3. Reactivity of the rhythmic background activity:
   0 = normal reactivity, 1 = diminished reactivity on eye opening, 3 = absent reactivity on eye opening, 3 = no reaction to somatosensory stimuli, 4 = no reaction to auditory stimuli, and 5 = absence of all reactivity.
4. Paroxysmal activity:
   0 = none, 3 = paroxysmal slow activity, and 5 = frontal intermittent rhythmic delta activity.

5. Focal disturbances:
   0 = no focal disturbance, 1 = mild disturbances unilateral, 2 = mild disturbances bilateral, 3 = severe unilateral and mild contralateral, 4 = severe bilateral disturbances, and 5 = multifocal abnormalities.
6. Sharp wave activity:
   0 = none, 2 = sporadic sharp waves, 3 = frequent sharp waves, 4 = triphasic waves, and 5 = Creutzfeldt-Jakob complexes or periodic lateralized epileptiform discharges.

Grand total electroencephalography score

Calculated by adding 1 to the sum of scores of the above 6 EEG parameters (Jonkman *et al*., 1989).

Evaluation with magnetic resonance imaging

MRI brain was done on 3T Magnetic Resonance Imaging Scanner (Achieva Philips). The following sequences were done in all the patients.

- T2 flair axial imaging - (TR = 1089 ms, TE = 16 ms, acq matrix = 260 × 163, field of view = 240 mm × 166 mm, slice thickness = 3.3 mm)
- T2 weighted fast field echo - (TR = 1089 ms, TE = 16 ms, acq matrix = 260 × 163, field of view = 240 mm × 166 mm, slice thickness = 5 mm, slice gap 1 mm)
- T2 vista high resolution - (TR = 2500 ms, TE = 366 ms, acq matrix = 256 × 255, field of view = 256 mm × 256 mm × 145 mm, voxel size 1 mm^3 slice thickness = 1 mm, slice gap 1 mm)
- T1-weighted three-dimensional turbo field echo/ T1-magnetization prepared rapid gradient echo - (TR = 8.2 ms, TE = 3.7 ms, acq matrix = 1 × 1 × 1, field of view = 256 mm × 256 mm × 145 mm, voxel size 1 mm^3 slice thickness = 1 mm, slice gap 1 mm)
- Diffusion tensor imaging - (TR = 9632 ms, TE = 56 ms, acq matrix = 112 × 109, field of view = 224 mm × 224 mm, slice thickness = 2.5 mm, no intersection gap, b = 800s/mm^2).

Image analysis

Conventional magnetic resonance imaging analysis

The MRI images were reviewed by a qualified neuroradiologist (Rose Dawn Bharath) and imaging findings were grouped under the following categories subjectively.

Diffuse cerebral atrophy, focal atrophy (frontal/ temporal/parietal/occipital); basal ganglia changes, ventricular size; cerebellar atrophy; white matter signal changes focal parenchymal changes, other findings, etc.

Quantitative magnetic resonance imaging analysis

Cortical reconstruction and volumetric segmentation were performed with the Freesurfer image analysis suite (Dale *et al*., 1999, Dale *et al*., 1993, and Fischl *et al*., 2001). This processing includes motion correction and averaging of multiple volumetric T1-weighted images, removal of nonbrain tissue using a hybrid watershed/ surface deformation procedure; automated Talairach transformation, segmentation of the subcortical white matter and deep gray matter volumetric structures including hippocampus, amygdala, caudate, putamen, ventricles; intensity normalization, tessellation of the gray matter-white matter boundary, automated topology correction, and surface deformation following intensity gradients to optimally place the gray/white and gray/ cerebrospinal fluid borders at the location where the greatest shift in intensity defines the transition to the other tissue class. Once the cortical models are complete, a number of deformable procedures can be performed for in further data processing and analysis including surface inflation, registration to a spherical atlas which utilized individual cortical folding patterns to match cortical geometry across subjects, parcellation of the cerebral cortex into units based on gyral and sulcal structure, and creation of a variety of surface based data including maps of curvature and sulcal depth. This method uses both intensity and continuity information from the entire three-dimensional MR volume in segmentation and deformation procedures to produce representations of cortical thickness calculated as the closest distance from the gray/white boundary to the gray/cerebrospinal fluid boundary at each vertex on the tessellated surface.

Statistical analysis

Analysis was done using the SPSS-15 (statistical package for social science) package.

Data were expressed using descriptive statistics such as mean, standard deviation for continuous variables and frequency, and percentages for categorical variables. Correlation between continuous variables was done using Pearson's correlation coefficient. Kruskal–Wallis test was used for correlation between continuous and categorical variables.

RESULTS

Total thirty patients of cortical dementia were studied cross-sectionally. Twenty of these were FTD and ten were AD.

Demographic characteristics: Frontotemporal dementia

Age

Mean age was 58.85 ± 6.87 years with a range of 43–70 years. Majority (55%) were in the sixth decade.

Mean age at onset of symptoms was 56.12 ± 6.60 years with a range of 41–66 years; only one patient had onset after 65 years. All the patients had an insidious onset and gradually progressive disease. Most common initial symptoms were a decline in social interpersonal conduct and change in behavior. Other symptoms observed were emotional blunting, loss of insight, poor personal hygiene, easy distractibility, perseverative and stereotyped behavior, and memory loss.

Neuropsychology

Detailed neuropsychological assessment could be done in ten patients only. Characteristic findings observed were a significant impairment on frontal lobe tests, poor set shifting (Wisconsin cord sorting test), response inhibition (Stroop test), poor organization, poor planning (tower of London test), poor temporal sequencing, and impaired sustained attention (digit vigilance test).

Clinical assessment of dementia severity

The following scales were used for the clinical assessment of patients:

1. Mini-mental state examination (MMSE) score: Mean score was 13.30 ± 6.33, with a range of 5–24.
2. Hindi mental state examination (HMSE) score: Mean score was 14.35 ± 6.28 with a range of 6–25.
3. Blessed dementia scale: Mean score was 12.55 ± 4.53 with a range of 4–20.
4. CDR scale: As per the CDR, patients were classified into mild (CDR-1), moderate (CDR-2), and severe dementia (CDR-3).

Of the total twenty patients, three had mild dementia, seven had moderate dementia, and ten had severe dementia.

Clinical dementia severity and grand total electroencephalography score

As the clinical severity of the dementia increases, there was a trend of having higher mean grand total EEG score and there was a significant correlation between the two ($P = 0.046$) details are given in Table 1.

Magnetic resonance imaging of brain

By visual assessment, most common findings observed were focal, frontal-temporal, and diffuse cerebral atrophy. Two patients had asymmetric perisylvian atrophy details are shown in Table 1.

Global grey matter volume

Global grey matter volume of the twenty patients ranged from 393829 mm^3 to 570019 mm^3, with a mean of 464581 mm^3 ± 52127 mm^3.

Clinical dementia rating and global gray matter volume

As the clinical severity of dementia increased, there was a progressive reduction of global gray matter volume with a significant correlation between the two parameters ($P = 0.011$), details are given in Table 2.

Correlation of mini-mental state examination, blessed dementia scale, grand total electroencephalography score, and global gray matter volume

There was a significant correlation between MMSE and grand total EEG score, MMSE and global gray matter volume, blessed dementia scale and grand total EEG score, blessed dementia scale and global gray matter volume.

Correlation between grand total EEG score and global gray matter volume was not significant ($P = 0.347$).

Alzheimer's disease

Mean age was 69.50 ± 8.59 years with a range of 51–82 years. Majority (50%) were in the seventh decade. Mean age at the onset of symptoms was 66.10 ± 8.30 years with a range of 47–76 years. Only one patient had onset before 50 years. Of the total ten patients, nine (90%) were males and one (10%) was female.

All the patients had insidious onset and gradually progressive disease. Duration of symptoms at presentation ranged from 2 to 6 years with a mean duration of 3.20 ± 1.29 years. Most common initial symptom was recent memory impairment. Other features observed were geographical disorientation, difficulty in calculation, and naming difficulty.

Table 1: Magnetic resonance imaging brain findings in frontotemporal dementia

Feature	Observation (*n*=20), (%)
Diffuse atrophy	14 (70)
Focal frontal	15 (75)
Focal temporal	14 (70)
Focal parietal atrophy	0
Focal occipital atrophy	0
Cerebellar atrophy	9 (45)
White matter signal changes	3 (15)

Table 2: Correlation of clinical dementia rating and global grey matter volume in frontotemporal dementia

Clinical dementia rating	Global gray matter volume in mm^3 (mean±SD*)	*P* (correlation)
1 - mild (*n*=3)	51,1836.1 (45,005.91)	0.011
2 - moderate (*n*=7)	49,2693.1 (50,624.24)	
3 - severe (*n*=10)	43,0725.40 (30,744.61)	
Total (*n*=20)	46,4580.7 (52,127.48)	

*Standard deviation

Hallucinations, delusions were infrequent seen in 20% each.

1. MMSE score:
   Mean score was 12.90 ± 5.56 with a range of 6–22.
2. HMSE score:
   Mean score was 14.20 ± 5.31 with a range of 8–23.
3. Blessed dementia scale:
   Mean score was 12.15 ± 4.70 with a range of 6–22.
4. CDR scale:
   As per the CDR patients were classified into mild (CDR-1), moderate (CDR-2), and severe dementia (CDR-3). Of the total ten patients, two had mild dementia, four had moderate dementia, and four had severe dementia.

Detailed neuropsychological assessment could be done in five patients only. Characteristic findings observed were impaired recent memory with a defective delayed recall on both auditory verbal learning test and complex figure test. Three patients had evidence of impaired visuospatial construction. Remote memory and frontal executive functions were found to be relatively well preserved.

Electroencephalography

EEG was done as per protocol in all the patients. Most common abnormalities observed were slowing of background activity and its reactivity. Other abnormalities are shown in Table 3.

Grand total electroencephalography score

In each patient, grand total EEG score was calculated and it ranged from 2 to 17 with a mean score of 9.80 ± 5.29.

Clinical dementia severity and grand total electroencephalography score

As the clinical severity of the dementia increases, there was a trend of having higher mean grand total EEG score and there was significant correlation between the two, (P = 0.031) details are given in Table 4.

Magnetic resonance imaging of brain

By visual assessment, most common findings observed were diffuse cerebral atrophy, medial temporal atrophy, and parietal atrophy. Details are given in Table 3.

Global gray matter volume

Global gray matter volume of the twenty patients ranged from 420287 mm^3 to 552795 mm^3, with a mean of 483208 ± 47371.5 mm^3.

Clinical dementia rating and global gray matter volume

As the clinical severity of dementia increased, there was a progressive reduction of global gray matter volume with a significant correlation between the two parameters (P = 0.041). Details are shown in Table 5.

Correlations of mini-mental state examination, blessed dementia scale, grand total electroencephalography score, and global gray matter volume

There was a significant correlation between MMSE and grand total EEG score, MMSE and global gray matter volume, blessed dementia scale and grand total EEG score, blessed dementia scale and global gray matter volume.

Correlation between grand total EEG score and global gray matter volume was not significant (P = 0.075). Details are given in Table 6.

Correlations of the total cohort (frontotemporal dementia and Alzheimer's disease): Clinical dementia severity and grand total electroencephalography score

As the clinical severity of the dementia increases, there was a trend of having higher mean grand total EEG score and there was a significant correlation between the two (P = 0.004). Details are shown in Table 7.

Table 3: Magnetic resonance imaging findings of Alzheimer's disease

Feature	Observation (n=10) (%)
Diffuse atrophy	10 (100)
Focal frontal	0
Focal temporal (medial)	8 (80)
Focal parietal atrophy	7 (70)
Focal occipital atrophy	0
Cerebellar atrophy	5 (50)
White matter signal changes	5 (50)

Table 4: Correlation of clinical dementia rating and grand total electroencephalography score in Alzheimer's disease

Clinical dementia rating	GTES (mean±SD)	P (correlation)
1 - mild (n=2)	4	0.031
2 - moderate (n=4)	7.50±4.041	
3 - severe (n=4)	15±1.414	
Total (n=10)	9.80±5.287	

GTES – Grand total electroencephalography score; SD – Standard deviation

Table 5: Correlation of clinical dementia rating and global gray matter volume in Alzheimer's disease

Clinical dementia rating	Global gray matter volume in mm^3 (mean±SD*)	P (correlation)
1 - mild (n=2)	527,217.3 (36,171.80)	0.041
2 - moderate (n=4)	503,598.7 (30,065.92)	
3 - severe (n=4)	440,812.6 (33,911.85)	
Total (n=10)	483,208.0 (47,371.52)	

*SD – Standard deviation

Global grey matter volume

Global grey matter volume of the twenty patients ranged from 393829 mm^3 to 570019 mm^3, with a mean of 470789.8 ± 50561.65 mm^3.

Clinical dementia rating and global gray matter volume

As the clinical severity of dementia increased, there was a progressive reduction of global gray matter volume with a significant correlation between the two parameters (P = 0.001). Details are shown in Table 8.

Correlations of mini-mental state examination, blessed dementia scale, grand total electroencephalography score, and global gray matter volume

There was a significant correlation between MMSE and grand total EEG score, MMSE and global gray matter volume, blessed dementia scale and grand total EEG score, blessed dementia scale and global gray matter volume.

Correlation between grand total EEG score and global gray matter volume was not significant (P = 0.123). Details are shown in Table 9.

Results of this study reveal the following in patients with frontotemporal dementia

Mean age at the onset of symptoms was 56.12 ± 6.60 years (range: 41–66 years). Males were more than females (M:F = 12:8). Most common initial symptom was change in behavior and poor social, interpersonal conduct. As per CDR, three patients had mild dementia, seven had moderate dementia, and the remaining ten (50%) had severe dementia. Most common EEG finding was reduced frequency of background activity seen in 85% of patients, and diffuse slow wave activity was observed in 75% of patients. Mean grand total EEG score was 7.80 ± 5.386 (range: 1–17). MRI of the brain revealed predominant frontal/temporal atrophy in 75% of patients. Mean global gray matter volume was 464581 ± 52127 mm^3 (range: 393829–570019 mm^3). CDR correlated with grand total EEG score (P = 0.046) and with global gray matter volume (P = 0.011). MMSE correlated with grand total EEG score (0.005) and with global gray matter volume (P = 0.003). Blessed dementia scale correlated with grand total EEG score (0.021) and with global gray matter volume (P = 0.004). There was no significant correlation between grand total EEG score and global gray matter volume (P = 0.347) in patients with AD. Mean age at the onset of symptoms was 66.10 ± 8.30 years (range: 47–76 years). Majority were males (M:F = 9:1). Most common clinical feature observed was recent memory impairment (100%). Other common features included geographical disorientation (80%) calculation difficulty (80%). As per CDR, two patients had mild dementia, four had moderate dementia, and the remaining four had severe dementia. Most common EEG finding was reduced frequency of background activity and diffuse slow wave activity seen in 90% focal changes

Table 6: Correlations of mini-mental state examination; blessed dementia scale; grand total electroencephalography score and global gray matter volume in Alzheimer's disease

Variable	GTES	Global gray matter volume
MMSE	−843**	0.692**
	0.002	0.027
Blessed dementia scale	0.655*	−0.773**
	0.040	0.009
GTES	1	−0.586
		0.075

**Correlation is significant at the 0.01 level (two-tailed). *Correlation is significant at the 0.05 level (two-tailed). GTES – Grand total electroencephalography score; MMSE – Mini-mental state examination

Table 7: Correlation of clinical dementia rating and grand total electroencephalography score in cortical dementia (frontotemporal dementia and Alzheimer's disease)

Clinical dementia rating (n=30)	GTES (mean±SD)	P (correlation)
1 - mild (n=5)	3.00±1.414	0.004
2 - moderate (n=11)	6.55±3.387	
3 - severe (n=14)	11.93±5.181	
Total (n=30)	8.47±5.348	

SD – Standard deviation

Table 8: Correlation of clinical dementia rating and global gray matter volume in cortical dementia (frontotemporal dementia and Alzheimer's disease)

Clinical dementia rating (n=30)	Global gray matter volume in mm^3 (mean±SD*)	P (correlation)
1 - mild (n=5)	517,988.6 (37,561.15)	0.001
2 - moderate (n=11)	496,658.8 (42,885.31)	
3 - severe (n=14)	433,607.5 (30,694.32)	
Total (n=30)	470,789.8 (50,561.65)	

*SD – Standard deviation

Table 9: Correlations of mini-mental state examination; blessed dementia scale; grand total electroencephalography score and global gray matter volume in cortical dementia (frontotemporal dementia and Alzheimer's disease)

Variable	MMSE	Blessed dementia scale	GTES	Global gray matter volume
MMSE	1	−0.879**	−0.663**	0.633**
		<0.001	<0.001	<0.001
Blessed dementia scale	−872**	1	0.539**	−0.660**
	<0.001		0.002	<0.001
GTES	−0.671**	−0.663**	1	−0.288
	<0.001	<0.001		0.123
Global gray matter volume	0.633**	−0.660**	−0.288	1
	<0.001	<0.001	0.123	

**Correlation coefficient-correlation is significant at the 0.01 level (two-tailed). GTES – Grand total electroencephalography score; MMSE – Mini-mental state examination

were seen in 10%. Mean grand total EEG score was 9.80 ± 5.29 (range: 2–17). Magnetic resonance imaging of the brain revealed diffuse cerebral atrophy in all and predominant medial temporal atrophy was seen in 80% of patients. Mean global gray matter volume was 483208 ± 47371.5 mm^3 (range: 420287–552795 mm^3). CDR correlated with grand total EEG score ($P = 0.031$) and with global gray matter volume ($P = 0.041$). MMSE correlated with grand total EEG score (0.002) and with global gray matter volume ($P = 0.027$). Blessed dementia scale correlated with grand total EEG score (0.040) and with global gray matter volume ($P = 0.009$). There was no significant correlation between grand total EEG score and global gray matter volume ($P = 0.075$).

DISCUSSION

This study on the severity of EEG changes in cortical dementia (both AD and FTD) using Jonkman score and its correlation with clinical severity of dementia and global gray matter volume assessed by volumetric MRI of the brain revealed the following. In both the groups, clinical severity of dementia correlated with the degree of abnormal EEG and global gray matter volume. This study is unique as we evaluated the EEG changes in cortical dementia (both AD and FTD) and the clinical severity of dementia and global gray matter volume assessed by volumetric MRI of the brain. Most common EEG abnormality found was reduced frequency of rhythmic background activity (85%) in patients with FTD and 90% in patients with AD other common findings were diffuse slow wave activity and reduced background reactivity. Paroxysmal activity and focal abnormalities and sharp wave activity were less frequent [Tables 4, 10-12 and Figures 1, 2]. Observed mean GTE score increased as the severity of dementia increased. Neuroimaging showed in both groups and global gray matter volume progressively reduced as the clinical severity of dementia increased [Tables 1-3, 13]. However, the degree of EEG abnormalities did not significantly correlate with global gray matter volume [Tables 5-9] indicating function fails earlier than global gray matter volume.

CONCLUSION

EEG abnormalities are common in both FTD and AD and the severity of EEG abnormalities using Jonkman score correlate with clinical severity but not with global gray matter volume. EEG may thus be a better marker of deterioration than global gray matter volume at a particular point of time when not supported by longitudinal follow-up. Rae-Grant *et al*. found correlation between severity of dementia assessed by Brief Cognitive Rating Scale and degree of pathologic EEG findings and they also observed that EEG slowing at the time of diagnosis of AD is a sensitive marker of cognitive decline and suggests a higher need

Table 10: Electroencephalography findings in frontotemporal dementia

EEG parameter (n=20)	Grade (%)					
	0	1	2	3	4	5
Frequency of background activity	3 (15)	4 (20)	3 (15)	5 (25)	4 (20)	1 (5)
Diffuse slow activity	5 (25)	5 (25)	3 (15)	3 (15)	3 (15)	1 (5)
Reactivity of the background activity	9 (45)	4 (20)	*	7 (35)	0	0
Paroxysmal activity	14 (70)	*	*	6 (30)	0	0
Focal disturbances	18 (90)	2 (10)	0	0	0	0
Sharp wave activity	14 (70)	*	6 (30)	0	0	0

*Grade not applicable in that particular parameter.
EEG – Electroencephalography

Table 11: Correlation of clinical dementia rating and grand total electroencephalography score in frontotemporal dementia

Clinical dementia rating (n=20)	GTES (mean±SD)	P (correlation)
1 - mild (n=3)	2.33±1.528	0.046
2 - moderate (n=7)	6.00±3.162	
3 - severe (n=10)	10.70±5.677	
Total (n=20)	7.80±5.39	

GTES – Grand total electroencephalography score; SD – Standard deviation

Table 12: Electroencephalography findings in Alzheimer's disease

EEG parameter (n=10)	Grade (%)					
	0	1	2	3	4	5
Frequency of background activity	0	1 (10)	3 (30)	3 (30)	3 (30)	0
Diffuse slow activity	1 (10)	3 (30)	3 (30)	2 (20)	1 (10)	0
Reactivity of the background activity	3 (30)	3 (30)	*	4 (40)	0	0
Paroxysmal activity	5 (50)	*	*	5 (50)	0	0
Focal disturbances	9 (90)	1 (10)	0	0	0	0
Sharp wave activity	5 (50)	*	4 (40)	1 (10)	0	0

*Grade not applicable in that particular parameter,
EEG – Electroencephalography

Table 13: Correlations of mini-mental state examination; blessed dementia scale; grand total electroencephalography score and global gray matter volume in frontotemporal dementia

Variable	GTES	Global gray matter volume
MMSE	−598**	0.633**
	0.005	0.003
Blessed dementia scale	0.509*	−0.616**
	0.022	0.004
GTES	1	−0.222
		0.347

**Correlation coefficient-correlation is significant at the 0.01 level (two-tailed). *Correlation is significant at the 0.05 level (two-tailed). GTES – Grand total electroencephalography score; MMSE – Mini-mental state examination

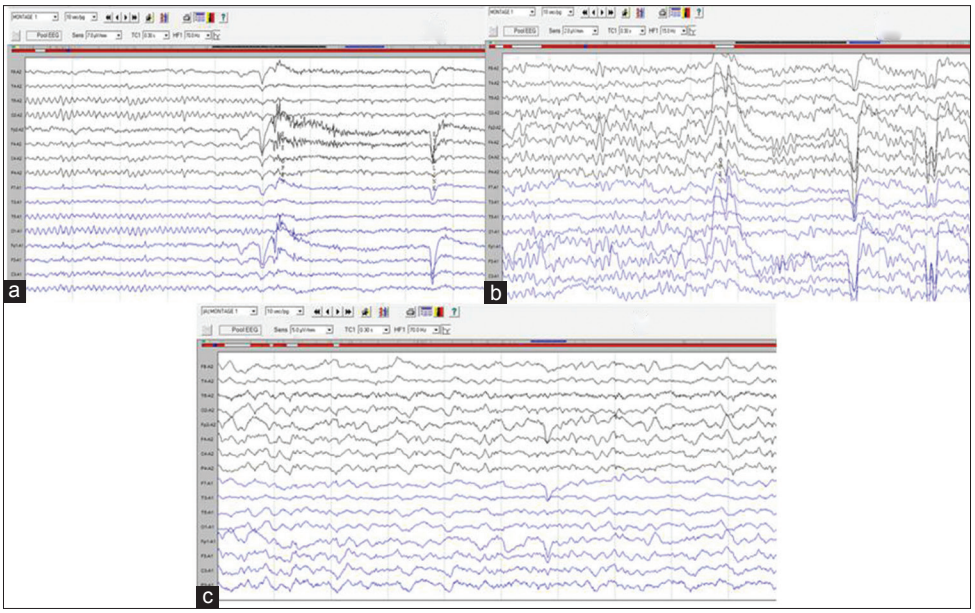

Figure 1: Electroencephalography changes in Alzheimer's disease: (a) Background activity of 8–9 Hz alpha with good reactivity to eye opening in mild Alzheimer's disease. (b) Background activity of 6–7 Hz with poor reactivity to eye opening in moderate Alzheimer's disease. (c) Diffuse slowing of background in delta range in severe Alzheimer's disease

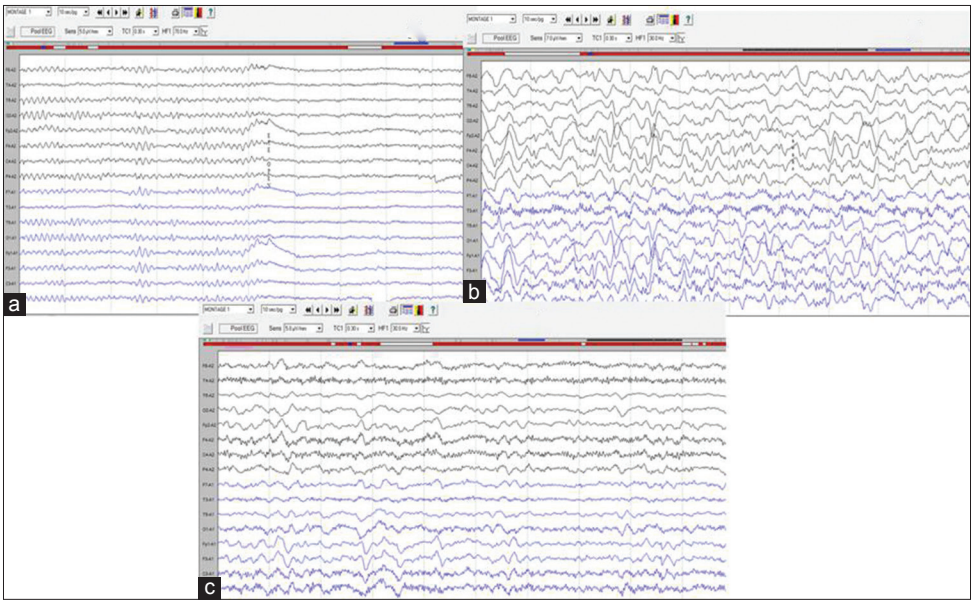

Figure 2: Electroencephalography findings in frontotemporal dementia: (a) Background activity of well-defined alpha of 8–9 Hz with good reactivity to eye opening in mild frontotemporal dementia. (b and c) Diffuse background delta slowing in severe frontotemporal dementia with low amplitude (c)

for institutionalization[7-10] which is supported by our study in both Frontotemporal and Alzheimer's type of dementia. The limitations of this study are the small number, very less number in the mild group, and lack of longitudinal evaluation.

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Conflicts of interest
There are no conflicts of interest.

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