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Translocation of Broca's area in a case of low-grade glioma: reinforcing the importance of preoperative functional magnetic resonance imaging

Suryansh Arora* and Kavita Vani

Abstract

Background: Functional MRI has enabled us to map the anatomical location of functional areas of brain including language centers and thus provides useful insights in preoperative planning and assessment for neurosurgeons. In recent years, fMRI has also provided evidence for neuroplasticity which implies that brain pathways have an ability to reorganize in response to any injury.

Case presentation: We present a case of a 27-year-old male, postoperative case of left frontotemporal glioma (WHO grade II) with residual tumor in inferior frontal, temporal and insular lobe in whom functional magnetic resonance imaging was carried out to elicit language centers. fMRI revealed activation of Wernicke's area in left cerebral hemisphere in the right-handed patient, while Broca's area was activated in right cerebral hemisphere, thus eliciting the translocation of Broca's area in response to low-grade glioma.

Conclusions: This case provided an example of the ability of brain to reorganize pathways in response to injury or insult. The routine use of preoperative fMRI in such cases will help in better planning and lead to an improved postoperative outcome.

Keywords: Functional MRI, Glioma, Neuroplasticity

Background

Neuroplasticity refers to reorganization of brain pathways for brain development and in response to insult. Though the mechanisms of neuroplasticity are poorly understood, it has been studied using modalities like direct electrocortical stimulation (DES), transcranial magnetic stimulation (TMS), functional MRI (fMRI) and positron emission tomography (PET). Functional reorganization of brain pathways has been elicited in slow growing lesions like low-grade gliomas [1].

We present a case of left frontotemporal glioma in a right-handed patient without language deficit in whom fMRI was performed to elicit eloquent areas of brain including Broca's and Wernicke's area.

Case presentation

A 27-year-old male, postoperative case of Diffuse Astrocytoma-NOS (WHO Grade II; IDH1 negative) presented to our center for follow-up imaging.

Retrospective evaluation of preoperative films was carried out, which revealed an area of hyperintense signal in white matter in left frontal, temporal, and insular lobe on T2WI. There was no evidence of restricted diffusion or post-contrast enhancement (Fig. 1a).

*Correspondence: drsuryansharora@gmail.com

Department of Radiodiagnosis, Atal Bihari Vajpayee Institute of Medical Sciences and Dr Ram Manohar Lohia Hospital, New Delhi, India

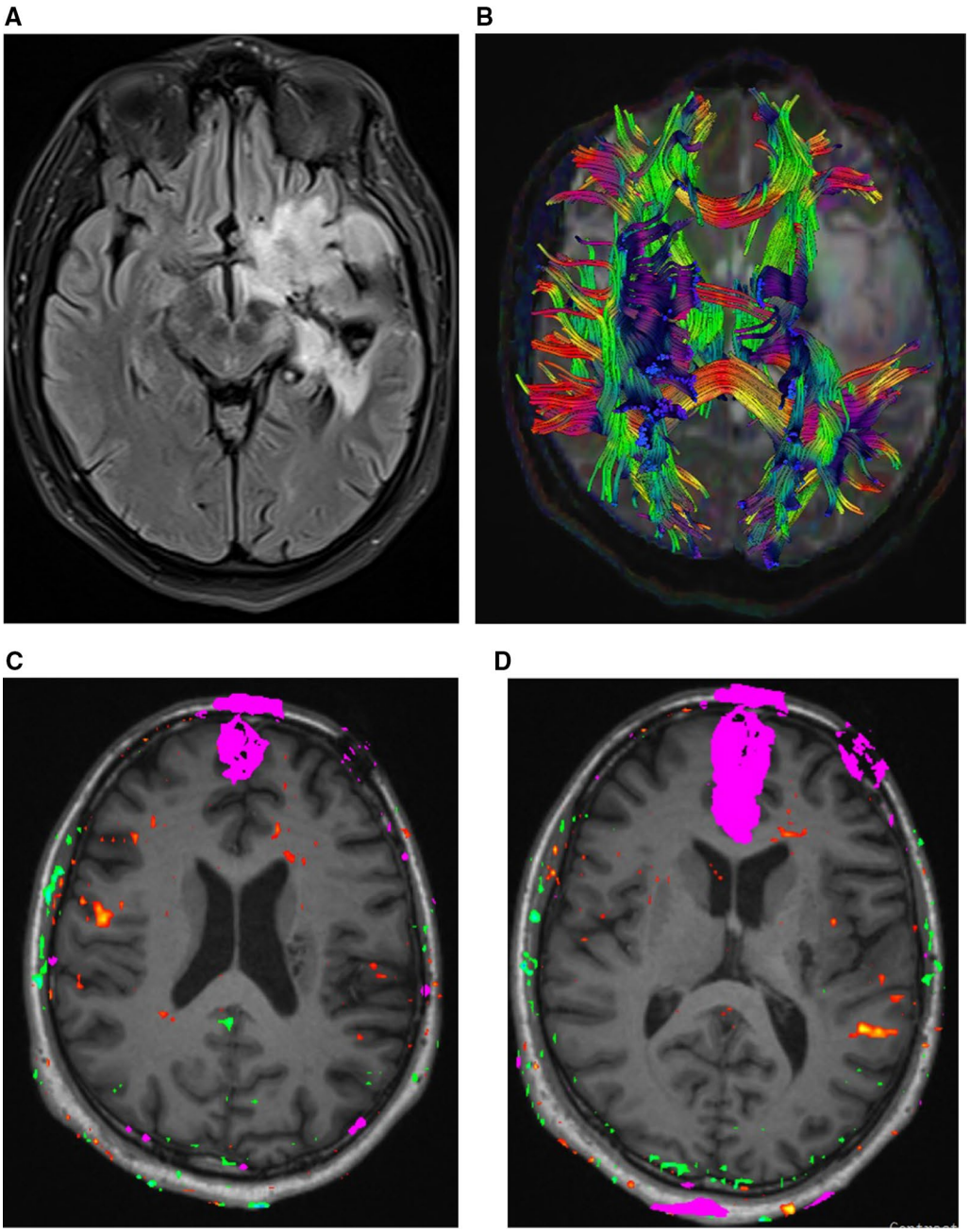

Fig. 1 **a** Axial FLAIR image-heterogeneous hyperintense signal noted in left frontotemporal region corresponding to the residual glioma with postoperative encephalomalacic changes in left temporal lobe. **b** Tractography image obtained using DTI images shows disruption as well as displacement of adjacent white matter tracts in left frontotemporal region. **c** Functional MRI shows activation of Broca's area in right inferior frontal lobe when patient was asked to read aloud alphabets. **d** Functional MRI shows activation of Wernicke's area in left posterosuperior temporal lobe when patient was narrated a story while acquiring BOLD images

During the preoperative work up, functional MRI was not carried out due to unavailability in a resource poor setting.

Surgical resection was carried out in September 2020 which involved anterior temporal lobectomy. Resection was not extended to include inferior frontal lobe to preserve speech.

Patient complained of persistent headache after surgical intervention.

Postoperative imaging carried out in June, 2021 revealed residual tumor in left frontotemporal region with increased choline peak on MR Spectroscopy (Choline: Creatine-1.24). Diffusion tensor imaging revealed disruption as well as displacement of adjacent white matter tracts with increased FA value. No evidence of restricted diffusion on diffusion images and no post-contrast enhancement were noted.

Functional MRI was carried out on 3T Siemens Magnetom Skyra with standard head coil to evaluate the speech centers. The fMRI data were acquired using gradient echo planar imaging (EPI) sequences (TR = 3000 ms, TE = 30 ms, 25 slices, slice thickness = 3 mm, 128 × 128 matrix, Parallel imaging-GRAPPA, acceleration factor = 2). High-resolution 3D isometric T1 weighted images were also acquired using gradient echo sequence with inversion recovery pulse (T1 MPRAGE) for coregistration with fMRI data.

Speech areas were assessed using language paradigms (Block Design-10 s of task followed by 10 s of rest, repeated 10 times) on nordicAktiva software. The patient underwent silent word generation and single word semantic decision task paradigms. The patient was explained the procedure of the study, and detailed instructions were given regarding the task to be performed. Imaging processing and analysis was carried out using 'Neuro3D' software (Siemens).

fMRI revealed sensory speech area (Wernicke's Area) in left posterior superior temporal lobe and motor speech area (Broca'a area) in right inferior frontal lobe. No fMRI signal was noted in expected Broca's area in left frontal lobe (Fig. 1c, d). The patient was right-handed and did not report any speech deficit in either preoperative or postoperative period.

Thus, translocation of Broca's area to right cerebral hemisphere due to left frontotemporal glioma was established on fMRI study.

Discussion

The primary centers implicated in language processing consist of motor speech area (Broca area), located in posterior inferior frontal gyrus and receptive language center (Wernicke area), located along posterior superior temporal gyrus. Additional involvement of temporal, parietal and frontal lobes in language processing has been noted in recent studies [2].

The speech centers are localized in left hemispheres in up to 95% of right-handed individuals [3].

Functional MRI utilizes changes in local blood flow and deoxygenated hemoglobin to map specific areas of brain using T2* weighted MR images. An increase in neuronal activity in a particular area of brain leads to increase in local blood flow. This increase in blood flow is more than the increased oxygen utilization. Thus, resultant decrease in deoxygenated hemoglobin leads to decrease in local susceptibility artifacts causing increased signal intensity on T2* weighted MR images. Various paradigms are used to evaluate different areas of brain which involve performing particular tasks by subject during imaging [4].

The location of language centers as elicited by fMRI revealed Broca's and Wernicke's area on opposite sides of brain in our case. This arrangement has not been described in normal individuals. We postulate that the slow growing glioma involving left frontotemporal region led to development of new pathways which enabled inferior frontal gyrus in right cerebral hemisphere to take over the function of motor speech as the left inferior frontal gyrus was unable to function properly.

Similar cases eliciting translocation of Broca's area to contralateral cerebral hemisphere have been reported by Holodny et al., Li et al. [5, 6].

Kim et al. reported a case of left frontal low-grade glioma leading to splitting of Broca'a area elicited on fMRI [7].

Similar studies have utilized functional MRI to elicit reorganization of motor and somatosensory pathways in response to stroke and slow growing tumors. Such studies provide insight into the concept of neuroplasticity [8].

Previously believed to be a static organ, the evidence obtained by studies using functional MRI, direct electrocortical stimulation (DES), PET, DTI and transcranial magnetic stimulation have shown that brain is capable of redistribution of function and reorganization of pathways in response to injury [9].

Conclusions

The mapping of eloquent areas using functional MRI has enabled the surgeons to resect larger areas of affected brain tissue with minimal neurological deficit.

In our case, limited tumor resection was carried out as preoperative assessment of language centers was not performed. However, functional MRI study provided evidence of translocation of Broca's area to contralateral hemisphere which makes resection of a larger area feasible.

Abbreviations

fMRI: Functional magnetic resonance imaging; DES: Direct electrocortical stimulation; TMS: Transcranial magnetic stimulation; PET: Positron emission tomography; DTI: Diffusion tensor imaging; EPI: Echo planar imaging; GRAPPA: Generalized autocalibrating partial parallel acquisition; MPRAGE: Magnetization-prepared rapid gradient echo.

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Author contributions
Both authors performed the fMRI acquisition. KV performed the post-processing of MRI images. SA performed the literature search and prepared the manuscript. Both authors prepared the figures and figure legends. Both authors reviewed and edited the manuscript. Both authors read and approved the final manuscript.

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Availability of data and materials
Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Declarations

Ethics approval and consent to participate
Waived off by Institute Ethics Committee, Dr RML Hospital, New Delhi in view of case report. Informed written consent was taken from the participant.

Consent for publication
Informed written consent was taken from the participant.

Competing interests
The authors declare that they have no competing interests.

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