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Surface-based morphometric abnormalities in patients with early psychosis: an MP2RAGE-based study at 7T

Zirun Wang[1,2], Yasser Alemán Gómez[3], Martine Cleusix[3], Raoul Jenni[3], Luis Alameda[3], Philippe Conus[4], Merixell Bach Cuadra[1,5], Patric Hagmann[6], Kim Q. Do[3], Lijing Xin[1,2]

[1] Center for Biomedical Imaging (CIBM), Lausanne, Switzerland, [2] Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, [3] Center for Psychiatric Neuroscience, Department of Psychiatry, Centre Hospitalier Universitaire Vaudois (CHUV) and University of Lausanne (UNIL), Lausanne, Switzerland, [4] Service of General Psychiatry, Department of Psychiatry, Centre Hospitalier Universitaire Vaudois (CHUV) and University of Lausanne (UNIL), Lausanne, Switzerland, [5] Radiology Department, Centre Hospitalier Universitaire Vaudois (CHUV) and University of Lausanne (UNIL), Lausanne, Switzerland, [6] Diagnostic Neuroradiology, Centre Hospitalier Universitaire Vaudois (CHUV) and University of Lausanne (UNIL), Lausanne, Switzerland

BACKGROUND

Schizophrenia is a neurodevelopmental disorder affecting cerebral morphometry. Most morphometrical studies of schizophrenia were performed based on MPRAGE images at 1.5T or 3T. It has been demonstrated that the MP2RAGE sequence leads to more excellent reproducibility and higher tissue contrast relative to MPRAGE [1,2]. Due to subtle brain abnormalities in EP, it is essential to use more sensitive neuroimaging techniques to study cortical features. High sensitivity of 7T and MP2RAGE images, together with Surface-based morphometry (SBM), may facilitate the observation of subtle cortical changes at the early stage of the disease. This study aims to investigate cortical features in patients with EP compared to healthy controls via, for the first time, Surface-based morphometry (SBM) analysis using MP2RAGE images at 7T.

METHODS

- 42 patients (34 males, 8 females), aged 18 to 33 and with less than 3 years of treatment, and 35 healthy controls (27 males and 8 females) [3] (Table 1) are included
- Subjects underwent magnetic resonance imaging scans in a 7 Tesla/68 cm MR scanner (Siemens Medical Solutions, Erlangen, Germany) with a 32-channel receive coil (NOVA Medical Inc., MA) with a single-channel volume transmit coil. 3D T1-weighted MR images were acquired using MP2RAGE (TE/TR = 1.87/5500 ms, TI1/TI2 = 750/2350 ms, $\alpha1/\alpha2 = 4°/5°$, slice thickness = 1 mm, FOV = 240 × 256 × 160 mm^3, matrix size = 240 × 256 × 160, bandwidth = 240 Hz/Px)) [4].
- Surface-based morphometry (SBM) was applied to investigate anatomical features (i.e. cortical surface area, thickness, and volume) using FreeSurfer (version 7.3.2). General Linear Model (GLM) was used with nuisance covariates age, gender, and total intracranial volume (TIV) for the group analysis. Permutation with 1000 times was performed as cluster-wise multiple comparison correction. Corrected two-tailed P-value under 0.05 is regarded as significant. The cortical parcellation was based on Desikan-Killiany Atlas [5].

Table 1: Demographic information of subjects

Characteristics*	**EP** (n = 42)	**HC** (n = 35)	**test P-value****
Age (years)	24.66 (4.79)	24.45 (5.35)	0.859
Gender (M:F)	34:8	27:8	0.682
Handedness (L:R)	40:2	29:6	0.076
Onset age (years)	23.39 (4.5)	-	-
Illness duration (years)	1.56 (1.77)	-	-
PANSS-positive score	11.62 (3.42)	-	-
PANSS-negative score	16.05 (5.60)	-	-
PANSS-general score	30.64 (7.25)	-	-
PANSS-total score	58.31 (13.92)	-	-

* Continuous variables are expressed in mean values (standard deviations); Categorical variables in frequency
** *t*-test for continuous variables; χ^2-test for categorical variables

RESULTS

- No significant difference in TIV and surface areas between patients and controls.
- The average cortical thickness of both left and right hemisphere are significantly reduced in the EP patients (left: p = 0.008, F = 7.26; right: p = 0.02, F = 5.72).
- At the cluster-wise level, the significant clusters were identified at the junction of the left lateral occipital, lingual and peri calcarine region where the cortical area and volume are shrunk in the patients. The peak P-value is located at the left fusiform (left in Figure 1) and para hippocampal (right in Figure 1), respectively.
- At the vertex-wise scale, some relatively small clusters where the cortical areas are reduced in the patient group were found at right lateral occipital, left postcentral, left caudal middle frontal, and right insula. The cortical thickness was decreased at left pericalcarine, right inferior temporal, and left lateral occipital lobe in the EP patient. The thickness increased slightly at the right lingual in patients. The cortical volume reduction was also highlighted in right isthmus cingulate, left postcentral, and left precentral.

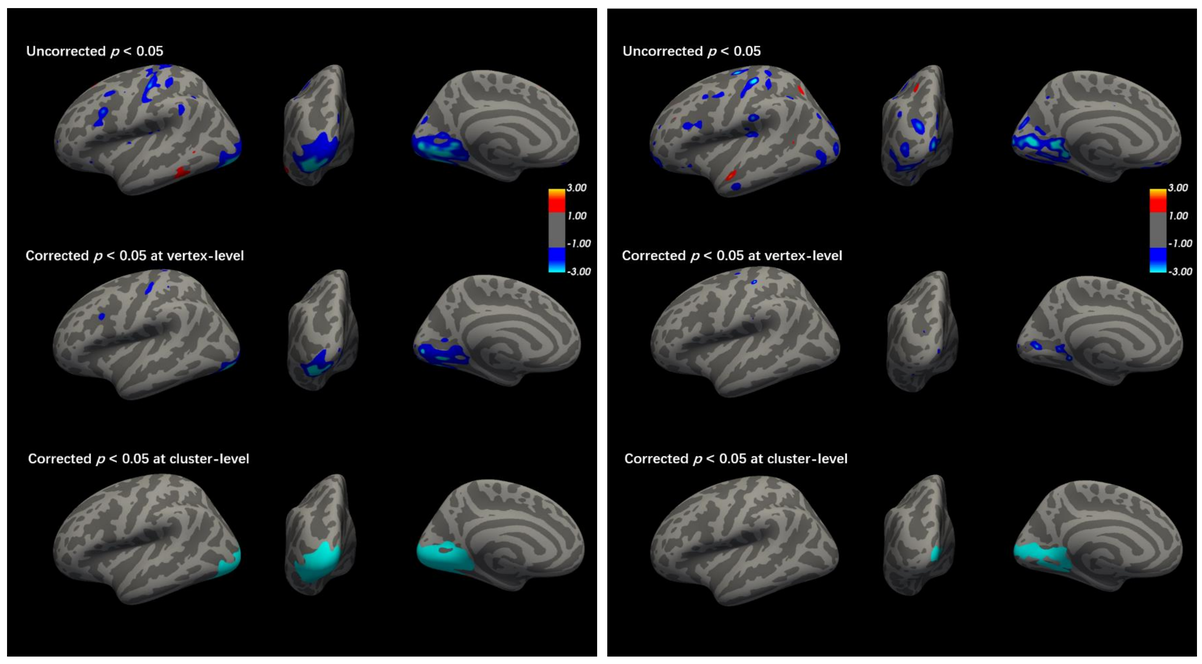

Figure 1: Statistical maps of cortical area (left) and cortex volume (right) change in the left hemisphere between EP patients and healthy controls. A large significant cluster (cyan cluster in the lower row) survived after permutation multiple comparison correction. The colour bar represents the significance level common logarithm of p-value. Blue and red stand for negative (patient < control) and positive (patient > control) contrasts, respectively.

DISCUSSION

This is the first 7T MP2RAGE-based SBM study in patients with EP. The most significant clusters with reduced cortical area and volume in EP were identified at the junction of left lateral occipital, lingual and peri calcarine region. The clusters, where the surface area and cortex volume in patients were aberrant, largely overlap. Previous studies [6-8] using MRRAGE images at 3T and 1.5T failed to report significant alterations in the occipital lobe of EP patients. However, research on the chronic cases [9,10] reported abnormal geometric changes in the subregions of occipital area. Therefore, our current results suggest that ultra-high field utilisation and MP2RAGE images could enable the detection of the neural disease at an early stage of neurodevelopmental process. A previous meta-analysis [11] showed that the majority of the cortex thinning and surface area shrinkage in patients with schizophrenia were situated in frontal and temporal lobe regions. Considering EP cases, studies mostly identified the cortical changes appearing at temporal and anterior cingulate cortex [12,13]. The different outcomes between ours and chronic research could be the cortex alteration expansion to the frontal part with the duration of illness.

CONCLUSION

In conclusion, the results of surface-based analysis using MP2RAGE images at an ultra-high magnetic field provide evidence of different cortical structural features between EP patients and controls. Equipped with such sensitive techniques, we may capture the subtle alterations at the early stage of neurological disorder. The findings are comparable with the relevant neuroimaging studies.

REFERENCES

1. G. Okubo et al., J Magn Reson Imaging, vol. 43, no. 1, pp. 55–62, Jan. 2016
2. A. Droby et al., PLOS ONE, vol. 16, no. 8, p. e0254597, Aug. 2021
3. P. S. Baumann et al., Early Interv Psychiatry, vol. 7, no. 3, pp. 322–328, Aug. 2013
4. J. P. Marques et al., Neuroimage, vol. 49, no. 2, pp. 1271–1281, Jan. 2010
5. R. S. Desikan et al., NeuroImage, vol. 31, no. 3, pp. 968–980, Jul. 2006
6. S. Rigucci et al., Acta Psychiatrica Scandinavica, vol. 128, no. 4, pp. 261–270, 2013
7. D. Tordesillas-Gutierrez et al., Schizophr Res, vol. 164, no. 1–3, pp. 74–82, May 2015
8. L. Asmal et al., Early Intervention in Psychiatry, vol. 12, no. 4, pp. 652–659, 2018
9. C. C. Schultz et al., Brain Struct Funct, vol. 218, no. 1, pp. 51–58, Jan. 2013
10. K. Li et al., Schizophrenia Research, vol. 220, pp. 201–209, Jun. 2020
11. T. G. M. van Erp et al., Biological Psychiatry, vol. 84, no. 9, pp. 644–654, Nov. 2018
12. S. Kim et al., International Journal of Imaging Systems and Technology, vol. 22, no. 1, pp. 73–80, 2012
13. K. Wen et al., Psychoradiology, vol. 1, no. 4, pp. 185–198, Dec. 2021

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