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Effects of Surgical Side and Site on Psychological Symptoms Following Epilepsy Surgery in Adults

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Abstract

This retrospective study examined the potential role of side *and* site of surgery in psychological symptom change after epilepsy surgery and determined the base rate of psychological change at the individual level. Two-hundred twenty-eight adults completed the Personality Assessment Inventory (PAI) before and after temporal (TLR; n=190) or frontal lobe resection (FLR; n=38). Repeated measures ANOVAs with bootstrapping examined differences in psychological outcome as a function of surgical site separately in patients who underwent left versus right-sided resections. Individual's PAI score changes were then used to determine the prevalence of clinically meaningful postoperative symptom change. Following *left-sided resections*, there were significant group-by-time interactions on Somatic Complaints, Anxiety, and Anxiety Related Disorders. There was also a trend in this direction on the Depression scale. TLR patients endorsed greater preoperative symptoms than FLR patients on all of these scales, except the Somatic Complaints scale. After surgery, TLR patients reported symptom improvement on all four scales, while scores of FLR patients remained relatively stable over time. Endorsement of Mania-related symptoms increased in both TLR and FLR groups from pre-to post-surgical testing. Following *right-sided*

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We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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resections, both groups endorsed symptom improvements on Somatic Complaints, Anxiety, and Depression scales following surgery. In addition, the TLR group endorsed more manic symptoms than the FLR group regardless of time. Patterns of meaningful change in individual patients were generally consistent with group findings, with the most frequent improvements observed following TLR. However, there were a small subset of patients who reported symptom exacerbation after surgery. Our results suggest that surgical lateralization and localization are important factors in postoperative psychological outcome and highlight the importance of considering psychological change at the individual patient level. Further research is needed to identify potential risk factors for symptom exacerbation to aid in preoperative counseling and identify those patients most in need of postoperative psychological surveillance.

Keywords

epilepsy surgery; frontal; temporal; lateralization; localization; psychological outcome

1. INTRODUCTION

Psychopathology occurs at higher rates in patients with epilepsy than in the general population. An estimated 20-40% of patients with epilepsy are diagnosed with psychiatric disturbances, while rates as high as 70% can be seen in patients with pharmacoresistant seizures [1-4]. Mood disorders are the most frequently observed psychiatric diagnoses in patients with epilepsy; the prevalence of depression ranges from 20-55% in this population [5]. Many studies suggest that depression is more frequent in patients whose seizures arise from left anterior (i.e., temporal, frontal) regions [6-8]. This finding is consistent with literature in other neurological populations and cognitive neuroscience theories regarding the neuroanatomy of emotion [9]. Many studies investigate other psychiatric symptomatology in patients with epilepsy [3, 10-14]; however, research examining psychiatric outcome following epilepsy surgery is limited.

In clinical practice, there is often concern regarding risk for de novo psychiatric symptoms or exacerbation of pre-existing psychiatric symptoms following epilepsy surgery [15- 18]. Research results are unclear; some studies purport that surgery leads to a reduction in psychiatric symptoms [19, 20], while others have found postoperative symptom exacerbation [21, 22]. Factors such as presurgical psychological adjustment, postoperative seizure-freedom, and time to follow-up have been shown to be related to psychological outcome [23-25], although these findings have not been universal [26, 27]. To complicate matters, most existing studies on this topic have involved small sample sizes and the grouping of frontal, parietal, and occipital cases to have a robust enough sample to make comparisons to a frequently larger sample of temporal lobe cases [3, 22, 28]. As such, very few studies have examined the potential role of both anterior surgical site and side in postoperative psychiatric outcome simultaneously. Further, most existing studies have limited their examination of psychiatric symptom change to group data, which may obscure important findings in individual patients.

This study sought to extend the current literature by further examining mood and psychological outcome following epilepsy surgery in a large group of adults with pharmacoresistant seizures. The primary aims were two-fold: 1) to explore the potential role of both side *and* site of surgery in self-reported postoperative psychological symptoms, and 2) to determine the prevalence of postsurgical change in self-reported psychological symptoms at the individual level.

2. MATERIALS AND METHODS

2.1 Participants

This retrospective study acquired data from an Institutional Review Board-approved data registry containing pre and postoperative neuropsychological data for patients who underwent epilepsy surgery at Cleveland Clinic between 1993 and 2014. Participants were selected for the study if they met the following inclusion criteria: 1) were at least 18 years of age; 2) completed both pre and postoperative neuropsychological evaluations that included the Personality Assessment Inventory (PAI [29]); 3) had a standard score of 70 or higher on the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III [30]) or on the Reading subscale of the Wide Range Achievement Test – Third or Fourth Edition (WRAT3 [31] or WRAT4 [32]); and 4) had a history of either frontal or temporal lobe resective surgery. Patients who had undergone other focal surgeries in posterior regions of the brain were not included due to small sample sizes that precluded the examination of side and site of surgery. Patients were also excluded from this study if they demonstrated right-hemispheric language dominance on fMRI or Wada testing, had an elevated score on more than one of the PAI validity scales, or if the evaluating neuropsychologist had concerns about patient effort during the evaluation. Patients who were excluded from the study (for reasons other than age or IQ/reading level; $n=490$) were not significantly different in age, sex, education, age at seizure onset, or duration of epilepsy from patients included in the study. However, there was a significant difference in race, with fewer non-White patients in the final study sample.

A total of 228 participants met inclusion criteria. Of these, 38 (16 left, 22 right) had undergone frontal lobe resections (FLR), and 190 (92 left, 98 right) had undergone temporal lobe resections (TLR). Participants ranged in age from 18 to 73 years ($M=36.47$, $SD=11.70$) and in education from 8 to 20 years ($M=13.37$, $SD=2.15$). Mean age at seizure onset was 17.57 years ($SD=12.65$), and mean duration of epilepsy was 18.90 years ($SD=12.25$). Participants were taking an average of 2.06 ($SD=0.72$) anti-epileptic drugs (AEDs) at the time of their preoperative evaluation and an average of 1.90 ($SD=0.81$) AEDs at their postoperative evaluation. Fifty-six percent of participants were female and 98% characterized themselves as Caucasian (Table 1). Patients completed postoperative neuropsychological testing a median of 6 months following surgery and 9 months following their preoperative assessment. The modes for these follow-up time points were also 6 and 9 months, respectively. There was no difference in time to follow-up between patients who underwent temporal versus frontal lobe resections, regardless of side of surgery [right side: $t(118)=-0.48$, $p=0.61$; left side: $t(106)=0.32$, $p=0.75$], and time to follow-up was not

significantly related to psychological change following surgery (r range = - 0.12 to 0.11, p range = 0.20 to 0.77).

Most of the patients in the study (58%) remained on the same number of AEDs postoperatively as they had been taking prior to surgery. Approximately 28% of patients had a reduction in the number of AEDs between their pre and postoperative neuropsychological assessments. Only a small proportion of patients (14%) had one or more AEDs added to their medication regimen during this time period. There was no significant difference in the proportion of FLR and TLR patients whose number of AEDs changed or remained stable following surgery. Similarly, the vast majority of patients (83%) remained on the same number of psychotropic medications as they were taking prior to surgery. Several patients (5%) had a reduction in psychotropic medications following surgery, and a small subset (12%) had a psychotropic drug (most often an antidepressant) added to their regimen. There was no significant difference in the proportion of FLR and TLR patients whose psychotropic medications changed or remained stable following surgery.

Psychiatric history was available for 215 patients (94%) in the study sample. Based on medical record review, 32% of these participants had been previously diagnosed with a mood and/or anxiety disorder and 10% had been diagnosed with an adjustment disorder prior to surgery. One patient had a history of atypical psychosis, and one patient, with a history of anxiety disorder, experienced occasional post-ictal psychosis. A summary of patient psychiatric diagnoses and psychotropic medications is provided in Table 1.

2.2 Measures

The Personality Assessment Inventory (PAI [29]), a standardized, self-report measure of adult personality, was used to evaluate psychological functioning. This measure produces four validity scales (Inconsistency, Infrequency, Negative Impression, and Positive Impression) that were used to determine profile validity as described in the Participants section above. The PAI also produces 11 clinical scales, 5 of which were selected for examination in the present study: Somatic Complaints, Anxiety, Anxiety-Related Disorders, Depression, and Mania. The PAI has been well-validated and is commonly employed in clinical settings to assist in assessing psychopathology [29].

2.3 Statistical Analyses

Given prior findings of greater depressive symptomatology in patients with left-sided seizure foci [6-8], all analyses described below were conducted separately by surgical side (left, right). Participants were further categorized based on surgical resection site (temporal, frontal) before analyses were conducted.

Potential group differences on relevant demographic and seizure variables were examined with chi-squares, Fisher's exact tests, and one-way ANOVAs. Next, analyses examined the role of both side and site of surgery on psychological symptoms. Exact tests were performed to determine if there were group differences in the proportion of individuals who had clinically significant scale elevations (t -score ≥ 70) on the PAI before and after surgery. A series of repeated measures ANOVAs was conducted on each of the five PAI clinical scales of interest to examine potential group differences in psychological outcome following

surgery. Bootstrapping (1000 replications) was used to adjust for influential cases. Post-hoc t-tests were used to facilitate interpretation of significant interactions. As this was an exploratory study designed to identify any potential differences in psychiatric outcome following epilepsy surgery as a function of surgical site and side, p-values were not adjusted for multiple comparisons.

To examine clinically meaningful postoperative change in psychological symptoms at the individual patient level, change scores were generated for each patient on each of the PAI clinical scales by subtracting their postoperative score from their preoperative score (i.e., positive change scores indicate improved symptomatology). Patients were then separated into one of three categories (improve, no change, decline) on each of the PAI scales using a one standard deviation cutoff (t-score change of 10 or more points). Fisher's exact tests (conducted separately in patients who underwent right- versus left-sided resections) were used to examine differences in individual change scores between patients who underwent temporal and frontal lobe surgeries.

3. RESULTS

3.1 Demographic and Seizure Variables

Patients who underwent left TLR had better seizure outcomes than those who underwent left FLR [$\chi^2(1)=11.36$, $p=0.001$]. No difference in seizure outcome was found among those who underwent right-sided resections. Differences in seizure outcome are expected as a function of surgical site, with the best outcomes following TLR [33, 34]. Given this known, strong relationship between seizure site and outcome, we did not statistically control for this factor. Not surprisingly, there were also differences in surgical pathology between patients who underwent TLR versus FLR, regardless of side of surgery. The vast majority of patients who underwent FLR (83%) had large resections involving two or more regions (e.g., lateral, mesial, orbitofrontal, supplementary motor area) within the frontal lobe, which precluded investigation of regional differences in mood and psychological outcome. There were no differences between surgical groups on any other demographic or seizure variables (Table 1).

3.2 Clinically Relevant Scale Elevations

Group means on the PAI scales ranged from 44.57 to 63.68, and did not exceed the cutoff recommended for identifying clinically significant symptomatology (i.e., standard score 70) [29]. Therefore, we examined individual patient scores for clinically meaningful elevations to better characterize the overall sample as well as identify potentially important differences among the surgical groups. The proportion of patients with clinically elevated scores was not significantly different between TLR and FLR groups in either hemisphere on any of the PAI scales, either before or after surgery (Table 2).

3.3 Group Comparisons: PAI Score Change Over Time

3.3.1 Left-Sided Resections—Repeated measures ANOVAs with bootstrapping revealed significant group-by-time interactions on the following PAI scales: Somatic Complaints [$F(1,106)=8.239$, bootstrap $p=0.005$], Anxiety [$F(1,106)=5.454$, bootstrap $p=0.008$], and Anxiety-Related Disorders [$F(1,106)=5.504$, bootstrap $p=0.005$]. There was a similar trend

on the Depression scale [$F(1,106)=3.359$, bootstrap $p=.057$]. Post-hoc independent samples t-tests revealed that the TLR group endorsed significantly greater symptoms than the FLR group on the Anxiety [$t(106)=2.198$, $p=.03$], Anxiety-Related Disorders [$t(106)=2.117$, $p=.037$], and Depression scales [$t(106)=2.184$, $p=.031$] prior to surgery. Paired samples t-tests suggested that TLR patients endorsed postoperative symptom improvement on all four of these scales following surgery (all $p<.003$), whereas the endorsements of FLR patients remained unchanged (all $p>0.05$) (Figure 1).

A main effect of time was observed on the Mania scale [$F(1,106)=6.784$, bootstrap $p=0.017$] with an overall increase in symptom endorsement at postoperative evaluation ($M=46.87$; $SE=1.23$) compared to the preoperative scores ($M=44.34$; $SE=1.16$). This small 2.5 point difference, while statistically significant, is unlikely to be of clinical significance, particularly since the mean scores at both time points do not exceed the threshold to be considered clinically elevated (i.e., t-score ≥ 70).

3.3.2 Right-Sided Resections—There were no significant group-by-time interaction effects among patients who underwent right-sided resections. However, there were main effects of time on the Somatic Complaints [$F(1,118)=8.489$, bootstrap $p=0.000$], Anxiety [$F(1,118)=4.099$, bootstrap $p=0.007$], and Depression [$F(1,118)=5.587$, bootstrap $p=0.008$] scales, such that patients endorsed fewer symptoms on these scales following surgery as compared to their preoperative endorsements regardless of surgical site. There was also a main effect of surgical site on the Mania scale [$F(1,118)=3.654$, bootstrap $p=0.030$], such that TLR patients ($M=49.32$, $SE=.999$) endorsed greater symptoms than FLR patients ($M=44.86$, $SE=2.11$) on this scale collapsed across time. Again, similar to the main effect on the Mania scale observed following left-sided surgery, the score differences for all of these main effects were quite small (2-4 t-score points) and, therefore, of questionable clinical significance.

3.4 Individual Outcome: Clinically Meaningful Postoperative Change

3.4.1 Left-Sided Resections—There was a significant difference in the proportion of patients who endorsed clinically meaningful changes (change score ≥ 1 SD) on the Somatic Complaints scale following surgery [$p=0.027$, Fisher's exact test]. Specifically, 19% of patients in the left FLR group endorsed significant symptom exacerbation on this scale following surgery, while only 4% of left TLR patients reported postoperative symptom worsening. Further, 29% of the patients in the left TLR group endorsed significant postsurgical symptom improvement, while only 6% of patients who underwent left FLR reported postoperative improvement on this scale (Table 3 and Figure 2). No significant differences were observed on the other PAI scales.

3.4.2 Right-Sided Resections—Group differences in individual change were only observed on the Anxiety scale [$p=0.004$, Fisher's exact test]. Only one of the right FLR patients (4%) demonstrated a significant score change, endorsing greater symptoms of anxiety following surgery. There was diversity in individual outcome among patients who underwent right TLR with 7% endorsing a postoperative increase in anxiety

symptomatology and 28% endorsing postoperative symptom improvement on this scale (Table 3 and Figure 2).

4. Discussion

Results of this study suggest that side and site of surgery are important factors in self-reported post-operative psychological outcome in patients with pharmacoresistant seizures. Specifically, patients with left temporal lobe epilepsy endorsed greater symptoms of anxiety and depression prior to surgery than patients with left frontal lobe epilepsy. Similar differences in pre-operative psychological status were not apparent in patients with right-sided seizure foci. Following surgery, patients who underwent left TLR reported a reduction in symptoms of anxiety and depression and endorsed fewer somatic complaints, while those who underwent left FLR did not endorse substantial post-operative changes on these PAI scales. Thus, the interactions between surgical group and time observed on these scales were largely driven by the preoperative differences in psychological symptoms between these groups; postoperative mean scores between these groups were quite similar. It is interesting to note that the majority of patients in the left TLR group (i.e., 82%) were seizure-free at follow-up, possibly reflecting reduced worry regarding future seizures. We are aware of only two prior studies that have directly compared psychological outcomes following temporal versus frontal resections and neither found similar site-by-time interaction effects. We suspect this is attributable to differences in study methodology including the type and item content of the instrument used to assess psychological outcome, varying length of postoperative follow-up, failure to account for side of surgical resection, and/or insufficient power related to small sample size [13, 19].

Psychological outcome after right-sided surgery was similar in TLR and FLR patients, with reported improvements in depression and anxiety symptoms following surgery as well as a reduction in Somatic Complaints postoperatively. However, right TLR patients endorsed more mania symptoms than the right FLR group. It should be noted that the mean score difference between the two groups was less than 5 t-score points and may not represent a clinically meaningful distinction. Nevertheless, there is some evidence in the literature to suggest that patients with right hemispheric lesions are more likely to demonstrate manic symptoms than those with lesions in the left hemisphere [35-39]. Mania in epilepsy is quite rare and occurs most often in the context of postictal psychosis [40, 41]. However, mania has also been observed postsurgically in a subset (~10%) of epilepsy patients, usually within weeks of surgery with a relatively transient course [40]. The risk for development of postoperative mania is highest among patients who undergo right temporal lobe resections [37, 41]; thus, our finding that right TLR patients endorse greater manic symptoms than right FLR patients is consistent with the current literature.

Because examination of group means can obscure potentially important postoperative changes at the individual patient level, this study also examined clinically meaningful change (i.e., t-score change of 10 points) in individual patients' PAI clinical scale scores following surgery. Among patients who underwent left-sided resections, differences in individual outcome were observed on the Somatic Complaints scale. The majority (66-75%) of patients in both surgical groups did not report significant symptom changes following

surgery. When significant changes were observed, more FLR patients reported an increase in Somatic Complaints (19%) compared to TLR patients (4%). Conversely, FLR patients were less likely to report improvements on this scale following surgery (6%) than TLR patients (29%). Additional analyses suggest patients who reported worsening on this measure were less likely to be seizure free than those with improvements [$\chi^2(1)=4.07$, $p=.08$]. Notably, 89% of patients who reported postoperative improvements on the Somatic Complaints scale were seizure-free at the time of follow-up. Among those who underwent right-sided resections, there was a large proportion of patients (28%) who endorsed significant improvements in anxiety symptoms following surgery; whereas the vast majority of FLR patients (96%) reported little postoperative change in anxiety symptomatology.

The proportion of patients with postoperative improvement on the PAI scales following left TLR (i.e., 5-29%) is an encouraging finding given the high prevalence of mood and anxiety disorders among patients with temporal lobe epilepsy. Nevertheless, it is important to note that there was a small subset of individuals (4-14%) who reported clinically significant worsening of mood and anxiety following left-sided TLR. Additional research is needed to identify risk factors for symptom exacerbation in this small subset of TLR patients.

There are several limitations of this study that deserve mention. First, patients who underwent left TLR had higher rates of seizure freedom than their frontal lobe counterparts. Thus, the differences in mood outcome among patients who underwent left-sided surgeries are potentially confounded by seizure outcome. Unfortunately, given the strong relationship between surgical site and seizure outcome, we were unable to adequately control for this factor, and future studies with larger samples of frontal lobe epilepsy patients will be required to disentangle the effects of surgical resection site on mood from postoperative seizure outcome. Nevertheless, the majority of patients in this study who reported worsening of psychological symptoms following surgery were seizure-free at follow-up (i.e., 67-77%), and there were no differences in seizure outcome between patients who endorsed worsening symptoms and those who did not (all $p > .05$). In addition, the sample size of the FLR group in this study was rather small and the vast majority of these patients had large resections that involved two or more frontal regions precluding examination of regional effects on psychological symptoms following surgery. As such, our results may not generalize to patients who undergo more limited resections within the frontal lobe. We believe that site and extent of frontal resection in a larger sample of patients with FLR will be important to consider in future studies of postoperative psychological outcome given there is good evidence for distinct roles in affective/emotional processing within discrete regions of the frontal lobe [42, 43]. Further, the role of frontal regions involved in self-awareness and insight may impact the ability of some patients to provide accurate assessments of their mental health and this should be examined in future studies. Finally, lack of a control group in the current study (i.e., group of non-surgical patients with epilepsy) makes it difficult to determine whether changes observed in psychological symptomatology are related specifically to surgery or to other factors.

5. Conclusion

Results of this study suggest that surgical lateralization and localization are important factors in postoperative psychological outcome in adults. Preoperative affective symptoms are most prevalent and most severe among left TLR patients; however, there is significant symptom improvement in most of these patients after surgery. While results indicate generally favorable psychological outcomes approximately 6 months following temporal or frontal lobe epilepsy surgery, it is important to note that there is a small subset of patients, identified through inspection of individual change scores, who report worsening of psychological symptoms following surgery. Further research will be required to determine which specific symptoms contribute to the postoperative scale increases observed in these patients and to identify potential risk factors that might be associated with symptom exacerbation. Clear identification of such factors will be important to inform preoperative counseling and identify those patients most in need of postoperative psychological surveillance.

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Abbreviations

PAI	Personality Assessment Inventory
TLR	Temporal Lobe Resection
FLR	Frontal Lobe Resection

Highlights

- Side and site of surgery influence postoperative psychological outcome
- Preoperative symptoms are higher in left temporal than left frontal lobe epilepsy
- Psychological symptoms often improve following left temporal resection
- A small subset of individuals report worsening psychological symptoms after surgery
- Future research needed to identify risk factors for decline in mood/anxiety

Figure 1.
Group x Time Interactions Among Patients Who Underwent Left-Sided Resections

Figure 2.
Clinically Meaningful Postsurgical Change (Change of ± 10 points) on PAI Scales

Table 1

Demographic, seizure, and psychiatric variables for surgical patients by side and site of surgery.

	Left-Sided Resection (N=108)				Right-Sided Resection (N=120)			
	Temporal n=92		Frontal n=16		Temporal n=98		Frontal n=22	
	M (SD)	F/ χ^2	p		M (SD)	F/ χ^2	p	
Age (years)	38.08 (11.61)	34.31 (8.52)	1.53	0.22	36.48 (11.88)	31.27 (12.21)	3.42	0.07
Education (years)	13.42 (1.94)	13.50 (1.71)	0.02	0.88	13.42 (2.41)	12.82 (2.11)	1.16	0.28
Age at Onset	18.11 (13.07)	12.75 (9.67)	2.45	0.12	18.03 (12.84)	16.77 (11.91)	0.18	0.68
Duration of Epilepsy	19.72 (12.26)	21.88 (12.31)	0.42	0.52	18.51 (12.11)	15.05 (12.57)	1.45	0.23
Pre-Operative AEDs ^a	2.09 (0.61)	2.38 (0.96)	2.55	0.11	1.95 (0.69)	2.23 (1.02)	2.39	0.13
Post-Operative AEDs ^a	1.92 (0.80)	2.25 (0.86)	2.21	0.14	1.80 (0.81)	2.00 (0.76)	1.16	0.28
	<u>Number (Percent)</u>				<u>Number (Percent)</u>			
Sex ^a :			0.37	0.60			0.49	0.49
Female	50 (54%)	10 (62%)			57 (58%)	11 (50%)		
Male	42 (46%)	6 (38%)			41 (42%)	11 (50%)		
Race ^a :			0.35	1.00			0.46	0.46
White	90 (98%)	16 (100%)			96 (98%)	21 (96%)		
Black	1 (1%)	0 (0%)			2 (2%)	1 (4%)		
Hispanic	1 (1%)	0 (0%)			0 (0%)	0 (0%)		
Handedness ^a :			0.02	1.00			0.65	0.66
Right	81 (88%)	14 (88%)			86 (88%)	18 (82%)		
Left	6 (7%)	1 (6%)			7 (7%)	2 (9%)		
Ambidextrous	5 (5%)	1 (6%)			5 (5%)	2 (9%)		
Short-Term Seizure Outcome ^{a,b} :			11.36	0.00			1.78	0.22
Completely Seizure Free	75 (82%)	7 (44%)			83 (85%)	16 (73%)		
Not Seizure Free	16 (18%)	9 (56%)			15 (15%)	6 (27%)		
Surgical Pathology ^{a,d} :			46.33	0.00			42.40	0.00
Cortical Dysplasia	5 (5%)	7 (44%)			11 (11%)	8 (38%)		
Hemangioma	2 (2%)	0 (0%)			4 (4%)	0 (0%)		
Neuronal Heterotopia	0 (0%)	0 (0%)			1 (1%)	0 (0%)		

	Left-Sided Resection (N=108)		Right-Sided Resection (N=120)		
	Temporal n=92	Frontal n=16	Temporal n=98	Frontal n=22	
MTS	69 (75%)	0 (0%)	58 (59%)	0 (0%)	
Infarct	2 (2%)	3 (19%)	3 (3%)	7 (33%)	
Nonspecific ^c	12(13%)	4 (25%)	16 (16%)	3 (14%)	
Cavernoma	1 (1%)	0 (0%)	0 (0%)	0 (0%)	
Tumor	1 (1%)	2 (12%)	5 (5%)	3 (14%)	
Psychiatric History ^{a,e}			0.47	0.96	2.91 0.70
No History	49 (57%)	9 (56%)	46 (51%)	13 (65%)	
Mood Disorder	19 (22%)	3 (19%)	22 (24%)	5 (25%)	
Anxiety Disorder	4 (5%)	1 (6%)	6 (7%)	0 (0%)	
Depression & Anxiety	5 (6%)	1 (6%)	5 (5%)	1 (5%)	
Adjustment Disorder	8 (9%)	2 (13%)	12 (13%)	1 (5%)	
Psychotic Disorder	1 (1%)	0 (0%)	0 (0%)	0 (0%)	
Pre-Operative Psychotropics ^d :					
Antidepressants	17(19%)	4 (25%)	0.37	0.51	0.01 1.00
Anxiolytics	1 (1%)	1 (6%)	2.00	0.28	0.00 1.00
Antipsychotics	4 (4%)	0 (0%)	0.72	1.00	0.46 1.00
Post-Operative Psychotropics ^d :					
Antidepressants	22 (24%)	5 (31%)	0.39	0.54	0.29 0.78
Anxiolytics	1 (1%)	0 (0%)	0.18	1.00	0.65 0.42
Antipsychotics	2 (2%)	0 (0%)	0.35	1.00	0.01 1.00

M=mean, SD=standard deviation, AEDs=antiepileptic drugs, MTS=mesial temporal sclerosis

^aTest statistics are provided for information only. While exact tests were performed, some of cells are too small to rely on the statistical results.

^b median 6 months following surgery

^c nonspecific pathologies include: gliosis, perivascular atrophy, meningeal fibrosis;

^d Surgical pathology available on all, but one patient (n=227)

^e Psychiatric history data available on a subset of patients (n=215)

Table 2

Clinically Significant Elevations (> 70) on PAI Scales

	Left-Sided Resections			Right-Sided Resections		
	Temporal (n=92)	Frontal (n=16)	Fisher's Exact Test p value	Temporal (n=98)	Frontal (n=22)	Fisher's Exact Test p value
Pre-op						
SOM	28%	6%	0.068	30%	9%	0.059
ANX	19%	0%	0.070	11%	0%	0.213
ARD	10%	0%	0.350	9%	5%	0.687
DEP	17%	6%	0.458	13%	18%	0.513
MAN	0%	0%	--	3%	0%	1.000
Post-op						
SOM	10%	19	0.381	15%	9%	0.735
ANX	8%	0%	0.591	8%	5%	1.000
ARD	5%	0%	1.000	3%	9%	0.227
DEP	9%	6%	1.000	11%	14%	0.720
MAN	3%	0%	1.000	3%	0%	1.000

SOM=Somatic Complaints, ANX=Anxiety, ARD=Anxiety Related Disorders, DEP=Depression, MAN=Mania

Table 3

Clinically Meaningful Changes after Surgery

	Left-Sided Resections (n=108)				Right-Sided Resections (n=120)			
	(92 Temporal, 16 Frontal)		Fisher's Exact Test p value		(98 Temporal, 22 Frontal)		Fisher's Exact Test p value	
	Improve	No Change	Decline		Improve	No Change	Decline	
SOM								
Temporal	27 (29%)	61 (66%)	4 (4%)	0.027	25 (26%)	68 (69%)	5 (5%)	0.830
Frontal	1 (6%)	12 (75%)	3 (19%)		4 (18%)	17 (77%)	1 (5%)	
ANX								
Temporal	26 (28%)	62 (67%)	4 (4%)	0.119	27 (28%)	64 (65%)	7 (7%)	0.004
Frontal	1 (6%)	14 (88%)	1 (6%)		0 (0%)	21 (96%)	1 (4%)	
ARD								
Temporal	21 (23%)	63 (69%)	8 (9%)	0.065	18 (18%)	75 (77%)	5 (5%)	0.455
Frontal	0 (0%)	15 (94%)	1 (6%)		2 (9%)	18 (82%)	2 (9%)	
DEP								
Temporal	24 (26%)	57 (62%)	11 (12%)	0.172	19 (19%)	75 (77%)	4 (4%)	0.395
Frontal	1 (6%)	12 (75%)	3 (19%)		2 (9%)	20 (91%)	0 (0%)	
MAN								
Temporal	5 (5%)	74 (80%)	13 (14%)	0.212	11 (11%)	78 (80%)	9 (9%)	0.595
Frontal	2 (12%)	10 (63%)	4 (25%)		1 (5%)	20 (91%)	1 (4%)	

Change categories (improve, no change, decline) determined by one standard deviation change (10 t-score points) in either direction, SOM=Somatic Complaints, ANX=Anxiety, ARD=Anxiety Related Disorders, DEP=Depression, MAN=Mania.