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ORIGINAL ARTICLE

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# Surgical treatment may improve depressive and hysterical traits in temporal lobe epilepsy with hippocampal sclerosis: Study using the Minnesota Multiphasic Personality Inventory

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## Abstract

**Aim:** The influence of surgeries on psychiatric symptoms and personality traits is not well known in patients with intractable temporal lobe epilepsy (TLE). We investigated changes in personality traits with respect to postoperative seizure outcomes, etiology, side of surgery, and sex differences.

**Methods:** Clinical information was retrospectively collected for 44 patients whose Minnesota Multiphasic Personality Inventory (MMPI) was examined before and 1 year after surgical treatment for drug-resistant TLE. Postoperative changes in MMPI *T*-scores were analyzed using a paired *t*-test. Participants were divided into two groups based on postoperative seizure outcome, the presence or absence of hippocampal sclerosis (HS) as the etiology, side of surgery, and sex differences. The effect of these clinical factors on postoperative changes in MMPI *T*-scores was evaluated using analysis of covariance (*P*-values < 0.05).

**Results:** The hypochondria (Hs) scale decreased significantly in all patients ($p = 0.022$). The postoperative seizure-free group had a significant decrease in the depression (D) scale ($p = 0.037$). The HS group had significant decreases in the D scale and the hysteria (Hy) scale ($p = 0.016$ and 0.004, respectively), and a significant increase in the masculinity-femininity (Mf) scale ($p = 0.009$). No significant differences existed between the sides of surgery or sex.

**Conclusion:** Depressive traits were improved in patients with postoperative seizure freedom. Depressive and hysterical traits were improved in patients with HS, which may be attributed to a reduction in anxiety and fear associated with aura. Most personality traits are not significantly changed or exacerbated by surgical treatment of TLE.

KEYWORDS

depression, epilepsy surgery, hysteria, personality traits, psychiatric complication

## INTRODUCTION

Surgery is considered for intractable epilepsy when long-term seizure control is difficult with pharmacotherapy. Surgical treatment for epilepsy may cause a decline in cognitive function postoperatively. The risk of postoperative functional impairment must be assessed through neuropsychological testing and the presence or absence of changes in cognitive function must be confirmed postoperatively. Many studies have reported on changes in intellectual and memory functions after epilepsy surgery; however, the evaluation of personality changes is not standard practice.

The Minnesota Multiphasic Personality Inventory (MMPI) is a psychological test that captures personality traits. It was originally developed to objectively perform psychiatric differential diagnosis, but this proved difficult. Currently, it is used to interpret and analyze patients' tendencies toward psychosis, mood disorders, neurosis, and such. Geschwind syndrome is well known for the interictal personality traits and behavioral abnormalities observed in patients with temporal lobe epilepsy (TLE).[1–3] However, in current clinical practice, some people deny the existence of an epileptic personality, and personality traits specific to TLE have not been demonstrated.[4,5] Similar to intelligence and memory tests, there have been previous reports comparing the postoperative changes in MMPI between the left and right hemispheres.[6] However, no clear changes with surgery or relationship with postoperative psychiatric disorders have been demonstrated.

Anxiety about seizures and their frequency significantly affects patients' quality of life. Depression is the most common psychiatric symptom associated with epilepsy.[7] A temporary depressive state can occur after epilepsy surgery,[8] but there are many reports of postoperative seizure freedom leading to improvement in depression once the subacute effects of surgery are gone.[9–11] In surgical treatment of TLE, depression is reportedly more likely to occur after left-sided resection,[12,13] and other reports indicate that post-operative psychosis is more likely to occur after right-sided resection.[14–16] This suggests a relationship between the side of surgery and psychiatric symptoms. Manic states and hallucinatory-delusional states are known pathological conditions similar to postoperative psychosis.[14,17] The hippocampus and amygdala, located in the medial temporal lobe, are part of the limbic system involved in emotion, memory, and drive. These structures have attracted attention as hypotheses for the etiology of depression, panic disorder, and anxiety disorder.[18–20] It has been reported that hippocampal sclerosis (HS) in TLE causes dysfunction of the medial temporal lobe and is a risk factor for depression,[21,22] and that the patients with preoperative anxiety and personality disorders have a higher rate of postoperative non-seizure freedom in surgery for medial TLE (MTLE) with HS.[23] This suggests that HS is closely related to psychiatric symptoms and postoperative seizure outcome, which is a factor in personality change.

Therefore, factors such as postoperative seizure outcome, etiology, the side of surgery, and sex differences are expected to differentially influence postoperative psychiatric symptoms and personality traits. Focusing on MMPI in surgical cases of TLE, this study aimed to clarify the effects of the surgical treatment of epilepsy on psychiatric symptoms, personality traits, and related factors.

## METHODS

### Participants

This study included patients with intractable TLE who underwent resective epilepsy surgery at the National Center of Neurology and Psychiatry between April 2015 and March 2020; and for whom MMPI had been performed preoperatively and 1 year post-operatively. Clinical information was obtained retrospectively from medical records. The clinical information obtained is as follows: sex, etiology, psychiatric history, side of surgery, presence or absence of aura, age at onset of epilepsy, age at surgery, duration of epilepsy, full-scale IQ on preoperative Wechsler Adult Intelligence Scale-Third Edition (WAIS-III), general memory on preoperative Wechsler Memory Scale-Revised (WMS-R), MMPI before and 1 year after surgery, and postoperative seizure outcome at 1 year. Seizure outcomes were classified based on the International League Against Epilepsy (ILAE) outcome classification.[24] Patients under 15 years of age, who are not covered by the New Japanese version of the MMPI, were excluded. A total of 86 patients underwent resective epilepsy surgery for intractable TLE during the study period. In 42 cases, MMPI could not be obtained 1 year postoperatively due to reasons such as referral to others or the end of consultation; excluding these cases, 44 patients were retained in the study.

### MMPI

The MMPI consists of 10 clinical scales and four validity scales. For clinical scales, the hypochondria (Hs), depression (D), hysteria (Hy), psychopathic deviate (Pd), masculinity-femininity (Mf), paranoia (Pa), psychasthenia (Pt), schizophrenia (Sc), hypomania (Ma), and social introversion (Si) scales were included; for validity scales, the cannot say ("?"), lie (L), frequency (F), and correction (K) scales were included. Subjects were not excluded based on the validity scales. The K scale, one of the four validity scales, was used to eliminate the influence of the defensive attitude on the scores.[25] The Hs, Pd, Pt, Sc, and Ma scales are corrected using the raw score of the K scale, according to the formula Hs + 0.5 K, Pd + 0.4 K, Pt + 1.0 K, Sc + 1.0 K, Ma + 0.2K.[25] Also in this study, these scales were corrected by the K scale to increase the accuracy of the clinical scales. The raw scores for each scale were then converted to *T*-scores: $T = 50 + 10 \times (X - M)/SD$, in which X denoted the raw score of a certain scale, M was the average raw scores of the standardization group, and SD was the standard deviation of the raw score of the standardization group. The *T*-score is the score obtained by converting the raw score into a distribution with an average of 50 and a standard deviation of 10. In general, scores above $T = 60$ are considered high, scores above $T = 70$ are considered fairly high, and scores below $T = 45$ are considered low.[26]

**TABLE 1** Patient characteristics.

| | |
|---|---|
| Male, *n* (%) | 20 (45.4%) |
| Onset of epilepsy, years (SD) | 15.3 (9.8) |
| Duration of epilepsy, years (SD) | 18.0 (12.3) |
| Mean age at surgery, years (SD) | 33.3 (11.4) |
| FSIQ on preoperative WAIS-III (SD) | 89.2 (14.7) |
| General memory on preoperative WMS-R (SD) | 90.2 (17.8) |
| Left side of the surgery, *n* (%) | 23 (52.2%) |
| Etiology of epilepsy, *n* (%) | |
| Hippocampal sclerosis | 26 (59.0%) |
| Cortical dysplasia | 8 (18.1%) |
| Cavernous hemangioma | 3 (6.8%) |
| Brain tumor | 3 (6.8%) |
| Encephalocele | 2 (4.5%) |
| Arteriovenous malformation | 1 (2.2%) |
| Unknown | 1 (2.2%) |
| Psychiatric history, *n* (%) | |
| Depression | 2 (4.5%) |
| Schizophrenia | 4 (9.0%) |
| Psychogenic non-epileptic seizures | 1 (2.2%) |
| Postoperative seizure outcome at 1 year, *n* (%) | |
| Class 1 | 32 (72.7%) |
| Class 2 | 1 (2.2%) |
| Class 3 | 6 (13.6%) |
| Class 4 | 4 (9.0%) |
| Class 5 | 1 (2.2%) |
| Class 6 | 0 |

*Note*: The postoperative seizure outcome was evaluated using the International League Against Epilepsy outcome classification.

Abbreviations: FSIQ, full-scale intelligence quotient; SD, standard deviation; WAIS-III, Wechsler Adult Intelligence Scale-Third Edition; WMS-R, Wechsler Memory Scale-Revised.

## Statistical analyses

The participants were divided into two groups according to the presence or absence of seizure freedom 1 year postoperatively, the presence or absence of HS as the etiology, the left or right side of the surgery, and sex differences. Differences between pre- and postoperative *T*-scores for all cases and each group were evaluated using a paired *t*-test. Analysis of covariance between two groups within each of the following was performed using preoperative *T*-score as the covariate and *T*-score change (postoperative *T*-score – preoperative *T*-score) as the objective variable: postoperative seizure outcome (seizure free or not), etiology (HS or non-HS), the side of surgery (left or right), and sex (male or female). The regression lines for the two groups were confirmed to be parallel.

**TABLE 2** Postoperative outcome of aura and seizure outcome in the HS and NHS groups.

| | HS (*n* = 26) | NHS (*n* = 18) |
|---|---|---|
| Preoperative presence of aura, *n* (%) | 26 (100%) | 9 (50.0%) |
| Postoperative disappearance of aura at 1 year, *n* (%) | 23 (88.4%) | 5 (55.5%) |
| Postoperative seizure outcome at 1 year, *n* (%) | | |
| Class 1 | 23 (88.4%) | 9 (50.0%) |
| Class 2 | 0 | 1 (5.5%) |
| Class 3 | 3 (11.5%) | 3 (16.6%) |
| Class 4 | 0 | 4 (22.2%) |
| Class 5 | 0 | 1 (5.5%) |
| Class 6 | 0 | 0 |

Abbreviations: HS, hippocampal sclerosis; NHS, non-hippocampal sclerosis.

All statistical analyses were performed using R Version 4.2.1 (http://www.R-project.org/), and *p*-values < 0.05 were considered significant.

To examine the clinical significance of the results, $T \geq 60$ was defined as abnormal. We noted postoperative increases and decreases in the number of patients with abnormal *T*-scores for each clinical scale. We further investigated the increase or decrease in the number of cases exhibiting abnormal values for which there were significant differences in covariance analysis between the two groups.

# RESULTS

## Patient background and clinical information

The clinical characteristics of the patients are summarized in Table 1. Twenty patients (45.4%) were male, 23 patients (52.2%) had left-sided surgery, and 26 patients (59.0%) had HS as etiology. The etiologies other than HS included cortical dysplasia, cavernous hemangioma, brain tumor, encephalocele, and arteriovenous malformation. These lesions were all located in the extra-hippocampal region. The hippocampus was removed in all patients with HS but was done only in three patients with other etiologies. All patients in the HS group underwent anterior temporal lobectomy with amygdalohippocampectomy (ATL) or selective amygdalohippocampectomy (SAH). Lesionectomy, focal cortical resection, anterior temporal lobectomy sparing hippocampus, and anterior temporal lobectomy with hippocampectomy were performed in five, four, six, and three patients, respectively, in the non-HS (NHS) group. Psychiatric history included depression in two patients, schizophrenia in four patients, and psychogenic non-epileptic seizures in one patient, all in the HS group. There was no psychiatric history in the NHS group. One year postoperatively, 32 patients (72.7%) had no seizures (ILAE Class 1). Table 2 summarizes the postoperative outcome of aura in the HS and NHS groups. All patients in the HS group had aura preoperatively and all seizures, including aura, resolved postoperatively in 88.4% of the patients.

**TABLE 3** Pre- and postoperative average *T*-scores of each MMPI scale for all patients.

| MMPI scales | Preoperative *T*-scores ± SE | Postoperative *T*-scores ± SE | *p* value |
|---|---|---|---|
| Hs | 55.1 ± 1.65 | 52.4 ± 1.64 | 0.022* |
| D | 60.7 ± 1.70 | 59.3 ± 1.71 | 0.322 |
| Hy | 57.4 ± 1.65 | 56.6 ± 1.52 | 0.598 |
| Pd | 51.0 ± 1.70 | 53.2 ± 1.68 | 0.142 |
| Mf | 50.1 ± 1.48 | 50.4 ± 1.54 | 0.741 |
| Pa | 53.5 ± 1.51 | 54.1 ± 1.89 | 0.749 |
| Pt | 54.7 ± 1.68 | 53.5 ± 1.77 | 0.546 |
| Sc | 56.6 ± 1.74 | 55.0 ± 1.94 | 0.389 |
| Ma | 53.3 ± 1.42 | 52.7 ± 1.53 | 0.625 |
| Si | 52.7 ± 1.47 | 51.0 ± 1.65 | 0.146 |
| ? | 54.5 ± 2.20 | 54.8 ± 1.93 | 0.886 |
| L | 54.4 ± 1.61 | 57.6 ± 1.41 | 0.115 |
| F | 55.7 ± 2.17 | 54.6 ± 2.11 | 0.615 |
| K | 49.6 ± 1.53 | 51.8 ± 1.66 | 0.201 |

Abbreviations: ?, cannot say; D, depression; F, frequency; Hs, hypochondria; Hy, hysteria; K, correction; L, lie; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; SE, standard error; Si, social introversion.

*$p < 0.05$.

**TABLE 4** Number of cases with *T*-scores of 60 or higher before and after surgery for each clinical scale.

| MMPI scales | Preoperative, *n* (%) | Postoperative, *n* (%) |
|---|---|---|
| **Hs** | 17 (38.6%) | 14 (31.8%) |
| **D** | 24 (54.4%) | 21 (47.7%) |
| **Hy** | 19 (43.1%) | 17 (38.6%) |
| **Pd** | 10 (22.7%) | 14 (31.8%) |
| **Mf** | 6 (13.6%) | 12 (27.2%) |
| **Pa** | 8 (18.1%) | 13 (29.5%) |
| **Pt** | 14 (31.8%) | 14 (31.8%) |
| **Sc** | 17 (38.6%) | 14 (31.8%) |
| **Ma** | 11 (25.0%) | 12 (27.2%) |
| **Si** | 11 (25.0%) | 9 (20.4%) |

Abbreviations: D, depression; Hs, hypochondria; Hy, hysteria; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; Si, social introversion.

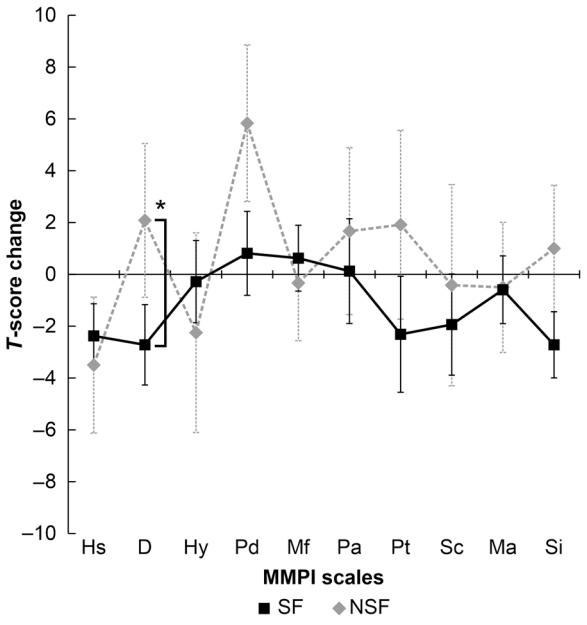


**FIGURE 1** Pre- and 1-year postoperative changes in *T*-scores on the Minnesota Multiphasic Personality Inventory (MMPI) clinical scale for the seizure-free (SF) and non-seizure-free (NSF) groups. The postoperative decrease in the D scale was significantly greater in the SF group than in the NSF group ($p = 0.037$). Pd scale *T*-score tended to increase postoperatively in the NSF group ($p = 0.063$). Error bars indicate standard error. *$p < 0.05$. D, depression; Hs, hypochondria; Hy, hysteria; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; Si, social introversion.

## Changes in *T*-score after surgical treatment

Table 3 shows the pre- and postoperative average *T*-scores for all patients. The mean preoperative D scale was >60. The *T*-scores decreased significantly on the Hs scale ($p = 0.022$). Table 4 shows the pre- and postoperative number and proportion (%) of cases with abnormal *T*-score ($T \geq 60$) for each clinical scale. The preoperative D

**TABLE 5** Mean *T*-scores on clinical scales before and after surgery in the SF and NSF groups.

| MMPI scales | | Preoperative *T*-scores ± SE | Postoperative *T*-scores ± SE |
|---|---|---|---|
| **Hs** | SF | 53.8 ± 1.81 | 51.4 ± 1.87 |
| | NSF | 58.5 ± 3.58 | 55.0 ± 3.37 |
| **D** | SF | 59.8 ± 1.82 | 57.1 ± 1.73 |
| | NSF | 63.3 ± 3.98 | 65.4 ± 3.86 |
| **Hy** | SF | 56.2 ± 2.06 | 55.9 ± 1.80 |
| | NSF | 60.8 ± 2.43 | 58.5 ± 2.87 |
| **Pd** | SF | 50.7 ± 1.79 | 51.5 ± 1.87 |
| | NSF | 52.0 ± 4.13 | 57.8 ± 3.40 |
| **Mf** | SF | 51.1 ± 1.57 | 51.8 ± 1.67 |
| | NSF | 47.2 ± 3.46 | 46.9 ± 3.41 |
| **Pa** | SF | 54.3 ± 1.74 | 54.4 ± 2.37 |
| | NSF | 51.6 ± 3.05 | 53.3 ± 3.02 |
| **Pt** | SF | 54.4 ± 1.99 | 52.0 ± 1.91 |
| | NSF | 55.6 ± 2.86 | 57.5 ± 3.92 |
| **Sc** | SF | 55.8 ± 2.11 | 53.9 ± 2.27 |
| | NSF | 58.5 ± 3.10 | 58.1 ± 3.80 |
| **Ma** | SF | 52.4 ± 1.71 | 51.8 ± 1.81 |
| | NSF | 55.7 ± 2.49 | 55.2 ± 2.91 |
| **Si** | SF | 52.9 ± 1.72 | 50.2 ± 1.83 |
| | NSF | 52.1 ± 2.94 | 53.1 ± 3.67 |

Abbreviations: D, depression; Hs, hypochondria; Hy, hysteria; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; NSF, non-seizure free; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; SF, seizure free; Si, social introversion.

scale was abnormal in more than half of the patients, as many patients showed a tendency toward depression preoperatively. The preoperative Hy scale was abnormal in 43.1% of the patients.

## The effect of postoperative seizure outcome on the change in *T*-score

Figure 1 shows the results of covariance analysis regarding postoperative seizure freedom. Postoperative decrease in the D scale *T*-scores was significantly greater in the seizure-free (SF) group than in the non-seizure-free (NSF) group ($p = 0.037$). Table 5 shows the pre- and postoperative mean *T*-scores in the SF and NSF groups. The number of cases with abnormal *T*-score on the D scale went from 15 (46.8%) to 13 (40.6%) in the SF group, compared to nine (75.0%) to eight (66.6%) in the NSF group.

## The effect of etiology on the change in *T*-score

Figure 2 shows the results of covariance analysis regarding the presence or absence of HS. The postoperative decrease in the D scale ($p = 0.016$), decrease in the Hy scale ($p = 0.004$), and increase in the Mf scale ($p = 0.009$) was significantly greater in the HS group than in the NHS group. Table 6 shows the pre- and postoperative average *T*-scores in the HS and NHS groups. The number of cases with abnormal *T*-score on the D scale went from 14 (53.8%) to 10 (38.4%) in the HS group, compared to 10 (55.5%) to 11 (61.1%) in the NHS group. The number of cases with abnormal *T*-score on the Hy scale went from nine (34.6%) to six (23.0%) in the HS group, compared to 10 (55.5%) to 11 (61.1%) in the NHS group. The number of cases with abnormal *T*-score on the Mf scale went from two (7.6%) to nine (34.6%) in the HS group, compared to four (22.2%) to three (16.6%) in the NHS group.

## The effects of the side of surgery and sex on the change in *T*-scores

Figure 3 shows the results of covariance analyses for the side of surgery. There was a tendency for *T*-scores on the right side to decrease postoperatively on the Hy scale ($p = 0.071$), though this was not statistically significant. Figure 4 shows the results of covariance analysis regarding sex differences. There were no significant differences in any of the clinical scales.

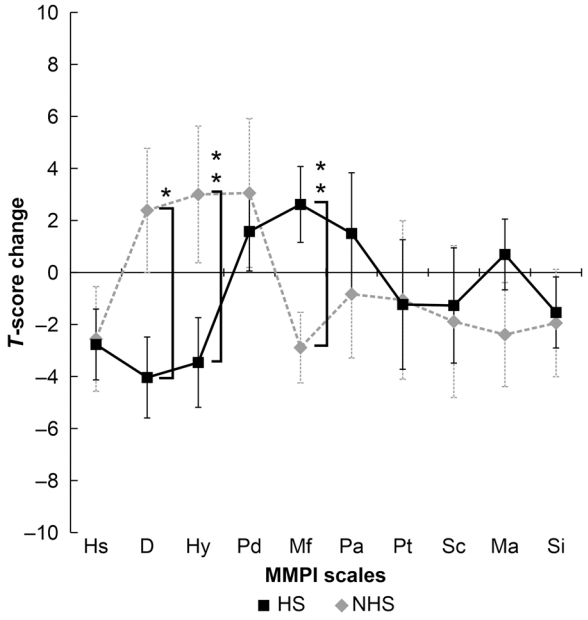


**FIGURE 2** Pre- and 1-year postoperative changes in *T*-scores on the MMPI clinical scale for the hippocampal-sclerosis (HS) and non-hippocampal-sclerosis (NHS) groups. The postoperative decrease in the D scale *T*-score and the Hy scale *T*-score was significantly greater in the HS group than in the NHS group ($p = 0.016$ and 0.004, respectively). The postoperative increase in the Mf scale *T*-score was greater in the HS group than in the NHS group ($p = 0.009$). Error bars indicate standard error. $^{*}p < 0.05$, $^{**}p < 0.01$. D, depression; Hs, hypochondria; Hy, hysteria; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; Si, social introversion.

## DISCUSSION

This study revealed that most scale results for personality traits did not change significantly after epilepsy surgery and the significant decrease in the D scale *T*-score was associated with postoperative seizure freedom. It was also shown that a significant decrease in the Hy scale *T*-score was associated with the etiology of HS. It appears that surgical treatment does not have a major effect on overall personality traits, but depressive traits improve due to the disappearance of seizures postoperatively. In addition, the alleviation of aura may improve the hysterical traits in patients with HS, because HS is often associated with aura and the aura may increase the Hy scale as a defense mechanism against anxiety and fear.

The decrease in the D scale *T*-scores was significantly greater in the patients with postoperative seizure freedom. This result is in line with previous reports suggesting that depression improves with the disappearance of seizures postoperatively.[9–11] There have been no reports of a two-group analysis using the D scale based on postoperative outcomes in TLE. Wachi et al. compared the mean clinical scales before and after surgery in the SF and NSF groups, but found no significant differences.[27] Depression is the most common mental condition that co-occurs with epilepsy. Among psychiatric complications of epilepsy requiring treatment, the proportion of depression is estimated to be 50%–75%.[7] If treatment-resistant depression is a clinical problem in TLE, depressive symptoms can be expected to improve by eliminating the seizures through surgical treatment. However, de novo or a temporary worsening of depression may occur after epilepsy surgery. Thus, postoperative depression must be evaluated carefully, as it can be severe enough to lead to suicide attempts.[8] The decrease in the D scale *T*-scores was significantly greater in the patients with HS. This likely owes to the good postoperative seizure outcome in patients with HS. The proportion of seizure-free patients was higher in the HS group (23 of 26 patients) than in the NHS group (nine of 18 patients).

The decrease in the Hy scale *T*-scores was significantly greater in the patients with HS. We hypothesized that this is related to the fact that MTLE with HS often accompanies aura in their seizure symptoms. In this study, all patients with HS had aura preoperatively, whereas only half of patients without HS did so. After surgery, 88.4% of the patients with HS became free from any seizures, including aura. We speculate that the Hy scale increases as a defense mechanism against anxiety and fear caused by physical symptoms (aura) and it decreases after surgery due to the disappearance of the aura. There are many reports on the Hy scale's association with chronic pain.[28,29] Caldwell et al.[28] hypothesized that the Hy scale increases in chronic low back pain not due to the direct effect of pain but due to psychological conflicts, such as pain fear, and that the reduction of fear by pain relief contributes to the decrease in the Hy scale. Based on this mechanism, Herron et al. reported that the Hs and Hy scales decreased by the reduction of back pain after surgery.[29] The epileptic aura is generally perceived as unpleasant emotions, such as anxiety, fear, a feeling of going crazy, and an epigastric rising sensation, and can be associated with the anxious anticipation of the coming seizure or loss of awareness. By the same mechanism, we hypothesized that the Hy scale is increased by these emotions causing psychological conflicts, and that the disappearance of aura after surgery contributed to the decrease in the Hy scale.

The increase in the Mf scale *T*-scores was significantly greater in the HS group. Because the Mf scale is interpreted differently depending on sex, it is necessary to discuss each sex separately. Postoperatively, men's *T*-scores increased by 5.7, while women's *T*-scores increased by only 0.9. The Mf scale was originally intended to identify homosexual men, and high scores in women are considered rare.[30] Basically, the more one adopts the customary sex role of the opposite sex or conflicts with one's own sex and sex role, the higher the score is. According to Ramesha et al.,[31] sexual dysfunction in male patients with MTLE caused by HS is common, but most of it is overlooked. Although some improvement is expected in the sexual dysfunction due to the reduction or disappearance of seizure frequency postoperatively, it is still considered to be inferior to the healthy control group. Sex role conflict due to persisting sexual dysfunction in men may have contributed to the increase in the postoperative Mf scale.

**TABLE 6** Mean *T*-scores on clinical scales before and after surgery in the HS and NHS groups.

| MMPI scales | | Preoperative *T*-scores ± SE | Postoperative *T*-scores ± SE |
|---|---|---|---|
| **Hs** | HS | 54.0 ± 2.03 | 51.2 ± 2.12 |
| | NHS | 56.7 ± 2.79 | 54.2 ± 2.60 |
| **D** | HS | 61.0 ± 1.92 | 57.0 ± 2.03 |
| | NHS | 60.4 ± 3.18 | 62.8 ± 2.85 |
| **Hy** | HS | 56.8 ± 2.40 | 53.4 ± 1.89 |
| | NHS | 58.3 ± 2.14 | 61.3 ± 2.11 |
| **Pd** | HS | 49.6 ± 1.92 | 51.2 ± 2.14 |
| | NHS | 53.1 ± 3.09 | 56.2 ± 2.63 |
| **Mf** | HS | 50.0 ± 1.69 | 52.6 ± 1.85 |
| | NHS | 50.2 ± 2.74 | 47.3 ± 2.54 |
| **Pa** | HS | 53.1 ± 2.16 | 54.6 ± 2.71 |
| | NHS | 54.2 ± 2.02 | 53.3 ± 2.55 |
| **Pt** | HS | 54.2 ± 2.18 | 53.0 ± 2.26 |
| | NHS | 55.4 ± 2.49 | 54.3 ± 2.90 |
| **Sc** | HS | 55.3 ± 2.39 | 54.0 ± 2.66 |
| | NHS | 58.4 ± 2.50 | 56.5 ± 2.86 |
| **Ma** | HS | 52.3 ± 1.82 | 53.0 ± 1.84 |
| | NHS | 54.7 ± 2.28 | 52.3 ± 2.72 |
| **Si** | HS | 54.3 ± 1.93 | 52.8 ± 2.03 |
| | NHS | 50.3 ± 2.21 | 48.3 ± 2.73 |

Abbreviations: D, depression; HS, hippocampal sclerosis; Hs, hypochondria; Hy, hysteria; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; NHS, non-hippocampal sclerosis; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; Si, social introversion.

The change in *T*-scores did not differ significantly between the left and right side of surgery. Similarly, Trenerry et al. compared *T*-scores between the left and right TLE surgery and found no significant differences in any of the clinical scales.[6] Quigg et al.[32] used the D scale of the MMPI in conjunction with the Clinical Depression Index (CDI) to investigate the relationship between the side of surgery and postoperative depression. Although no significant difference was observed on the D scale, CDI showed that patients may be more susceptible to depression after right-sided surgery.[32] A relationship may exist between the side of surgery and psychiatric symptoms, but no consensus has been reached. The changes in *T*-scores did not differ significantly between men and women patients. There have been no reports regarding sex differences in postoperative personality changes.

*T*-scores on the Hs scale decreased significantly postoperatively. Wachi et al.[27] reported the same result previously, but the cause was not clear. The Hs scale is said to increase as a person becomes excessively anxious about his/her own health. Previous reports indicated that depression and anxiety disorders improved after surgery for refractory TLE.[9,10] It is likely that the postoperative reduction in seizure frequency led to a reduction in anxiety about their health status. Furthermore, strong motivation is required for choosing surgical treatment. Such a decision itself may lead to acceptance of the disease and to reduction of excessive anxiety about epilepsy.

In this study, we performed a covariance analysis focusing on the postoperative changes in *T*-scores. The group-wise comparison may not elucidate the clinical significance of the change itself. This was a retrospective study conducted at a single institution with a small number of patients. In particular, many cases were excluded because of the loss to follow-up, so caution is needed when generalizing the study results. In the future, it is hoped that a multicenter prospective study will verify the validity of the results of this study. The lack of multivariate analysis was also a limitation of this study, and future studies should investigate the multivariate analysis with a larger sample size. Personality change might require a longer time, so it was a limitation in this study that its changes were analyzed only at 1 year postoperatively. Future follow-up studies with longer time periods might generate new evidence.

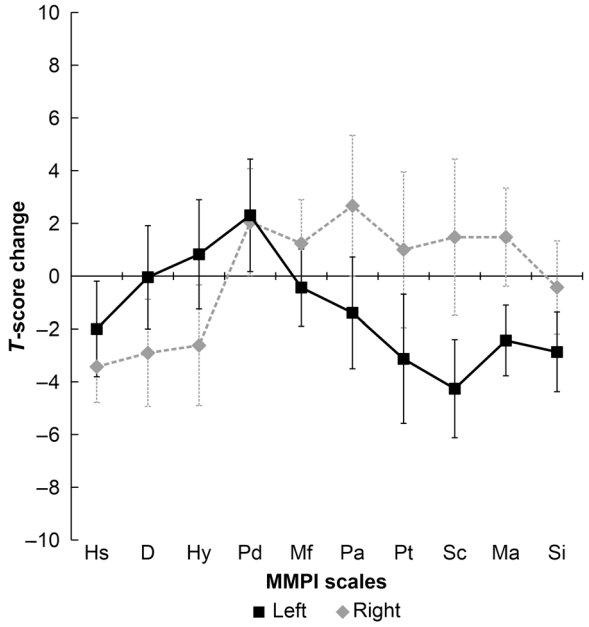


**FIGURE 3** Pre- and 1-year postoperative *T*-score change on the MMPI clinical scale for the left or right group. There was a trend toward a postoperative decrease in the Hy scale *T*-score on the right side ($p = 0.071$). Error bars indicate standard error. D, depression; Hs, hypochondria; Hy, hysteria; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; Si, social introversion.

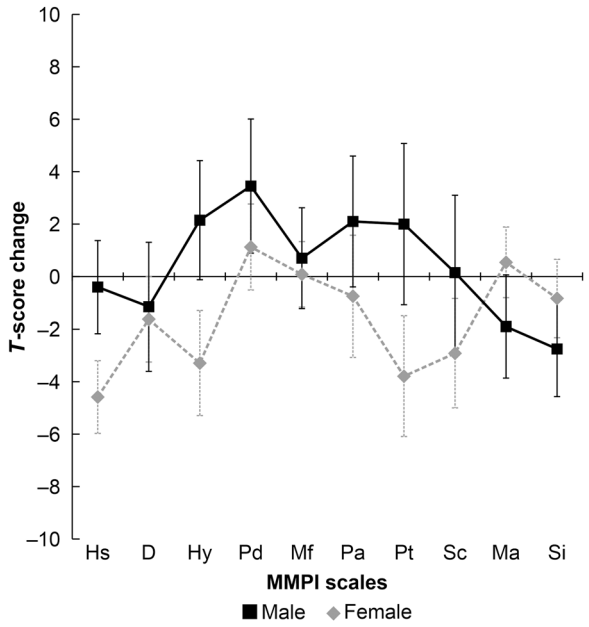


**FIGURE 4** Pre- and 1-year postoperative *T*-score change on the MMPI clinical scale for the male or female group. No significant differences were found in any of the clinical scales. Error bars indicate standard error. D, depression; Hs, hypochondria; Hy, hysteria; Ma, hypomania; Mf, masculinity-femininity; MMPI, Minnesota Multiphasic Personality Inventory; Pa, paranoia; Pd, psychopathic deviate; Pt, psychasthenia; Sc, schizophrenia; Si, social introversion.

## AUTHOR CONTRIBUTIONS

Masaki Iwasaki, the corresponding author of the work, certifies that all authors have participated sufficiently in the conception and design of the work and were involved in the acquisition of data. All of them have also participated in the analysis and interpretation of the data, as well as drafting the manuscript. All authors also revised the work and contributed to the final approval of the version for publication. Each author also agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. While each author was involved in all the aspects above, specific authors carried a greater burden of responsibility as follows: Hiroyuki Otabe and Masaki Iwasaki developed the study concept and design of the work, recruited patients and acquired data, statistically interpreted the data, produced the figures, and drafted the article. Masaki Iwasaki critically revised the work for important intellectual content and supervised the research.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to the necessary de-identification processes and obtaining the appropriate patient consent.

## ETHICS APPROVAL STATEMENT

The study was approved by the Ethics Committee of the National Center of Neurology and Psychiatry, Tokyo, Japan (No. A2018-092).

## PATIENT CONSENT STATEMENT

Written informed consent was waived because of the retrospective study design.

## CLINICAL TRIAL REGISTRATION

N/A.

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