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Outcome of frontal lobe epilepsy surgery in adults

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Summary Our aim is to investigate seizure outcome and prognostic factors after pure frontal lobe epilepsy (FLE) surgery.

We retrospectively studied the operative outcome in 97 consecutive adult patients who underwent resective surgery for intractable partial epilepsy between 1991 and 2005.

Based on Kaplan—Meier, the probability of an Engel Class I outcome was found to be 54.6% (95% CI 44—64) at 6 months, 49.5% (95% CI 39.3—59.6) at 2 years, 47% (CI 34—59) at 5 years and 41.9% (CI 23.5—60.3) at 10 years.

If the patient was seizure free at 2-year follow-up, the probability of remaining seizure free up to 10 years was 86% (95% CI 76—98). For 13.6% of the patients a running down of seizures could be shown.

Factors predictive of poor long-term outcome were incomplete resection, using of subdural grids, IED in follow-up EEG, tonic seizures and an unspecific aura or a postoperative aura. Factors predictive of good long-term outcome were the presence of a well-circumscribed lesion in preoperative MRI, ipsilateral IED in preoperative EEG, surgery before age of 30 and short epilepsy duration prior to surgery.

In the multivariate analysis, preoperative well-circumscribed lesion in MRI predicts seizure remission whereas persistent postoperative auras predict seizure relapse. FLE surgery should depend on restrictive patient selection to assure favorable outcome.

Introduction

Among epilepsy surgery series, frontal lobe resections represent the second most frequent procedure (Mosewich et al., 2000).

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Short-term outcome was reported by various authors. However, there is a lack of studies investigating the long-term outcome following frontal lobectomy (Jeha et al., 2007). A recent review of articles, that were published from 1991 to 2005 about long-term outcome after epilepsy surgery, revealed only seven articles (9%) addressing frontal lobectomy (Tellez-Zenteno et al., 2005). Furthermore, some studies were limited in their findings as they either included patients suffering from epilepsies not restricted to the frontal lobe, or as they were performed in the pre-MRI era (Jeha et al., 2007).

Regarding statistics, few studies used multiple logistic regression to evaluate predictors of seizure-freedom and only few studies retrospectively researched the predictors for frontal lobe epilepsy (FLE) surgery (Janszky et al., 2000). Most studies were cross-section studies, only one previous longitudinal study was found in the literature (Jeha et al., 2007). Furthermore, the outcome of tapering of the anti-epileptic drugs after FLE surgery is still unclear.

The aim of this study was to evaluate the short- and long-term outcome in a cohort of patients with FLE and suspected lesions in the preoperative MRI, who underwent a ''pure'' (i.e. resections restricted to the frontal lobe area) surgery. Furthermore, we wanted to find factors predicting the long-term outcome taking into consideration the above-mentioned problems.

Clinical materials and methods

We retrospectively reviewed the records of all adult patients (16 years of age and older) who underwent pure FLE surgery at the Epilepsy Centre Bethel in Bielefeld, Germany, within the period from 1991 to 2005. There were 134 consecutive patients who had undergone FLE surgery and were followed up on for more than 2 years. We excluded patients who had only biopsies and patients who had a history of epilepsy surgery performed outside our clinic. This left 97 patients who met the inclusion criteria.

Patient characteristics

In this study 97 patient were included; 57 males (59%) and 40 females (41%). The mean age at epilepsy onset was 13.2 years (range 0.04—65 years), the mean age at epilepsy surgery was 28.5 years (range 16—69 years), the mean duration of epilepsy was 15.2 years (range 1—48 years), and the mean follow-up duration was 6.9 years (range 2—14 years). We recorded tonic seizures in 34 patients (35%), simple motor seizure in 29 patients (29.8%), hypermotor seizures in 21 patients (21.6%) and automotor in 13 patients (13.4%). Fourteen patients (14.4%) had a history of head trauma. Twelve patients (12.4%) had a history of meningitis. The clinical characteristics of these patients are detailed in Table 1.

EEG and MRI characteristics

In non-invasive EEG recordings, abnormalities were most prominent within the frontal region even though diffuse changes were frequent.

In 62 patients (63.9%) interictal epileptiform discharges (ED) were restricted to the frontal lobe. However, in 19 patients (19.5%) we did not detect any ED and in another 19 patients (19.5%) there were contralateral IED. In 55 patients (56.7%) EEG seizure onset was localised to the frontal area. Furthermore, 32 patients (32.9%) were classified as multiregional EEG seizure. In five patients (5.1%) there were no seizure patterns in the EEGs.

In follow-up EEGs performed 6 months after epilepsy surgery, interictal ED were detected in 24 patients (24.7%).

All our patients had a structural abnormality in their preoperative MRI. The MRI revealed a well-circumscribed lesion in 52 patients (53.6%) and less well-circumscribed lesions in another 45 patients (46.4%).

The postoperative control MRI showed the resection was complete in 59 patients (60.8%). In 38 patients (39.2%) the resection was deemed incomplete. Pre- and post-operative difference as seen on EEG and MRI finding are shown in Table 2.

Table 1 Patient's characteristics

Variable	Male	Female	Total
Mean age at epilepsy onset (years)	13.3 ± 13.1	13.1 = 11.8	13.2 = 12
Mean age at epilepsy surgery (years)	29.6 ± 12.4	26.9 ± 11.4	28.5 ± 11.8
Mean age at second surgery (years)	28.4 ± 8.5	26.5 ± 8.7	27.6 ± 8.3
Mean duration of epilepsy (years)	16.2 ± 12.1	13.8 ± 8.9	15.2 ± 10.6
Mean follow-up duration (years)	7.0 ± 3.8	6.8 ± 3.6	6.9 ± 3.8
Pathology			
FCD	23 (40.4%)	18 (45%)	41 (42.27%)
Tumours	11 (19.3%)	15 (37.5%)	26 (26.8%)
Gliosis	9 (15.8%)	3 (7.5%)	12 (12.43%)
Vascular	7 (12.3%)	1 (2.5%)	8 (8.25%)
Rasmussen syndrome	4 (7%)	1 (2.5%)	5 (5.15%)
MCD	10 (17.5%)	4 (10%)	14 (14.4%)
Dual pathology	5 (8.7%)	4 (10%)	9 (9.2%)
Predisposing			
History of CNS infection	9 (15.8%)	3 (7.5%)	12 (12.37%)
History of head trauma	1 (17.5%)	4 (10%)	14 (14.43%)
Family history of epilepsy	4 (7%)	4 (10%)	8 (8.25%)
Mental retardation	3 (5.3%)	2 (5%)	5 (5.15%)

Table 2 Pre- and post-operative EEG

Variable	Non-seizure-free	Seizure-free	Sig.
Preoperative EEG			
Spikes in interictal EEG			
Absent	3 (18.8%)	13 (81.3%)	0.007
Present	45 (55.6%)	36 (44.4%)	
Ipsilateral frontal spikes			
Absent	18 (5%)	18 (5%)	0.552
Present	31 (49.2%)	31 (50.8%)	
Generalized spikes			
Absent	38(48.1%)	41(51.9%)	0.379
Present	10(55.6%)	8(44.4%)	
Contralateral spikes			
Absent	36 (46.2%)	42 (53.8%)	0.141
Present	12 (63.2%)	7 (36.8%)	
Extrafrontal spikes			
Absent	27 (43.5%)	35 (56.5%)	0.089
Present	2 1(6%)	14 (4%)	
Ictal rhythm			
Absent	4 (28.6%)	1 (71.4%)	0.079
Present	44 (53%)	39 (47%)	
Ipsilateral ictal EEG seizure Pattern			
Absent	22 (52.4%)	2 (47.6%)	0.385
Present	26 (47.3%)	29 (52.7%)	
Multiple EEG seizure types			
Absent	27(41.5%)	38(58.5%)	0.022
Present	21(65.6%)	11(34.4%)	
EEG 6-month postoperative			
IED absent	3(41.1%)	43(58.9%)	
IED present	18 (75%)	6 (25%)	0.004
EEG 2 years postoperative			
IED absent	29 (41.4%)	(41) 58.6%	
IED present	19 (73.1%)	7 (26.9%)	0.005
I Pre- and post-operative MR			
Preoperative MRI lesion			
Well-circumscribed	20 (38.5%)	32 (61.5%)	
Less-circumscribed	28 (62.2%)	17 (37.8%)	0.016
Postoperative MRI			
Incomplete resection	24 (63.2%)	14 (36.8%)	
Complete resection	24 (40.7%)	35 (59.3%)	0.025

Preoperative evaluation

All patients underwent presurgical evaluation at the Epilepsy Centre Bethel in Bielefeld, Germany, following the local protocol, which includes EEG-video monitoring, high resolution MRI, neuropsychological testing, ophthalmological assessment (perimetry), and if necessary, additional optional imaging including PET and SPECT.

To display speech and motor functions, functional MRI and/or the intracarotid amobarbital test (Wada test) were used.

Subdural grids were implanted in 45 patients (45.6%). Semi-invasive monitoring using foramen oval and epidural electrodes was performed in two patients (2.06%).

Surgical procedure and postoperative evaluation

All patients underwent pure frontal lobe resective epilepsy surgery, namely lesionectomies, cortical resections, lobectomies and lesionectomy with multiple subpial transections (MST), all of which were restricted to the frontal lobe (Fig. 1). Table 3 shows the number and seizure outcome in every resection type.

Intraoperative electrocorticography (ECoG) was performed as a matter of routine in the majority of patients. Sometimes somatosensory evoked potentials (SSEP) were used intraoperatively.

Following local protocol, postoperative follow-up examinations took place for all patients 6 months and 2 years after surgery including EEG, MRI, neurological and psychological evaluation. After

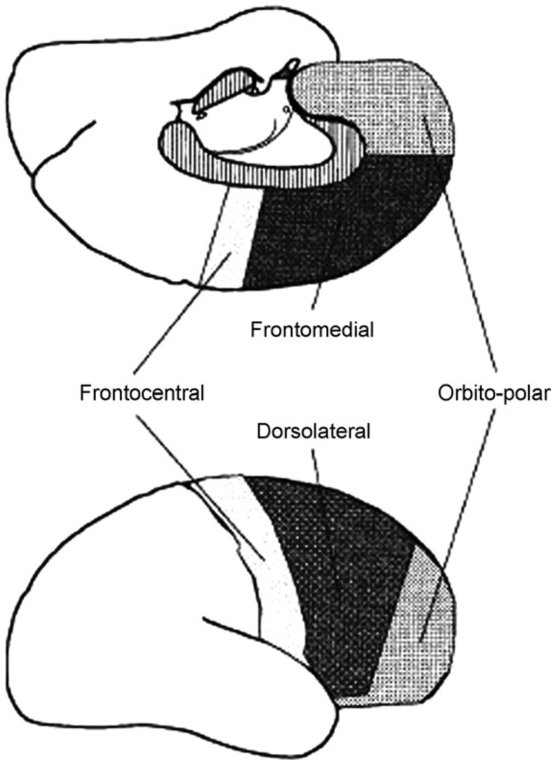

Figure 1 Resection areas as defined in our study.

2-year visits, a special questionnaire was sent to all patients assessing the seizure and quality of life at 3, 5, 10 and 15 years.

Data collection

Information on the variables we intended to investigate was provided either from data in the patients' charts (age, sex, age at epilepsy onset, various risk factors, preoperative seizure semiology, and pathological reports) or electronically from the EDP system of the hospital (EEG-video monitoring, side of surgery, intraoperative and early postoperative complications). Moreover, we reviewed the answers to the questionnaires mailed to the patients and drew information from telephone calls that had been made as a part of postoperative follow-up programme.

For patients with intellectual impairments or psychic disorders, information was usually provided by their family members.

We excluded the patients who did not complete their 2-year check up; most of these were from outside Germany. For six patients (6.1%) the data was not available for long-term outcome and one patient (1.03%) died. we included only the available data and we made a note of the exceptions in survival database created.

Evaluation of outcome

Outcome was evaluated using modified Engel seizure classification (Engel et al., 1993). Patients in Engel Class 1 were the ones considered seizure free. Seizures that occurred within 1 month after surgery were not included in this analysis. Seizure types were classified according to the semiological seizure classification suggested by Lüders et al., 1998.

Our protocol for antiepileptic drugs (AED) withdrawal was as follows: Patients generally continued on their preoperative levels of AEDs for 2 years after surgery. If they remained seizure free and if the patient wished to discontinue medication, AEDs would be systematically reduced. If the patient had a seizure during AEDs withdrawal, AEDs were restarted. However, many seizure-free patients refused to stop taking AEDs.

Statistical analysis

Due to the wide range of 2—14 years in following up these patients, time-to-event methods were used to connect various risk factors with the maintenance of Class I outcome after surgery. Kaplan—Meier methods were, therefore, used to estimate the probability of remaining in Class I as a function of time. Cox multivariate stepwise logistic regression analysis was used to estimate hazard ratios and 95% CIs for each risk factor concerned. We reported seizure recurrence by obtaining survival estimates at 0.5, 2, 5 and 10 years after surgery. Univariate analysis was used to detect the factors affecting the long-term outcome and stepwise logistic regression was used to evaluate the predictor.

Results

Overall outcome

The majority of seizure recurrences took place during the first 2 years after surgery (Fig. 2). Overall, 48 of 97 patients were seizure-free in 2 years. The number of patients in each Engel Class is summarized in Table 4.

The probability of remaining in Class I was 54.6% (95% CI 44—64) at 6 months, 49.5% (95% CI 39.3—59.6) at 2 years, 47% (CI 34—59) at 5 years, and 41.9% (CI 23.5—60.3) at 10 years. The rate of Class I outcome remained 41.9% for the 31 patients with more than 14 years of follow-up.

Regarding Engel 1a outcome (complete seizure-free), 46 patients (47.4%) were in class Engel 1a at the 6 months

Table 3 Resection area and side of the operation

Variable	Not seizure-free	Seizure-free	Sig
Resection area			
Orbito-polar	10 (50.0%)	10 (50.0%)	0.515
Fronto-central	20 (58.8%)	14 (41.2%)	
Fronto-medial	8 (44.4%)	10 (55.6%)	
Dorso-lateral	10 (40.0%)	15 (60.0%)	
Side of the operation			
Right	29 (49.2%)	30 (50.8%)	0.550
Left	19 (50.0%)	19 (50.0%)	

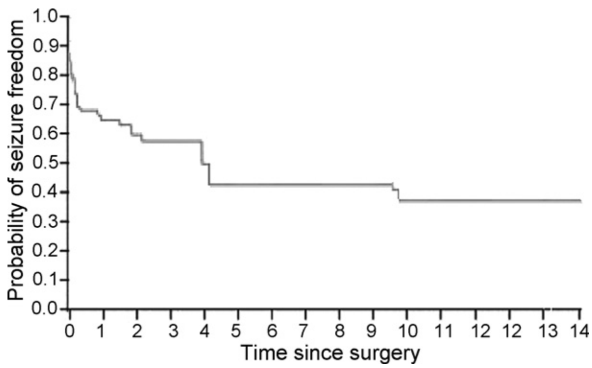

Figure 2 Kaplan—Meier showing the probability Engel Class 1 over time.

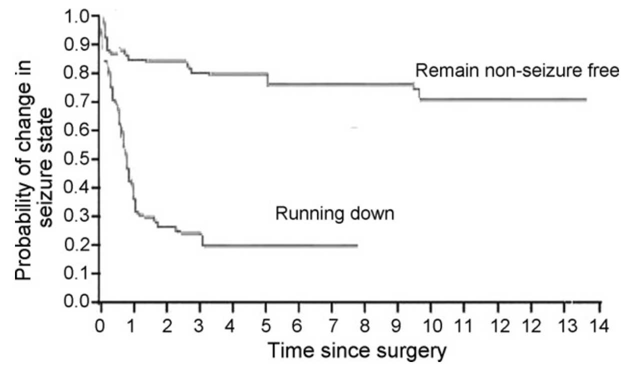

Figure 3 Kaplan—Meier curve shows the probability to become seizure-free in patients start non-seizure free after surgery (running down phenomena).

follow-up, 45 (46.4%) at 1 year, 40 (41.2%) at 2 years, 23 (34.8%) at 5 years and 11(35.5%) at 10 years follow-up.

Recurrence after surgery

The greatest risk of recurrence (87%) was in the first 2 years after surgery. If the patient was seizure-free at 2-year follow-up, the probability to remaining seizure free up to 10 years was 86% (95% CI 76—98). Patients with a history of meningitis and MCD had high risk of relapse, with rates of 2.8 (95% CI 0.6—3.6) and 2.2 (95% CI 0.78—5.99), respectively. The greatest risk of recurrence was among patients with Rasmussen syndrome. Here four of five patients (80%) relapsed within 10 years, estimated risk of recurrence was 3.5 (95% CI 0.42—30.032).

Running down phenomenon

At the 6-month follow-up 44 patients did not achieve seizure-freedom, However, four of these patients (9%) become seizure-free by 2-year follow-up. The seizure-free numbers rose to six patients at 5-years follow-up (13.6%). By using the Engel seizure classification would normally be categorized in class 2. We analyzed the data for this special group of patients by determining whether they were seizure-free 2 years prior to the last follow-up. By using Kaplan—Meier curve (Fig. 3) we saw that the probability of these patients becoming seizure free was greatest in 2 years. If a patient was not-seizure-free at 6 months, the probability to becoming seizure-free within 5 years is 17% (95% CI 10—24%).

Only two factors have been found to have a significant relation with running down of seizures, these are the absence of IED in EEG at first 6-month postoperative follow-up ($p = 0.01$) and the absence of history of secondary generalized tonic—clonic seizures ($p = 0.015$).

Outcome in relation to pathological finding

Among the cohort in whom FCD was diagnosed, the likelihood of remaining in Class I after 0.5, 2, 5, and 10 years was 51.2% (95% CI 47—55%), 48.8% (CI 40—56%), 48.8% (CI 40—56%), and 52.6% (CI 42—62%), respectively.

In the group with tumours, the likelihood of being in Engel Class I was 65.4% (95% CI 60—70%) at 6 months, 53.8% (CI 45—61%) at 2 and 53.3% (CI 46—60%) at 10 years. Table 5 shows number and percentages of Engel class 1 comparing with Classes 2—4.

Outcome according to resection area

The Kaplan—Maier curve (Fig. 4) shows the probability of become seizure free between patients based on the type of resection. Patients were operated in the central area had the highest rate of relapse and patients were operated in the dorso-lateral had the lowest rate of relapse, but there were no significant difference in outcome ($p = 0.517$).

Outcome in patients withdrawn from AED

Thirty patients (30.9%) were withdrawn from AEDs. In 26 patients (26.8%) AEDs had to be changed after surgery. There was a low risk of recurrence with drug withdrawal with an estimated risk ratio of 1.262 (95% CI 0.532—2.994). Patients with cavernomas faired best AED withdrawal; 40% of these patients were seizure-free with AEDs withdrawal. However, only 20% of patients suffering from FCD and in 14%

Table 4 Number of patients and percentage in each Engel Class

Outcome	6 months	2 years	5 years	10 years
Class 1	53 (54.64%)	48 (49.48%)	31 (46.97%)	13 (41.94%)
Class 2	14 (14.43%)	19 (19.59%)	9 (13.64%)	4 (12.90%)
Class 3	14 (14.43%)	13 (13.40%)	12 (18.18%)	8 (25.81%)
Class 4	16 (16.49%)	17 (17.53%)	14 (21.21%)	6 (19.35%)

Table 5 Number of FCD and tumors patient's and percentage comparing Engel 1 class (seizure free with Classes 2—4 (non-seizure-free)

	FCD		Tumors	
	Not seizure-free	Seizure-free	Not seizure-free	Seizure-free
6 months	20 (48.8%)	21 (51.2%)	9 (34.6%)	17 (65.4%)
2 years	21 (51.2%)	20 (48.8%)	12 (46.2%)	14 (53.8%)
5 years	16 (51.6%)	15 (48.4%)	7 (46.7%)	8 (53.3%)
10 years	9 (47.4%)	10 (52.6%)		

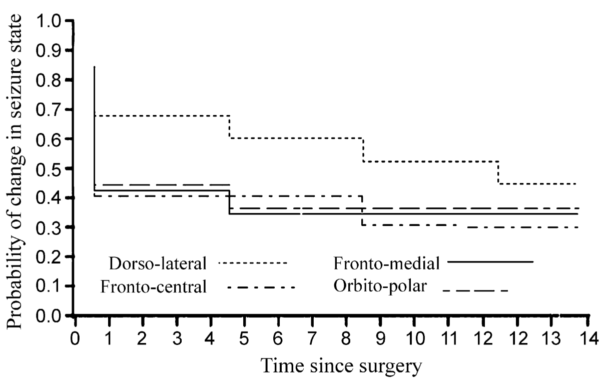

Figure 4 Kaplan—Meier curve shows the probability to become seizure-free based on the resection area.

of patients with the diagnosis of a tumour were seizure-free after surgery and AED withdrawal.

Predictors (univariate analysis)

Having a *p*-value of less than 0.05, a well-circumscribed focal lesion on preoperative MRI (Fig. 5), ipsilateral IED, and an operation before age of 30 years were correlated with favorable outcome. Incomplete resection, mental retardation, using of subdural grids, IED in the follow-up EEG, tonic seizures, unspecific auras and postoperative persistent auras were correlated with unfavorable outcome. Table 6 shows the factors having importance in the univariate analysis.

Multivariate analysis

Variables that were significant in univariate analysis were investigated by using Cox stepwise logistic regression. This showed that presence of a well-circumscribed focal lesion on preoperative MRI predicts seizure remission: $p = 0.003$, HR 0.25 (95% CI 0.101—0.616), and persistent postoperative aura predict seizure relapse: $p = 0.001$ HR 2.982 (95% 1.735—5.122) (Fig. 6).

Complications

Thirteen of our patients (13.4%) had complications as a result of surgery. Five of these (5.15%) were permanent complications and eight (8.24%) were transient. Among the permanent complications three were paresis, one a facial paresis and one diagnosed as visual field defect. The eight transient complications consisted of two subdural haemorrhages that did not need evacuation, two postoperative wound infections and four transient paresis successfully treated with drugs and physiotherapy. Patients who developed complications showed a higher seizure recurrence risk compared to surgical patients who experienced no complication: RR 3.250 (95% CI 0.838—12.612).

The presence of complications showed a slightly higher risk of seizure relapse [RR 1.575 (95% CI 0.815—3.041)], but this was not statistically significant ($p = 0.127$). Fig. 7 shows numbers and types of complications among patients.

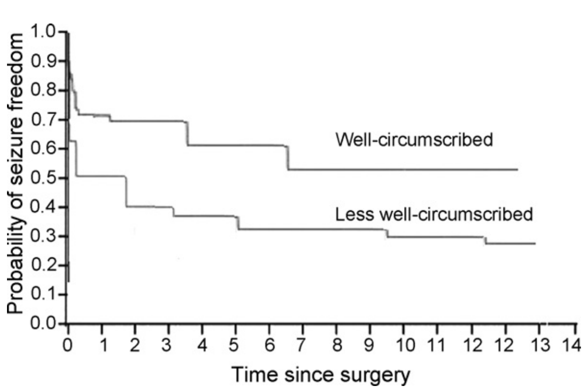

Figure 5 Kaplan—Meier curve shows the probability of seizure-freedom among patients based on type of the lesion on preoperative MRI.

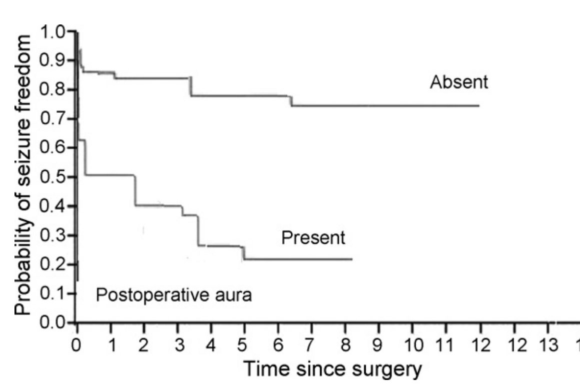

Figure 6 Kaplan—Meier curve shows the probability of seizure-freedom among patients based on the presence or absences of postoperative aura.

Table 6 The results of univariate analysis

Variables	*p*-Value	HR	95% CI
Well-circumscribed focal lesion in preoperative MRI	0.010	0.658	0.489–0.885
Ipsilateral IED	0.000	0.773	0.604–0.989
Incomplete resection	0.048	2.56	1.05–6.19
Invasive monitoring	0.042	1.06	1.11–2.32
Mental retardation	0.004	1.60	1.11–2.34
IED at 6-month EEG postoperative	0.001	3.38	1.10–10.38
IED at 2-year EEG postoperative	0.026	1.65	1.34–2.86
Tonic seizure	0.034	1.625	1.038–2.542
Unspecific auras	0.038	1.60	1.11–2.32
Age at surgery	0.003		
<30 years (n = 64)		Reference	
>30 years (n = 33)		1.08	0.79–1.46
Duration of the epilepsy	0.025	Reference	
<20 years (n = 68)		0.555	0.332–0.928
>20 years (n = 29)			
Persistent postoperative aura	0.003	3.96	1.52–6.05
Yes (31)			
No (66)			

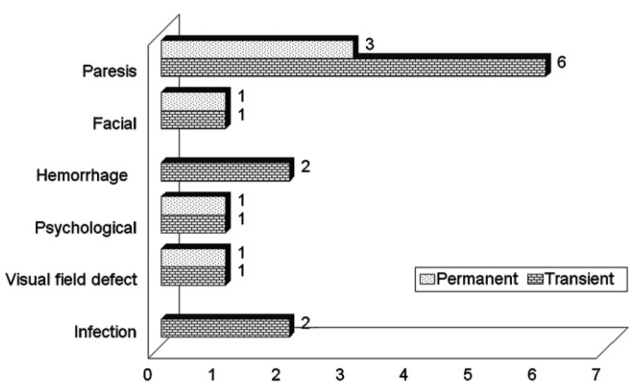

Figure 7 Bar presentation of numbers and types of complications among patients.

Discussion

Overall outcome

Previously reported rates of seizure-freedom following FLE surgery varied greatly from as low as 9% to as high as 80% (Chung et al., 2005; Elsharkawy et al., 2008; Ferrier et al., 1999; Fish et al., 1993; Lee et al., 2005; Mosewich et al., 2000; Rasmussen, 1991; Swartz et al., 1998; Talairach et al., 1992; Tellez-Zenteno et al., 2005; Wieser and Hajek, 1995; Yun et al., 2006; Zaatreh et al., 2002; Zentner et al., 1996).

Jeha et al. (2007) reported in a study similar to our study long-term seizure-freedom in 40% of patients after FLE surgery (Jeha et al., 2007).

In our study 46.9% of our patients were seizure-free at year 5 and 41.9% at year 10 after frontal epilepsy surgery. Only 35% of the patients were considered to be in Engel Class 1a.

In accordance to previous studies, the best results were achieved in patients suffering from tumours and focal cortical dysplasia (Zaatreh et al., 2002).

Seizure relapse and running down

In our study most seizure relapses occurred in the first 2 years (87%). Nevertheless, most running down (66.7%) occurred in the first 2 years as well. This confirms the advantage of using 2-year follow-up as a landmark predicting the long-term outcome after FLE for relapse and running down (Cohen-Gadol et al., 2006; Jeha et al., 2007).

The absence of secondarily generalized tonic—clonic seizure and the absence of IED at EEG 6-month follow-up were significantly related to running down of seizures, possibly indicating that the structural abnormalities in the epileptogenic area was not widespread, Salonova reported that the epileptogenic area was medium-size in patients showing a running down after temporal lobe epilepsy surgery (Salanova et al., 1996).

Patients with vascular lesions showed the lowest rate of relapse among pathological subgroups. This may be due to the fact that most of these patients had well-circumscribed cavernomas which were easier to resect completely. Favorable outcome after vascular resections has been reported (Wetjen et al., 2002).

Anti-epileptic drugs

In their meta-analysis Tellez-Zenteno et al. (2007), reported that 20% of patents achieved long-term AED discontinuation in studies including all types of surgery and 36% of patients in studies that did not focus on temporal lobe surgery (Tellez-Zenteno et al., 2007). In our study a total of 30.9% of the patients were withdrawn from AED. The problem facing AEDs is the absence of standard strategies after surgery.

Every epilepsy centre has its own strategy. In our centre the discontinuation of AEDs is the patient's decision so most probably this number does not reflect the actual situation of AEDs discontinuation although it gives a general benchmark.

Predictors of outcome

Similar to previous reports, results of our univariate analysis showed that a focal lesion in preoperative MRI, ipsilateral IED, surgery before age of 30 years, short duration of epilepsy and the absence of IED in EEG recorded 6 months after surgery are correlated with seizure-freedom (Mosewich et al., 2000; Siegel et al., 2006; Swartz et al., 1998).

Incomplete resection, invasive monitoring, mental retardation, IED at 2-year spostoperative EEG, tonic seizures, unspecific auras and persistent postoperative auras were all correlated with non-seizure-freedom. The diagnosis of an MCD in histology (RR 2.3) and a postoperative infection (RR 3.4) were significantly associated with poor outcome (Armon et al., 1996; Jeha et al., 2007; Kellinghaus and Luders, 2004; Swartz et al., 1998).

In multivariate analyses, however, presence of a well-circumscribed focal lesion in preoperative MRI independently predicts seizure remission, whereas persistent postoperative auras predict seizure relapse.

These results emphasize the importance of a complete removal of the epileptogenic tissue.

Outcome in relation to epilepsy duration

According to our data the duration of epilepsy before surgery is significant in univariate analysis. Short epilepsy duration cannot independently predict the outcome. This means that epilepsy duration has its effect through other factors, and this may explain the contradiction between studies in the literature. Some authors observed that duration of epilepsy was not a prognostic factor and had no relationship to outcome (Alexandre et al., 2006; Ferrier et al., 1999; Lee et al., 2005; Spencer et al., 2005; Yun et al., 2006).

Other authors showed a significant correlation between shorter duration of preoperative epilepsy duration and improved outcomes (Blume et al., 2004; Kral et al., 2001; Siegel et al., 2006).

Our results may also suggest that epilepsy is an active process over time. One may speculate that the epileptogenic zone (Rosenow and Luders, 2001) or epileptic pacemakers (Bancaud and Talairach, 1992) spread in the course of time, becoming more diffuse and therefore, more difficult to localize. Hence they result in a greater likelihood for an incomplete resection later on (Berg and Shinnar, 1997).

We assume that early operative intervention stops this process and gives the patient more chance to becoming seizure free and enjoy long term-seizure-free outcome.

Postoperative aura

By applying multivariate analysis we could see that patients suffering from persistent auras postoperatively had a fourfold higher risk of recurrence [HR 3.96 (95% CI 1.52—6.05)]. Evaluating surgical failures of surgical failures Salanova found that 46% of reoperated patients exhibited an aura (Salanova et al., 1994). Spencer found that mesial temporal lobe epilepsy patients with continued auras relapsed to a higher rate than those without auras (Spencer et al., 2005). Berg et al. (2006) found that continuing auras were marginally associated with relapse in patients whose AEDs were reduced postsurgically.

From our institute, Schulz et al. (1997) concluded in a study of stimulation-induced auras (SIA) that the area of the SIA overlapped the epileptogenic lesion as well as the EEG seizure onset zone in 75% of the patients (Schulz et al., 1997). Jeha et al. (2007) found that postoperative auras were more frequent in surgical failures.

Our findings indicate that presence of a postoperative aura represents a residual epileptogenic zone and indicate incomplete resection.

Complications

Reports of frontal epilepsy surgery showed a relatively high rate of complications (Pondal-Sordo et al., 2006; Schramm et al., 2002).

Our results are in agreement with reported complications after FLE surgery (Olivier, 1995, 1996; Swartz et al., 1998).

Our two wound infections and three permanent neurological deficits fall within the range of previously published results (Cascino et al., 1992, 1994; Pondal-Sordo et al., 2006; Rydenhag and Silander, 2001).

The presence of complications showed a slightly higher risk of seizure relapse, but this was not statistically significant. These higher rates reflect the fact that most complications occur in complex cases where in which delineation of the epileptogenic zone is difficult or an operation in the eloquent area with MST has been performed. This means that most probably there was remnant epileptic tissue which led to the higher relapse frequency rate.

Conclusions

We investigated the long-term outcome of 97 patients after pure FLE surgery with a follow-up period of up to 14 years.

Regarding the long-term outcome, 42% of our patients became seizure-free over the 14 years. In 31% of all patients AEDs were successfully withdrawn. If the patient was seizure free at 2-year follow-up, the probability of remaining seizure free for 10 years was 86% (95% CI 76—98). A percentage of the patients (13.6%) who were not seizure free after surgery will become seizure free within 5 years (running down).

Presence of well-circumscribed focal lesions on preoperative MRI predicted favorable seizure outcome. Seizure relapse can be predicted by a postoperative persistent aura. FLE surgery should currently depend on restrictive selection for patients to achieve a successful outcome.

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