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Original Investigations

Epilepsy Surgery in Patients with Unilateral Mesial Temporal Sclerosis and Contralateral Scalp Ictal Onset

Tek Taraflı Mezial Temporal Sklerozu ve Skalp EEG'de Kontralateral İktal Başlangıcı Olan Hastalarda Epilepsi Cerrahisi

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ABSTRACT

AIM: Concordance of EEG findings and MRI is best correlated with favored surgical outcome in patients with unilateral mesial temporal sclerosis (MTS). If there is no evidence for unilateral focus with scalp EEG, invasive recordings are undertaken. In this report we describe the investigation process for epilepsy surgery in patients with unilateral MTS and contralateral ictal scalp EEG findings.

MATERIAL and METHODS: The data of all adult patients who had undergone videoEEG recording with subdural and/or depth electrodes at our center in almost 7.5 years, were reviewed. Four patients with unilateral MTS and contralateral ictal onset on scalp EEG were included. Their invasive EEG recordings and surgical outcomes were examined.

RESULTS: Four patients met the inclusion criteria. Invasive recordings demonstrated ictal onset in the mesial temporal lobe ipsilateral to MRI findings. In one patient we have also proven the false lateralization of scalp EEG simultaneously during the recordings with depth electrodes. All operated cases are seizure free during follow-up.

CONCLUSION: Before the decision of epilepsy surgery we have to identify the semiology and ictal EEG findings in patients with unilateral MTS and concordant IEDs. Bilateral depth recordings must be considered to show the ipsilateral hippocampal epileptogenic focus.

KEYWORDS: Mesial temporal sclerosis, Scalp EEG, Invasive EEG, Depth electrodes, Hippocampus

ÖZ

AMAÇ: Tek taraflı mesial temporal sklerozu (MTS) olan hastalarda EEG ile MRG bulgularının uyumu cerrahi sonrası iyi prognozu belirlemede en değerli verilerdendir. Eğer skalp EEG ile tek taraflı odak ispat edilemezse invasiv kayıtlar gerekmektedir. Bu yazıda tek taraflı MTS'si olan ve skalp EEG'de konralateral iktal başlangıcı olan hastaların incelenme basamakları değerlendirilmiştir.

YÖNTEM ve GEREÇLER: Son 7.5 yıl içinde merkezimizde subdural ve/veya derin elektrotlarla video-EEG kaydı yapılan tüm yetişkin hastaların bulguları incelendi.Tek taraflı MTS'si olan ve skalp EEG'de kontralateral iktal başlangıcı olan 4 hasta çalışmaya dahil edildi. Bu hastaların invasiv kayıtları ve cerrahi sonrası prognozları değerlendirildi.

BULGULAR: Dört hasta dahil edilme kriterlerine uyuyordu. İnvasiv kayıtlardaki iktal EEG bulguları MRG'deki mesial temporal lop bulguları ile uyumlu idi. Bir hasta derin elektrodlarla incelenirken, aynı zamanda skalp EEG ile yanlış lateralizasyonun kaydedildiği ispat edilmiştir. Ameliyat edilen hastaların takiplerinde nöbetsiz oldukları gözlenmiştir.

SONUÇ: Epilepsi cerrahisine karar vermeden önce, tek taraflı MTS'si ve bununla uyumlu olan interiktal epileptiform aktiviteleri olan hastaların, semiyolojileri ve iktal EEG bulguları belirlenmelidir. Ayrıca ipsilateral hipokampal epileptojenik odağı göstermede bilateral derin hipokampal elektrotlar kullanılmalıdır.

ANAHTAR SÖZCÜKLER: Mezial temporal skleroz, Skalp EEG, Invasiv EEG, Derin elektrot, Hipokampus

INTRODUCTION

Since the introduction of high resolution magnetic resonance imaging (MRI) no invasive recordings are required to perform a temporal lobectomy in patients with intractable epilepsy and especially those who have unilateral mesial temporal sclerosis (MTS) and concordant interictal and ictal surface EEG recordings, functional imaging and clinical findings. MRI findings with hippocampal atrophy and hyperintensity in T2-weighted images and FLAIR sequences are predictive of good outcome after temporal lobectomy (4-5, 7, 16). In patients with unilateral MTS on MRI, there is also evidence about the effect of EEG findings on surgical outcome. Temporal lobe epilepsy (TLE) frequently has bilateral EEG findings, such as independent interictal spikes in both temporal lobes (28) or ictal propagation from one temporal lobe directly to the other (13, 18). Patients with exclusively unitemporal interictal epileptiform discharges (IED), and more than 90% of ictal EEG onsets from the ipsilateral temporal lobe were significantly correlated with excellent outcome (23). Concordance of only interictal EEG and MRI was also reported as best correlated with favored surgical outcome (12, 22-23). The combination of MRI and ictal scalp EEG was significantly worse in predicting the outcome than was the combination of MRI and IEDs (12, 22).

If neuroimaging suggests the presence of MTS but does not provide unequivocal evidence for unilateral focus with scalp EEG findings, invasive recordings are undertaken to substantiate evidence that the epilepsy arises from one temporal lobe. Bilateral hippocampal depth electrodes can confirm that the ictal EEG pattern on the surface may be misleading (3).

In this report we describe the investigation process for epilepsy surgery in patients with unilateral hippocampal sclerosis and discordant, contralateral ictal scalp EEG findings. Accordingly, the importance of the invasive procedure and proof of the epileptogenic zone by simultaneous recording of scalp-depth electrodes are discussed.

MATERIAL and METHODS

We retrospectively reviewed the data of all adult patients who had undergone videoEEG recording with subdural and/or depth electrodes at VideoEEG Monitoring Unit in Hacettepe University Hospitals during the period from August 2003 to February 2011. The patients who met the following criteria were included: 1) Findings of unilateral hippocampal sclerosis without any dual pathology on MRI. 2) Ictal scalp EEG recordings with rhythmic sharp theta activities on the contralateral temporal lobe with or without diffuse changes during phase 1 investigation.

Four patients met the inclusion criteria. They had MRI with unilateral MTS and contralareral scalp ictal EEG onset. All EEGs were recorded by a 128-channel recording device with 400-Hz sampling rate. These were reviewed by using both bipolar and referential montages at a variety of filter and gain settings.

All patients, except one, had neuropsyhological tests and/or the Wada test for evaluation of memory functions and speech dominance. Neuropsychological tests essentially included measurements of verbal - nonverbal memory and attention (Wechsler-Memory Test, Auditory Verbal Learning Test, the Stroop Test, and theFacial Recognition Test). Cerebral language representation and memory performance related to medial temporal lobe were also tested by the Wada test, intracarotid amobarbital procedure, in two patients (Table I).

Three of four patients were examined with bilateral hippocampal depth electrodes with or without combined subdural electrodes covering the temporal lobe cortexes. Bilateral hippocampal depth electrodes were inserted through the occipital burr holes according to navigation parameters. Subdural electrodes covered the basal, mesial and lateral temporal cortex. Only subdural electrodes were used in one patient (Table I, Patient 3). Also simultaneous scalp EEG recordings were available in two patients (Patient 1 and 4). Electrode positions were verified by computerized tomography and MRI in all patients (Figure 1). Intracranial EEG seizure onsets were defined as the initial sustained rhythmic

Table I: Demographic, MRI and Scalp-Invasive EEG Findings of Patients

Patient	Age	Age onset of seizures	Risk Factor for Epilepsy	NPT / WADA test	MRI	Side of IED on scalp EEG (%)	No. of seizures/ Ictal onset on scalp EEG	Ictal onset on invasive EEG	Surgical Outcome, Follow up (year)
1	33	16y	FS	L, FT dysfunction/R dominance	L, HS	LT (90%)	2/ LT 4/ RT	L Hc	Class I (2)
2	27	3y	FS Meningitis	L, T dysfunction/-	L, HS	LT (90-95%)	2/ RT	L Hc	Class I (3)
3	25	6 m	Perinatal injury	-	L, HS	LT (70-80%)	3/ RT	L anterior inferior-mesial T	Class I (4)
4	33	7y	Trauma	R, T dysfunction/L dominance	R, HS	RT (60-70%)	4/ LT	R Hc	-

NPT: *Neuropsychological test,* ***IED:*** *Interictal epileptiform discharges,* ***y:*** *year,* ***m:*** *month,* ***FS:*** *Febrile seizure,* ***L:*** *Left,* ***R:*** *Right,* ***T:*** *Temporal,* ***F:*** *Frontal,*
HS: *Hippocampal seizure,* ***Hc:*** *Hippocampus. Outcome is graded as Engel's Class I-IV.*
Patient 3: *Examined only with subdural electrodes covering the inferior, mesial and lateral temporal lobe cortex.*
Patient 1, 4: *Examined with simultaneous scalp EEG and invasive EEG*

change from background activity or low-voltage with high frequency discharges with electrodecremental patterns. Simultaneous scalp ictal EEG was analyzed for discharge frequency, morphology, spatial distribution, and evolution.

RESULTS

All 4 patients had unilateral MTS on MRI with hippocampal atrophy and hyperintensity in T2-weighted images and FLAIR sequences. They had no dual pathology on MRIs. Their scalp EEGs recorded contralateral ictal onsets and the majority of IEDs showed concordance with MRI. Their invasive recordings demonstrated ictal onset in the mesial temporal lobe ipsilateral to MRI findings. In 3 patients who accepted surgery, anterior temporal lobectomy with amygdalohippocampectomy was done and the diagnosis of mesial temporal sclerosis was confirmed pathologically. Surgical outcome with regard to seizures was also defined according to Engel's classification (10). All operated cases are seizure-free during follow-up. The detailed demographic features and EEG findings of all 4 patients are presented in Table I. Samples for scalp and invasive EEG recordings are shown in Figure 2A,B.

Figure 1: Positions of hippocampal depth electrodes on cranial CT of patient 1.

DISCUSSION

For mesial TLE, scalp EEG can demonstrate temporal lobe origin but definitive lateralization may not be possible in all cases and may result in false lateralization (24, 31). Although all of our patients had more than 70% of IEDs (only for patient 4 that ratio was 60-70%) on the side of MTS, they had discordance in ictal scalp EEG. Ictal EEG onsets generally showed rhythmicity of epileptiform discharges on the contralateral temporal lobe with or without initial brief (less than 15 s) diffuse slowing. But recordings with depth hippocampal and/or subdural mesial temporal lobe electrodes, ictal onset from sclerotic hippocampus were confirmed in all patients. Furthermore 3 patients are seizure free for 2-4 years after surgical removal of sclerotic hippocampus seen in the MRI. The last patient has not been operated yet. But in that patient we have proven the false lateralization of scalp EEG simultaneously during the recordings with depth electrodes. We noted initial onset from depth electrodes with subsequent spread to contralateral temporal cortex prior to detection from ipsilateral scalp subtemporal subdural electrodes.

In about 3-7.5 % of cases with unilateral MTS, the initial ictal EEG changes can be seen in the contralateral temporal lobe on scalp EEG recordings (9, 24, 35). This ratio is higher (approximately 30%) in TLE patients with different pathology (21). Variability of these lesions may lead to difference in propagation pathways (24). EEG recordings with intracranial electrodes and the surgical outcomes in 5 patients having unilateral MTS and pathologically proven hippocampal sclerosis were also presented by Mintzer et al (20). All five

Figure 2A: Scalp EEG findings of patient 4 with generalized attenuation on background at the ictal onset and clear left temporal build up in 10 seconds. Black arrow showed the clinical seizure onset. **LF:** 0.03 Hz, **HF:** 70 Hz.

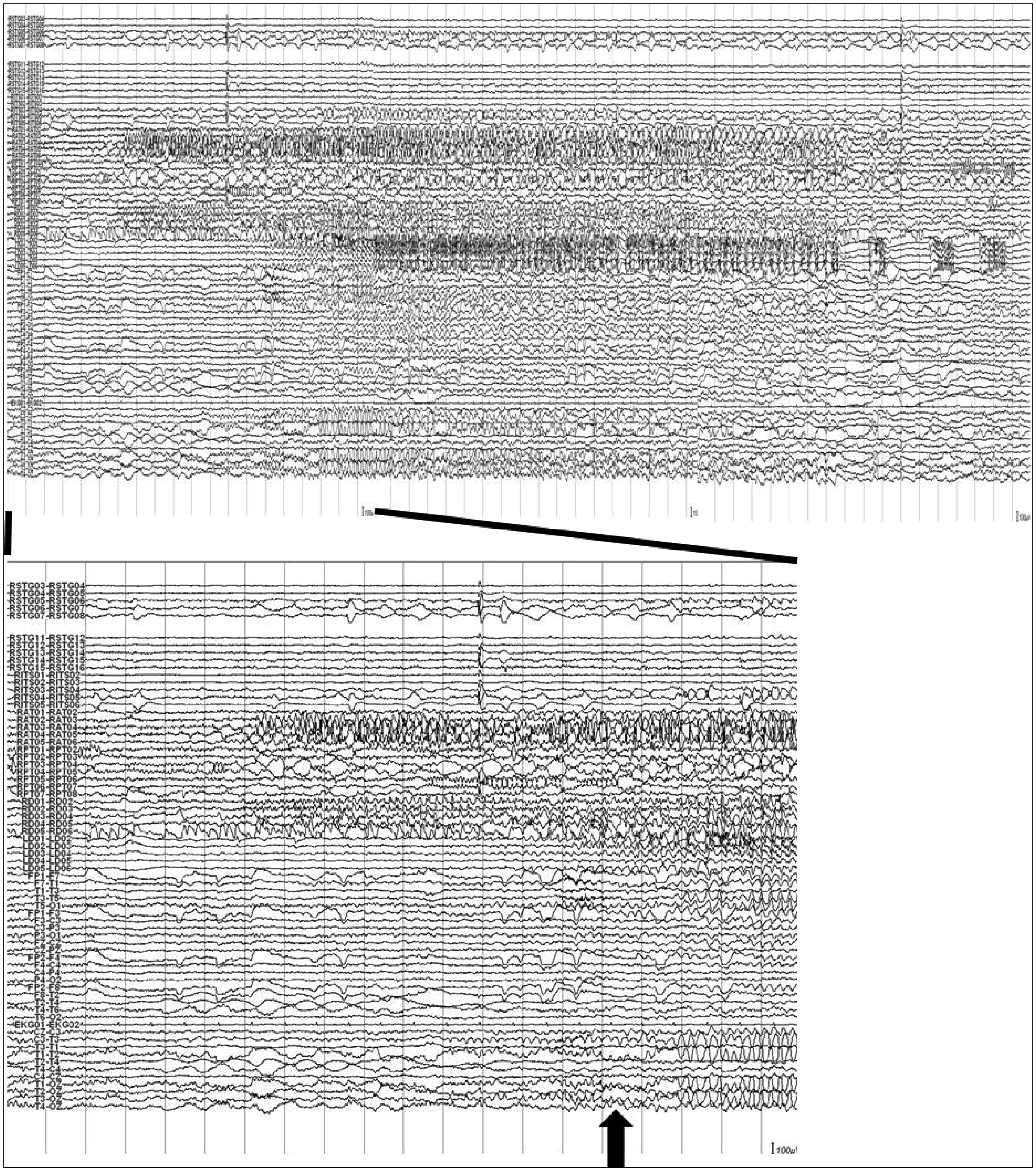

Figure 2B: Invasive EEG of patient 4 showed the ictal onset on right depth electrodes propagating to left depth in 6 seconds. Almost in the same time rhythmical changes on scalp EEG were seen on the left temporal region (black arrow). **LF:** 0.03 Hz, **HF:** 70 Hz. **RSTG:** Grid covering superior lateral temporal lobe. **RITS:** Strip covering inferior lateral temporal lobe. **RAT:** Strip covering anterior basal-mesial temporal lobe. **RD:** Right hippocampal depth electrode. **LD:** Left hippocampal depth electrode.

patients had contralateral ictal scalp EEG findings but intracranial ictal EEG onsets were concordant with MRI. They did not prove the contralateral spread with simultaneous scalp and depth recordings in any patient. Mintzer et al. suggested that the reason of atypical cortical spread of ictal discharges was related to “burned out hippocampus”. Although we do not have quantitative MRI findings, all four patients had clear hippocampal atrophy. Detailed pathological examinations of hippocampal neighborhood structures like subiculum in this type of patients might be important to identify the severity of the disorder involving the propagation pathways. (26). That may be a valuable knowledge for interpretation of ictal scalp EEG recordings in TLE patients with contralateral MRI findings.

In patients with severely damaged hippocampus the propagation of epileptiform discharges to the ipsilateral neocortex could not occur due to damage of pathways between hippocampus and neocortex. But the exact mechanism for that unusual discordance of scalp and depth ictal onset is not so clear. Functional commisural connections like dorsal hippocampal commissure may be an explanation of initial seizure spreading to contralateral neocortex (2, 8, 13). Spencer et al also suggested the existence of operational hippocampal commissure after detection of initial spreading to contralateral hippocampus (32). In addition to hippocampal commissure, activation of frontal limbic pathways may also play a role in rapid contalateral spread (17, 29). All these suggestions about rapid propagation of seizure activity to the contralateral hippocampus show the necessity of optimal placement of both depth hippocampal electrodes to record electrical activity directly from the hippocampus.

Recordings obtained from depth electrodes are dependent upon their accurate placement within the amygdala and hippocampus (27). We have EEG recordings with depth hippocampal electrodes from 3 patients but in one patient we only had subdural EEG findings. Although the presence of studies reporting the electrical activity detected by depth electrode was not always reflected by the subdural electrodes (1, 30, 33), several studies have demonstrated efficacy of subdural electrodes especially introduced to subiculum without depth electrodes for the diagnosis of TLE (19, 26, 36). We have also proven the success of the recordings with subdural electrodes covering mesial-basal temporal region in the third patient who is seizure free for 4 years after temporal lobectomy. But recordings after availability of navigation methods in our center, we have used to insert hyppocampal depth electrodes and covered the parahippocampus and subiculum by subdural electrodes for patients with undetermined lateralization of mesial TLE. The efficacy of that was accompanied by a low complication rate (6). There were no intracranial hemorrhages or infections in our patients.

Although there are a few reports related with ictal EEG results more conceivable than interictal EEG, there is also evidence about superiority of lateralized interictal findings (generally with more than 90% in ratio) (12, 14-15, 22, 25, 34). Our results also confirmed that the concordance of interictal scalp EEG (≥70%) and MRI findings are more powerful than ictal scalp EEG and MRI in patients with unilateral MTS. IEDs that were generating from irritative zone generally more widespread than the epileptogenic zone, can easily propagate from both ipsilateral and controlateral hippocampi to cortex in different pathways. The ratio of IEDs may be a clue for the presence of initial spreading to contralateral hemisphere. In our four patients the lateralized scalp IEDs appeared with more than 70% in ratio. Especially in patients with almost more than 30% contralateral IEDs like our last patient, the threshold for propagation of ictal activity to contralateral temporal lobe may be lower (Figure 2A,B).

These findings should not be interpreted as indication that scalp and invasive ictal EEGs are not useful in patients with unilateral MTS and ipsilateral IEDs. We could not rule out patients with extratemporal and extrahippocampal seizure onsets or coexistence of frequent psychogenic nonepileptic seizures without ictal EEG recordings. Although there is no absolute indication for depth electrodes in patients with confounding ictal surface EEG recordings and MRI-detected unilateral MTS, sometimes seizures originating from the hippocampus or neocortical temporal lobe could not be clearly distinguished with only scalp EEG (11). The type and extent of surgical resection can be defined by invasive EEG monitoring in these patients.

Before the decision of epilepsy surgery we have to identify the semiology and ictal EEG findings of seizures in all patients with unilateral MTS and concordant IEDs. Accordingly in the case of unilateral MTS especially with more than 30% contralateral IEDs and contralateral scalp ictal EEG onset, bilateral depth hippocampal recordings must be considered to show the ipsilateral hippocampal epileptogenic focus.

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