

Comparative Evaluation of Conventional and Advanced Magnetic Resonance Imaging (MRI) Sequences in Mesial Temporal Lobe Sclerosis Patients with Seizure

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Abstract

Background: Diffusion Tensor Imaging (DTI) is a new noninvasive dimension of magnetic resonance imaging (MRI) that provides insight into the white matter microstructure. In epilepsy, widespread DTI abnormalities have been reported in multiple studies in medical literature. In mesial temporal lobe sclerosis (MTLS) patients, conventional MRI may show enlargement of ipsilateral temporal horn & reduction in volume of hippocampus in later stages of disease. However, DTI has been found to be useful in demonstrating the focus of epileptiform activity in brain especially in white matter very early in disease. Since DTI is a sensitive technique to detect subtle structural abnormalities causing epilepsy, hence it can be used to plan more successful epilepsy surgery. Therefore, we conducted a pilot study on twenty patients with seizure disorder using DTI where focal organic brain lesions were ruled-out. **Aim:** To assess the role of DTI in patients of MLTS with seizures. **Subjects and Methods:** Twenty patients with seizure disorder secondary to MLTS were evaluated using conventional MRI and DTI. We compared the final diagnosis achieved by clinical parameters correlated with EEG localization. **Results:** Ten out of twenty patients revealed abnormality on DTI that correlated with EEG correlation without obvious abnormality on conventional MRI representing a significant impact of DTI. **Conclusion:** DTI can sensitively detect structural changes in MLTS with epilepsy often undetectable on conventional MRI. Hence, DTI can serve as an important radiological tool guiding in management and presurgical evaluation of epilepsy patients considered as idiopathic or and refractory medication.

Keywords: Magnetic Resonance Imaging, Mesial Temporal Lobe Sclerosis, Seizure.

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Introduction

A seizure is defined as the signs/symptoms caused by abnormal excessive neuronal activity in the brain. Epilepsy is the tendency to have unprovoked seizures. About 1% of people worldwide are distressed from epilepsy and the sensitivity of conventional MRI with the current epilepsy protocol in identifying the epileptogenic focus is only slightly greater than 50%.^[1] Seizures can be focal or generalized. Focal seizures account for nearly 60% of cases in adults.^[2] Diffusion tensor imaging (DTI) can detect white matter changes with magnetic resonance imaging (MRI) apparent focal cortical dysplasia and MRI-negative epilepsy concordant with the abnormal epileptic focus in > 50% of the patients.^[3] Temporal lobe epilepsy (TLE) is the commonest cause of focal seizures.^[4]

According to ILAE (International League Against Epilepsy), TLE can be divided in to:^[2]

- Medial temporal lobe epilepsy (MTLE) – a commoner type affecting hippocampus, parahippocampal gyrus & amygdala in medial part of temporal lobe. Up to one-third patients will not have adequate seizure control with medication, when surgery (temporal lobe resection) provides seizure-free survival.
- Lateral temporal lobe epilepsy (LTLE) – rare type affecting neocortex in lateral part of temporal lobe.

DTI is a new noninvasive, specialized dimension of MRI technique providing insight into the microstructure of brain especially the white matter. In focal epilepsy, DTI abnormalities have been reported.^[3] In MTLE patients, conventional MRI may show enlargement of ipsilateral temporal horn & reduction in hippocampal volume only in later stages. DTI has been found to be useful in demonstrating the abnormal focus in medial temporal brain prior to appearance of obvious findings on conventional MRI.^[4]

Since DTI is a sensitive technique to detect subtle microstructural abnormalities causing epilepsy, hence it can be used to objectively to identify the epileptic focus for successful epilepsy treatment planning / surgery. Hence, we conducted a pilot study on MTLE patients with seizures where conventional MRI did not reveal any abnormality.

Aims and Objectives

- To evaluate the role of DTI in MTLE patients with seizure
- To assess the accuracy of DTI in detecting epileptic focus in MTLE patients with seizure.

Subjects and Methods

We evaluated 20 MTLE patients with seizures using DTI (with one or more episodes of seizure (not less than 24 hrs after ictus) on SIEMENS MAGNETOM AVANTO 1.5 Tesla MR scanner.

Inclusion criteria

Patients of all ages and both sex with clinical & EEG diagnosis of MTLE with normal conventional MRI.

Exclusion criteria

- Non-cooperative patients
- Pregnancy
- Contraindications to MRI
- Medical illness with CNS impact viz. alcohol or other drug abuse, psychiatric disorders

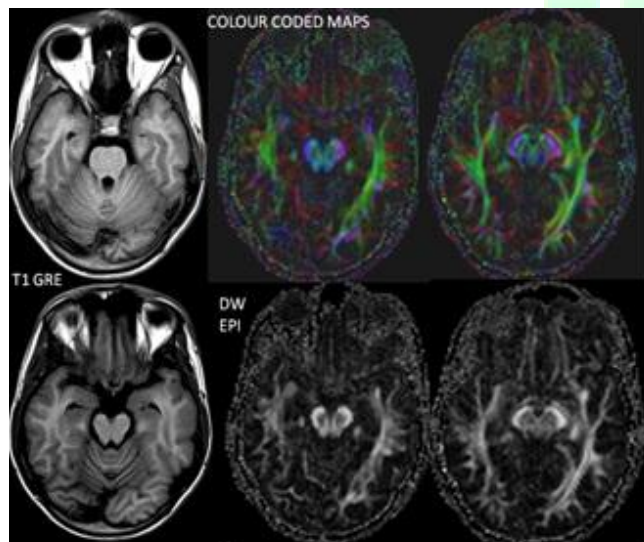


Image 1: Set of images obtained in DT sequence

DTI parameters [Image 1 & 2]

The raw data of DTI sequence was transferred to a workstation where image reconstruction and post-processing analysis was performed. Areas of region of interest (ROI) of similar size were placed on a color-coded fractional anisotropy (FA) maps superimposed over isotropic 3D T1GRE images.

FA and apparent diffusion coefficient (ADC) values from each of these ROI was calculated in bilateral hippocampus especially the anterior part.

Color-coded maps were generated in axial, coronal & sagittal plane and the information is recorded on a predefined format.

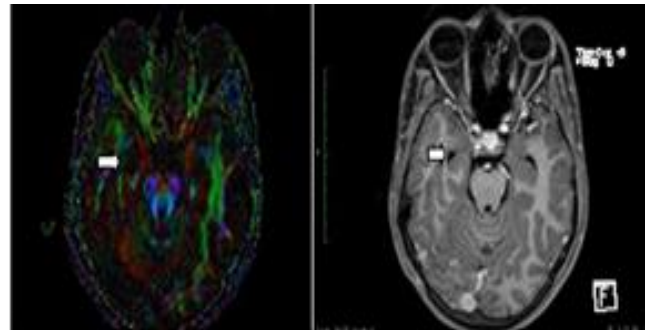


Image 2: DTI image on left side shows anisotropy of the white matter tracts in the temporal lobe on right side as compared to the left side of patient while T1GRE axial image on right side shows dilated temporal horn of right lateral ventricle in a patient of MTLE with seizure

Results

Table 1 shows the distribution of patients in our study according to age with maximum number in 3rd decade.

Table 1: Age group versus Number of patients

| S. No | Age Group | No of Patients |
|-------|-----------|----------------|
| 1 | 21-30 | 10 |
| 2 | 31-40 | 6 |
| 3 | 41-50 | 4 |

Table 2 shows equal distribution of patients in our study based on sex.

Table 2: Gender versus Number of patients

| S. No | Gender | No of Patients |
|-------|--------|----------------|
| 1 | Male | 10 |
| 2 | Female | 10 |

Ten out of twenty patients revealed abnormalities of varying severity on DTI that correlated with clinical diagnosis.

Figure 1 shows distribution of temporal lobe affected by disease with right side being more commonly involved than left.

Figure 2 Fifty percent i.e. ten out of twenty patients in our study revealed abnormality on DTI [Mean Diffusivity (MD) $>2.5 \times 10^{-3}$ mm²/sec on affected side while $<0.8 \times 10^{-3}$ mm²/sec in normal & contralateral normal side; Fractional Anisotropy (FA) < 0.012 on abnormal side while > 0.16 on normal side]. Thus, DTI could accurately detect early MTLE in 50% patients that had normal conventional MRI.

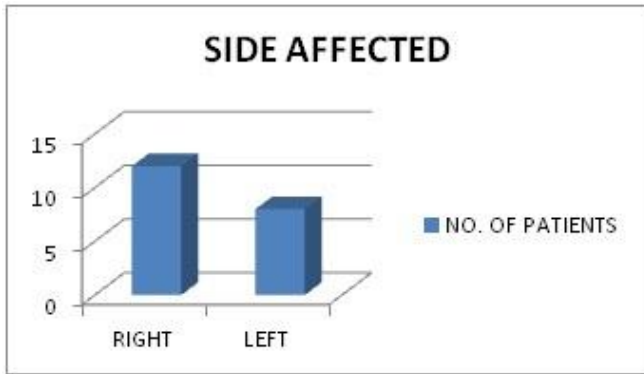


Figure 1: Laterality of side affected versus Number of patients

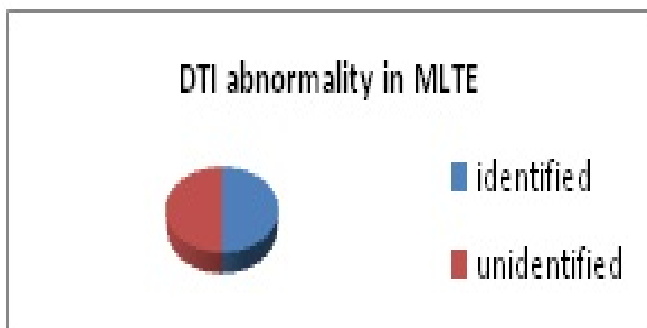


Figure 2: DTI abnormality in MTLE

Discussion

Temporal lobe epilepsy is the most common form of focal epilepsy. The hippocampus is a major source of seizure activity and microstructural alterations occur before they become evident on conventional MRI. High-resolution MRI is an important imaging tool for the evaluation of patients with Medial Temporal Lobe Epilepsy (MTLE), however, false negative results are very common.^[5]

During the ictal phase of seizures, there is an increase in oxygen consumption in the seizure focus, which is more than the increased blood flow. It results in relative ischemia and cytotoxic edema; latter seen as decrease in apparent diffusion coefficient (ADC) values. As time progresses, epilepsy results in neurogliosis, increased extracellular space and increased interictal ADC and change in mean diffusivity (MD).^[5]

Abnormal lateralized EEG patterns such as TIRDA (Temporal intermittent rhythmic delta activity) is quite specific for the ipsilateral seizure onset.^[6] Interictal spikes or sharp waves are often unilateral; however, in about one-third patients, they may be bitemporal.

Ictal EEG patterns appear in the form of background attenuation, start-stop phenomena, 5–10 Hz rhythmic sinusoidal waveforms or repetitive sharp waves or spikes. The 2–5 Hz lateralized activity is often due to lateral neocortical focus. Post-ictal slowing if lateralized, is often

ipsilateral to the seizure focus.^[7]

The results of our ipsilateral hippocampus involvement are consistent with the results of Thivard et al,^[4] in 2005 and Assaf et al,^[4] in 2003.

Thivard et al,^[5] found increased MD & ADC and reduced fractional anisotropy in the ipsilateral hippocampus and temporal lobe structures. Lower MD values are noted in contralateral normal hippocampus.

Assaf et al,^[6] in 2003 studied 12 patients of unilateral temporal lobe epilepsy and found MD values to be more sensitive than FA values. They found significant increase in mean diffusivity and decreased fractional anisotropy values in hippocampal formation of ipsilateral side compared to normal side in MTLE patients.

Limitations of the Study

- 1.5T scanner as higher field magnets are more sensitive
- Small sample volume
- Patients with unilateral disease
- Other factors as age of patient, age of onset of seizure and duration of epilepsy are not taken in to consideration
- Operative results were not included

Conclusion

DTI is highly sensitive MRI technique for detection of microstructural changes in brain that underlie MTLE and are most often undetectable on conventional MRI and appear late in the disease. Hence, DTI can serve as an important radiological tool not only in early diagnosis but also in presurgical evaluation of MTLE patients often considered as idiopathic and medically intractable.

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