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Parietal Cortex Volume and Functions in Major Depression and Bipolar Disorder: A Cloud-Based Magnetic Resonans Imaging Study

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ABSTRACT

Introduction: The present study aimed to compare the Parietal Lobe (PL) volumes and Cancellation Test (CT) performances of euthymic patients with Bipolar Disorder-1 (BD) and Major Depressive Disorder (MDD), and healthy controls.

Methods: The present study included 63 participants in three groups; two patient groups in remission involving patients with BD and MDD diagnosed according to DSM-5 and a control group with healthy individuals. Sociodemographic Data Form, CT, and Hand Preference Questionnaire were applied to all participants. Participant PL volumes were measured with the Cloud-Based Brain Magnetic Resonance Image Segmentation – Parcellation System.

Results: Both patient groups exhibited lower PL volume when compared to the control group, and there was no difference between the patient groups based on PL volume. It was determined that MDD and BB patients scored less in the CT when compared to the control group. There was a weak correlation between right and left PL volumes and CT performances.

Conclusion: The present study findings demonstrated that BD and MDD patients in remission exhibited lower PL volume and CT performance when compared to healthy controls, emphasizing that PL could be structurally and functionally significant in the pathophysiology of mood disorders.

Keywords: Bipolar disorder, depression, neuropsychological test, parietal lobe volume

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INTRODUCTION

Parietal Lobe (PL) has been increasingly studied to elucidate the etiology of psychiatric diseases in recent years (1). As a part of adaptive control, PL was associated with cognitive functions of major cognitive, attention and work memory regions (2). Several studies analyzed the functions and the anatomy of PL in mood disorders (MD). Neurocognitive tests demonstrated that working memory, visuospatial attention and problem-solving ability deteriorated during the manic period, and episodic memory deteriorated during the depressive period in bipolar disorder (BD) (3). Atypical functional cerebral asymmetry and impairment in visuospatial attention were identified in the right frontoparietal lobe during the euthymic period in BD patients (4,5). The deterioration in visual-spatial planning in BD and major depressive disorder (MDD) was associated with low parietal activity. Studies conducted with functional magnetic resonance imaging (fMRI) demonstrated that this deterioration was more common in MDD and BD patients when compared to healthy individuals, and it was more prevalent in BD patients when compared to the MDD patients (6). The correlations between PL and attention and working memory have been emphasized in several studies. The results of the selective attention tests conducted in these studies suggested that the right frontal and parietal regions were associated with selective attention; and thus, BD (2,7,8). Similarly, it has been known that the posterior parietal lobe was associated with attention and memory, and these parameters were significantly different in MDD and BD patients when compared to healthy individuals (9).

Highlights

- **Parietal lobe (PL) volume is decreased in Bipolar Disorder (BD) and Major Depressive Disorder (MDD).**
- **The decrease in PL volume may not be episode-specific but permanent.**
- **Decreased PL volume may be associated with worsening of Cancellation Test performance.**

It was suggested that the persistence of cognitive deficits after recovery could be associated with neuroanatomical changes in MD (10). It was demonstrated that depressive and manic episodes led to neural function and glial cell changes (11,12). Due to the above-mentioned factors, the parietal lobe could be associated with the etiopathogenesis of BD and MDD. However, no previous study investigated this hypothesis in patients in remission. Thus, the present study aimed to compare PL volume and functions in BD and MDD patients and healthy controls and cross-sectionally analyze whether there was a correlation between the PL volume and cognitive functions of these patients.

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METHODS

The study sample included BD and MDD patients in remission and healthy individuals. Patients who were presented to Inonu University Psychiatry Outpatient Clinic between 01/03/2020–30/06/2020, were diagnosed with BD or MDD and met the euthymic BD-1 and MDD remission criteria based on Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) and the evaluation of a psychiatrist (13). The control group included healthcare professionals with similar age, gender, education and hand preference of the patient group and without any known psychiatric disorder.

Patients who were between 18 and 65 years old, literate, without alcohol-substance addiction that required detoxification, any additional psychiatric diagnosis, a history of an intracranial space occupying lesion, or a known neurological disease such as stroke, epilepsy, or multiple sclerosis, or any implant that could prevent an MRI scan (pacemaker, stent, prosthesis, implant, etc.), without a history of loss of consciousness for more than 10 minutes due to head trauma were included in the study. The patients included euthymic patients who had experienced at least one episode of illness and were continuing their medical treatment.

Sample size analysis demonstrated that at least 21 participants should be included in the groups when the effect size was predicted as 0.41 to compare the PL volumes of the BD, MDD and control groups within 95% confidence level (alpha=0.05) and 80% power (beta=0.20). Thus, 63 participants were included in the study (21 in each group).

All participants signed the informed consent form, and the study complied with the Declaration of Helsinki ethical principles. The study protocol was approved by the Malatya Clinical Research Ethics Committee on 19/02/2020 (No: 2020/39).

Data Collection

The sociodemographic data form and the cancellation test (CT) that aims to determine the PL function were applied to all groups by a psychiatrist within 30–45 minutes. Furthermore, a hand preference questionnaire was applied to all participants by the interviewer (14). It was determined that the right hand was dominant in all participants.

Cloud-Based Brain Magnetic Resonance Image Segmentation-Parceling System Imaging

Magnetic resonance imaging procedures were conducted with a 3 Tesla MRI device (Siemens Skyra, Erlangen, Germany) and a 32-channel head-neck coil in the İnönü University Turgut Özal Medical Center Radiology Department. Participants were advised to remain still during imaging to avoid incorrect measurements. Axial T2-weighted FLAIR sequence (TR: 3510 ms, TE: 100 ms, slice thickness: 4 mm, matrix: 203×320, FOV: 225 mm) was employed in the initial imaging to exclude parenchymal pathologies (tumor, infarct, vascular malformation, etc.), and in the next stage, sagittal T1-weighted 3D MPRAGE (Magnetization Prepared Rapid Acquisition Gradient Echo) sequence was conducted for volumetric analysis (TR: 2300 ms, TE: 2.32 ms, FOV: 240 mm, matrix: 256×256, slice thickness: 0.9 mm) (Figure 1). Average imaging time was 6 minutes 26 seconds. The volumetric data was transferred from the main device console to a personal computer through an external memory, and the guide (hdr) and image (img) analysis formats were recorded on a software (DtiStudio) for each participant.

In the study, parietal lobe measurements were conducted with the MRICloud method. MRICloud is a neuroinformatic platform with high processing capacity, and could provide automatic brain MRI segmentation and quantitative analysis measurements (15). MRICloud was preferred due to its practicality, and the fact it does not require the determination of anatomical limits and correction of the total head volume as in manual volume measurement methods (15). The formats developed for each participant were loaded into a free network-based module (www.mricloud.org) that automatically analyzed the template images volumetrically on the remote interface. The volumetric findings that were calculated at five different cranial levels were saved in individual files (Figure 1).

Sociodemographic Data Form

The sociodemographic data form developed by the authors included data on participant age, gender, marital status, education level, employment, family type, income level, smoking/alcohol/substance use, anamnesis data on psychiatric illnesses in the family, neurological disease, head trauma, dominant hand, the duration of a current psychiatric illness (if any), the age of onset of the disease, hospitalization history, drug use, and manic/depressive episode history.

Cancellation Test

The Neuropsychological Test for Cognitive Function (NPTCF) battery is a neuropsychological test that evaluates right PL functions (16,17). Thus, the cancellation test (CT) was preferred to analyze the PL function in our study. Weintraub and Mesulam developed CT in 1985 (18). The reliability of the Turkish version of the CT was conducted by Cantez et al. (19) on adults, and its standardization was reviewed based on the NPTCF battery (16). Cancellation test was applied based on the application and scoring guidelines that were standardized by the above-mentioned studies (20).

Cancellation test included three subcomponents: motor, sensory and motivational. The motor component was associated with the scan and discovery of stimuli, the sensory component was associated with perceptual errors, and the motivational component was associated with emotional traits (16). The motor component was abbreviated as CT1 and indicates the number of marked targets. The motor component includes scanning for and finding spatial stimuli. The sensory component was abbreviated as CT2, CT3 and CT4. CT2 indicates the number of missed targets, CT3 indicates the number of incorrectly marked targets, and CT4 indicates the total number of errors. Sensory disorders could lead to spatial perception distortions and inability to recognize stimuli, and deterioration in scanning and orientation abilities. The motivational component, abbreviated as CT5, indicates scanning period scores. This component was associated with the emotional value of spatial events (17).

Cancellation test includes four subtests on A4 size sheets: regular letters, irregular letters, regular shapes and irregular shapes. CT1, CT2, CT3, CT4 and CT5 scores are calculated for the test. Cancellation test administration usually takes about 20 minutes.

Statistical Analysis

Following the control of the data collected through data forms, statistical analyses were performed using IBM Statistical Package for Social Sciences (SPSS) program version 23.0 software (Statistical Product and Service Solutions for Windows, Version 23.0, IBM Corp., Armonk, NY, US, 2015). Descriptive statistics are presented as mean±standard deviation for numerical variables that exhibited normal distribution, median and minimum-maximum values for numerical variables that did not exhibit normal distribution and counts and percentages for categorical variables. The normal distribution of the numerical variables was determined with the Kolmogorov-Smirnov test. In pairwise comparisons, the t-test or Mann-Whitney U test was employed for continuous variables based on the distribution of the data, and the chi-square test was used for discontinuous variables. In the comparison of more than two groups, a one-way analysis of variance or Kruskal-Wallis analysis of variance was employed based on the distribution of the data. Furthermore, inter-group PL volume comparisons were analyzed with generalized linear models, where total brain volume was accepted as the confounding variable (controlled for the PL volume/total cranial volume) to avoid bias. Also,

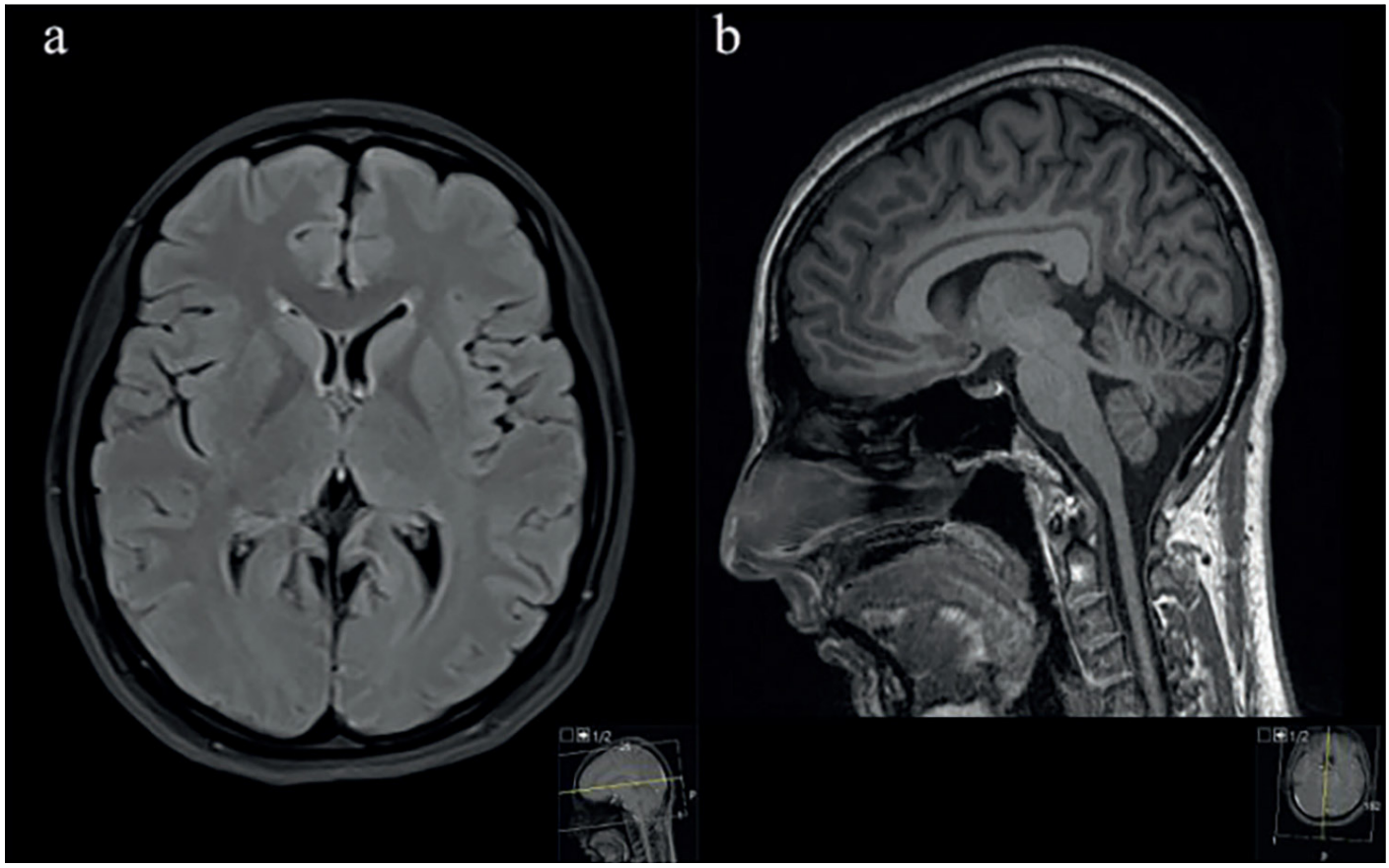

Figure 1. Axial T2 FLAIR **(a)**, sagittal T1 MPRAGE (Magnetisation Prepared Rapid Acquisition Gradient Echo) **(b)** volumetric images.

Pearson correlation analysis or Spearman Rho correlation coefficient was employed to determine the correlations between the variables. In all analyses, p<0.05 was accepted as statistically significant.

RESULTS

The study was conducted with 63 participants, 21 in each group. The mean participant age was 41.95±13.3, 42.86±14.6 and 39.29±8.5 in the BD, MDD and control groups, respectively. Each group included 11 (52.54%) female and 10 (47.6%) male participants. There was no significant difference between the groups based on age and gender. Nineteen (90.5%) patients with BD received combined therapy, 13 (57%) patients with MDD received antidepressant monotherapy and eight (38.2%) combined therapy. The number of patients with BD who experienced 2–5 depressive episodes was 13 (62%) and 14 (66.7%) patients experienced 2–5 manic episodes, 10 (47.6%) patients with MDD experienced a single episode. The distribution of the sociodemographic and psychiatric disease variables is presented in Table 1.

It was determined that the PL volumes in both hemispheres were significantly lower in BD and MDD patient groups when compared to the control group (p=0.015 for right PL volume; p=0.001 for left PL volume). There was no significant difference between the patient groups based on the PL volume (Table 2).

Including total brain volume as a confounding variable, the left PL volume was significantly smaller in the BD and depressed patient groups than in the control group (p<0.001 and p=0.001, respectively). Left PL volume was similar in BD and depression patient groups (p=0.494). When total brain volume was taken as the confounding variable, the right PL volumes were significantly lower in BD and depression patients when compared to the right PL volume in the control group (p<0.001 and p=0.007, respectively). Left PL volumes were similar in BD and depression patient groups (p=0.157) (Table 2, Table 2.1 and Table 2.2). When total brain volume was taken as the confounding variable (controlled for the PL volume/total brain volume), no significant differences were observed in PL volume in inter-group comparisons.

It was observed that the median CT1 and total CT1 regular letter, regular shape, and irregular letter subtest scores were significantly lower in the BD group when compared to the control group (p<0.05). Also, the median CT1 irregular shape subtest score was significantly lower in the MDD group when compared to the control group (p=0.01).

It was determined that the median CT2 and CT4 regular letter, regular shape and irregular letter subtest scores were significantly higher in the BD group when compared to the control group (p<0.05), CT2 irregular shape and CT4 regular and irregular shape subtest scores were significantly higher in MDD patients when compared to the control group. Median CT5 and total CT5 regular letter, regular shape, irregular letter and irregular shape subtest scores were higher in BD and MDD patients when compared to the control group (p<0.05). It was determined that there was a deterioration in the motivational component in the BD and MDD groups when compared to the control group. However, no statistically significant difference was determined between the CT scores of the patient groups (Table 3).

It was determined that there was a weak and negative correlation between the right PL volume of the patients and the median CT5 and total CT5 scores in all subtests. A weak significant and negative correlation was determined between the left PL volume of the patients and the median

Table 1. Participant demographics and psychiatric disorders

		BD	MDD	Control	p[a]
Age (Mean ± SD)		41.95±13.3	42.86±14.6	39.29±8.5	0.630
		n (%)	n (%)	n (%)	p[b]
Gender	Female	11 (52.4%)	11 (52.4%)	11 (52.4%)	1.000
	Male	10 (47.6%)	10 (47.6%)	10 (47.6%)	
Employment	Yes	16 (76.2%)	14 (66.7%)	2 (9.5%)	0.001
	No	5 (23.8%)	7 (33.3%)	19 (90.5%)	
Edcuation	Literate	2 (9.5%)	2 (9.5%)	0	0.189
	Primary school	6 (28.6%)	4 (19.0%)	1 (4.8%)	
	Junior high school	1 (4.8%)	4 (19.0%)	1 (4.8%)	
	High school	4 (19.0%)	4 (19.0%)	6 (28.6%)	
	College	8 (38.2%)	7 (33.3%)	13 (61.9%)	
Marital status	Married	12 (57.1%)	11 (52.4%)	15 (71.4%)	0.323
	Unmarried	8 (38.1%)	6 (28.6%)	3 (14.3%)	
	Widowed	1 (4.8%)	4 (19.0%)	3 (14.3%)	
Family history	Yes	8 (38.1%)	7 (33.3%)	4 (19.0%)	0.478
	No	13 (61.9%)	14 (66.7%)	17 (81.0%)	
Smoking	Yes	11 (52.4%)	7 (33.3%)	13 (61.9%)	0.169
	No	10 (47.6%)	14 (66.7%)	8 (38.1%)	
Dominant hand	Right	21 (100%)	21 (100%)	21 (100%)	1.000
	Left	0	0	0	
Hospitalization	Yes	20 (95.2%)	12 (57.1%)	0	-
	No	1 (4.8%)	9 (42.9%)	21 (100%)	
Treatment	N/A	0	0	21 (100%)	-
	AD	0	13 (61.9%)	0	
	MS	2 (9.5%)	0	0	
	Combined	19 (90.5%)	8 (38.2%)	0	
Depressive episode history	N/A	3 (14.2%)	0	21 (100%)	-
	Single episode	5 (23.8%)	10 (47.6%)	0	
	2-5 episodes	13 (62.0%)	8 (38.1%)	0	
	>5 episodes	0	3 (14.3%)	0	
Manic episode history	N/A	0	21 (100%)	21(100%)	-
	Single episode	7 (33.3%)	0	0	
	2-5 episodes	14 (66.7%)	0	0	

[a]: Student-t test; [b]: Chi-square test; AD: Antidepressant; BD: Bipolar Disorder; MDD: Major Depressive Disorder; MS: Mood stabilizer; N/A: Not available; SD: Standard Deviation.

Table 2. PLV comparison between BD, MDD and control groups

	BD Median (Min-Max)	MDD Median (Min-Max)	Control Median (Min-Max)	p*
Right PLV (mm^3)	43690[a] (36193-58555)	47358[a] (36829-141017)	57813[b] (31976-136145)	**0.015[a]**
Left PLV (mm^3)	42961[a] (36421-69755)	44017[a] (34923-141033)	61025[b] (35520-198175)	**0.001[a]**

*Kruskal-Wallis H test; [a]: Pairwise comparison; [b]: Pairwise comparison; (a: BD and MDD are different from control b: BD are different from control)
BD: Bipolar Disorder; MDD: Major Depressive Disorder; Max: Maximum; Min: Minimum; PLV: Parietal lobe volume.

Table 2.1. Comparison of left and right parietal lobe volumes between the groups when total brain volume is the confounding variable*

Group		Mean±Std. Error	%95 CI
Left PLV	Bipolar disorder	43958.1±5659.73	[32865.23- 55050.96]
	Depression	49431.81±5659.73	[38338.94- 60524.68]
	Control	75364.38±5659.73	[64271.51- 86457.25]
Right PLV	Bipolar disorder	44652.29± 807.58	[33269.64- 56034.93]
	Depression	56274.14±5807.58	[44891.5- 67656.79]
	Control	78502.38±5807.58	[67119.73- 89885.03]

*Generalized linear model.
CI: Confidence interval; PLV: Parietal lobe volume; Std.: Standard

Table 2.2. Pairwise comparisons of left and right parietal lobe volumes between the groups when total brain volume is the confounding variable*

	Reference group	Group of comparison	Difference means	95% CI	p
Left PLV	Bipolar disorder	Depression	-5473.71	[-21161.4- 10213.97]	0.494
		Control	-31406.29	[-47093.97- -15718.6]	<0.001
	Depression	Bipolar disorder	5473.71	[-10213.97- 21161.4]	0.494
		Control	-25932.57	[-41620.25- -10244.89]	0.001
	Control	Bipolar disorder	31406.29	[15718.6- 47093.97]	<0.001
		Depression	25932.57	[10244.89- 41620.25]	0.001
Right PLV	Bipolar disorder	Depression	-11621.86	[-27719.35- 4475.64]	0.157
		Control	-33850.1	[-49947.59- -17752.6]	<0.001
	Depression	Bipolar disorder	11621.86	[-4475.64- 27719.35]	0.157
		Control	-22228.24	[-38325.73- -6130.74]	0.007
	Control	Bipolar disorder	33850.1	[17752.6- 49947.59]	<0.001
		Depression	22228.24	[6130.74- 38325.73]	0.007

*Generalized linear model.
CI: Confidence interval; PLV: Parietal lobe volume.

Table 3. Comparison of Cancellation Test scores between the groups

		BD median (min-max)	MDD median (min-max)	Control median (min-max)	p*
Regular letters	CT1	58 (36-60)	60 (53-60)	60 (59-60)	**0.001**[b]
	CT2	2 (0-24)	0 (0-7)	0 (0-5)	**0.001**[b]
	CT3	0 (0-1)	0 (0-1)	0 (0-4)	0.788
	CT4	2 (0-24)	0 (0-8)	0 (0-9)	**0.001**[b]
	CT5	157 (84-737)	211 (80-772)	107 (68-240)	**0.001**[a]
Regular shapes	CT1	59 (53-60)	60 (53-60)	60 (60-60)	**0.001**[b]
	CT2	1 (0-22)	1 (0-29)	0 (0-3)	**0.001**[b]
	CT3	0 (0-25)	0 (0-26)	0 (0-3)	0.206
	CT4	2 (0-47)	1 (0-55)	0 (0-6)	**0.001**[a]
	CT5	155 (76-342)	167 (67-500)	87 (50-170)	**0.001**[a]
Irregular letters	CT1	59 (41-60)	59 (39-60)	60 (60-60)	**0.001**[b]
	CT2	1 (0-19)	1 (0-21)	0 (0-4)	**0.001**[b]
	CT3	0 (0-0)	0 (0-2)	0 (0-4)	0.601
	CT4	1 (0-19)	1 (0-21)	0 (0-8)	**0.001**[b]
	CT5	180 (73-623)	177 (81-360)	106 (54-180)	**0.001**[a]
Irregular shapes	CT1	60 (54-60)	60 (52-60)	60 (60-60)	**0.017**[c]
	CT2	0 (0-9)	0 (0-13)	0 (0-1)	**0.006**[c]
	CT3	0 (0-9)	0 (0-5)	0 (0-1)	0.351
	CT4	0 (0-18)	0 (0-18)	0 (0-2)	**0.006**[c]
	CT5	144 (69-378)	138 (53-325)	75 (46-138)	**0.001**[a]
Total	CT1	234 (191-266)	239 (208-240)	240 (236-240)	**0.001**[b]
	CT5	622 (315-2048)	651 (281-1634)	384 (228-728)	**0.001**[a]

*Kruskal-Wallis H Test.
[a]: BD and MDD are different than the control; [b]: BB is different than the control; [c]: MDB is different than the control.
BD: Bipolar Disorder; CT1: Marked target count; CT2: Missed target count; CT3: Incorrectly marked letters; CT4: Total error count; CT5: Scanning period; max: maximum; MDD: Major Depressive Disorder; min: minimum.

Table 4. Correlation between PL volume and median patient Cancellation Test scores

		RIGHT PL		LEFT PL	
		r	**p***	**r**	**p***
Regular letters	CT1	0.150	0.240	**0.314**	**0.012**
	CT2	-0.140	0.274	**-0.329**	**0.009**
	CT3	-0.152	0.234	-0.229	0.071
	CT4	-0.141	0.271	**-0.335**	**0.007**
	CT5	**-0.323**	**0.010**	**-0.510**	**0.001**
Regular shapes	CT1	0.053	0.678	0.198	0.120
	CT2	-0.125	0.327	**-0.311**	**0.013**
	CT3	-0.191	0.133	**-0.341**	**0.006**
	CT4	-0.189	0.139	**-0.371**	**0.003**
	CT5	**-0.283**	**0.025**	**-0.506**	**0.001**
Irregular letters	CT1	0.154	0.229	0.203	0.110
	CT2	-0.131	0.305	**-0.252**	**0.046**
	CT3	-0.062	0.631	**-0.304**	**0.016**
	CT4	-0.131	0.307	**-0.261**	**0.039**
	CT5	**-0.331**	**0.008**	**-0.536**	**0.001**
Irregular shapes	CT1	-0.143	0.264	-0.026	0.839
	CT2	0.041	0.750	-0.066	0.606
	CT3	-0.143	0.263	-0.232	0.068
	CT4	-0.027	0.833	-0.124	0.332
	CT5	**-0.274**	**0.030**	**-0.414**	**0.001**
Total	CT1	0.177	0.166	**0.291**	**0.020**
	CT5	**-0.329**	**0.008**	**-0.532**	**0.001**

Spearman's rho correlation coefficient.
CT1: Marked target count; CT2: Missed target count; CT3: Incorrectly marked letters; CT4: Total error count; CT5: Scanning period; PL: Parietal Lobe; r: Correlation coefficient.

CT5 and total CT1 regular letters subtest scores. It was determined that there was a weak, significant, and negative correlation between the left PL volume and the median CT2 and CT4 regular letter subtest, and CT2, CT3 and CT4 regular shape and irregular letter subtest scores. It was determined that there was a moderate correlation between the left PL volume and the mean CT5 and total CT5 regular letters, irregular letters, and regular shape subtest scores, and a weak negative correlation with the CT5 irregular shape subtest score (Table 4).

DISCUSSION

The first of the significant findings of the study was that the PL volume was lower in both hemispheres in BD and MDD patients when compared to the control group, and there was no difference between the PL volume of the patient groups. The limited number of studies on PL volume in MDD or BD reported that PL volume was low in MDD and BD patients. In one of these studies, it was demonstrated that BD-1 patients exhibited lower temporoparietal lobe volume when compared to the control group, independent of manic or depressive episodes (21). In another study, it was reported that gray matter density in PL was lower in BD patients with poor prodromal period symptoms and high levels of prodromal symptoms when compared to the control group (22). Similarly, an MRI study conducted with MDD patients reported low gray matter volume in PL (23).

An fMRI study reported decreased PL function, especially in MDD patients (12). Similarly, another fMRI study, where PL functions of BD and MDD patients were compared during the depressive episode, reported lower functions in unipolar depression when compared to bipolar depression, especially in the right inferior PL (24).

The present study findings were consistent with the reports in the literature. However, since the PL volume and CT performance were lower during the euthymic period in both diseases, the anatomical PL volume could be important in the etiology of these diseases and the low cognitive functions in MDD and BD patients could not be an episode-specific state but a trait. Furthermore, when total brain volume was taken as a covariate, the findings remained significantly unchanged. The volumes of both right and left parietal lobe were similar between the patient groups but significantly lower than the control group. This finding demonstrated that the low PL volumes in BD and MDD patients could be a parietal lobe-specific volumetric decrease independent of the total brain volume, alleviating the significance of our findings.

Another significant finding of the study was that although there was no significant difference between the median CT scores of the patient groups, BD patients performed worse in motor, sensory and motivational components, and MDD patients performed worse in sensory and motivational components when compared to the control group. Previous studies on the CT performances of MDD patients reported that the CT motivational component performances of MDD patients were worse in all subtests when compared to the control group, as expected from the symptomatology of depression (25). Also, in a study on the CT performances of BD patients, it was reported that these patients exhibited worse performances in the irregular shapes subtest during the manic period (26). Similarly, another study where CT was used as an analysis instrument reported that BD patients exhibited slightly poor performances, independent of attack or remission periods (27).

In the present study, a weak, significant and negative correlation was determined between the motivational component and the right PL

volume in all CT subscales. Thus, it could be suggested that the decrease in right PL volume was poorly or moderately correlated with the deterioration in the motivational component, which is associated with the emotional value of spatial events. Furthermore, it could be suggested that there was a weak-moderate correlation between the left PL volume and the motivational component, and a weak correlation with the motor and emotional components, and as the left PL volume decreased, all three components could deteriorate. The poor correlation between CT performance and patient PL volume could be attributed to the small sample size. However, the same finding also suggested that the decrease in parietal lobe volume in BD and MDD patients in remission could be associated with worsening neuropsychological test performances.

One of the strengths of the current study was the fact that it was conducted during the euthymic period of BD and MDD patients. Frequent residual symptoms during the euthymic period in both clinical conditions indicate that these disorders are not episode-specific. Indeed, the present study findings demonstrated the structural PL changes in both BD and MDD patients, consistent with similar study findings and the correlations between these structural changes and cognitive functions.

Another strength of the study was the comparison of BD and MDD patients since both mood disorders share similar PL volumes and CT scores. Thus, it could be suggested that the present study findings could contribute to the hypothesis that MDD and BD could share a similar psychological and neurophysiological pathogenesis.

The present study also has certain limitations. Parietal lobe volumes of the patients were not known before the onset of the disease. Thus, the study findings could not determine whether PL volume changes during the euthymic period after an episode. Furthermore, the study investigated the correlation between PL volume and CT performance only in the patients. Thus, longitudinal studies are required to elucidate the changes in PL volumes in BD and MDD patients and compare the correlation between PL volume and IT performance in the control group.

Along with studies reporting a correlation between polypharmacy and decreased gray matter volume (28), additional studies emphasizing the protective properties of neuroprotective drugs such as lithium (29) are also available in the literature. However, studies on the neuroprotective properties of lithium were criticized since confounding factors such as the length of lithium use, other psychotropic drugs used with lithium (polypharmacy), and history of lithium use (dose, duration, uncertainties in treatment compliance) could have jeopardized the interpretation of the findings. Since the present study aimed to determine the effects of the disease on the parietal lobe volume in BD and MDD patients and did not have the methodological properties (such as sample size) of the studies on the effects of lithium on neurogenesis, it could be suggested that the analyses of the effects of lithium use on the parietal lobe volume could lead to biased findings. These findings were not included in the study. However, the lack of data on lithium use in patients was another limitation of the current study. It could be suggested that large samples and a methodological design that could investigate the neuroprotective effect of lithium on PL are required.

Certain previous neuroimaging studies reported that volume measurements differed in white and gray matter (23). Since the total volume was considered in the present study without this discrimination was another limitation. Finally, concerns about the validity of the MRICloud method employed to measure the volumes in the present study could be considered as another limitation of the study. Although the MRI software, where the volume is calculated automatically, reliably and quantitatively, plays a key role in the imaging, diagnosis and comprehension of several diseases, it was suggested that the specificity of the software could be lower when compared to manual methods (30).

The present study findings emphasized that PL could be important in the comprehension of the pathophysiology of BD and MDD and the development of neuroanatomical and functional markers in these diseases. Since the PL is an under-researched brain region in both this and other psychiatric disorders, longitudinal studies with larger samples are needed to analyze the current study findings on the prognosis of the disease with advanced imaging methods such as fMRI.

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