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Application of Awake Craniotomy and Intraoperative Brain Mapping for Surgical Resection of Insular Gliomas of the Dominant Hemisphere

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■ BACKGROUND: **Radical resection of dominant insular gliomas is difficult because of their close vicinity with internal capsule, basal ganglia, and speech centers. Brain mapping techniques can be used to maximize the extent of tumor removal and to minimize postoperative morbidities by precise localization of eloquent cortical and subcortical areas.**

■ METHODS: **Patients with newly diagnosed gliomas of dominant insula were enrolled. The exclusion criteria were severe cognitive disturbances, communication difficulty, age greater than 75 years, severe obesity, difficult airways for intubation and severe cardiopulmonary diseases. All were evaluated preoperatively with contrast-enhanced brain magnetic resonance imaging (MRI), functional brain MRI, and diffusion tensor tractography of language and motor systems. All underwent awake craniotomy with the same anesthesiology protocol. Intraoperative monitoring included continuous motor-evoked potential, electromyography, electrocorticography, direct electrical stimulation of cortex, and subcortical tracts. The patients were followed with serial neurologic examination and imaging.**

■ RESULTS: **Ten patients were enrolled (4 men, 6 women) with a mean age of 43.6 years. Seven patients suffered from low-grade glioma, and 3 patients had high-grade glioma. The most common clinical presentation was seizure followed by speech disturbance, hemiparesis, and memory loss. Extent of tumor resection ranged from 73% to 100%. No mortality or new major postoperative neurologic deficit was encountered. Seizure control improved in three fourths of patients with medical refractory epilepsy. In one patient with speech disorder at presentation, the speech problem became worse after surgery.**

■ CONCLUSION: **Brain mapping during awake craniotomy helps to maximize extent of tumor resection while preserving neurologic function in patients with dominant insular lobe glioma.**

INTRODUCTION

Gliomas are the most common primary tumors of brain.[1,2] Currently, the optimal management of gliomas is based on maximal safe resection, which has been shown to affect progression-free survival of the patients suffering from high-grade gliomas (HGGs) or low-grade gliomas (LGGs).[3-5] Nevertheless, owing to the infiltrative nature of gliomas, it is not always possible to achieve gross total resection of tumor while preserving the function of the eloquent structures of cerebral cortex and subcortical white matter tracts. Gross total resection with a low risk of morbidity (i.e., onco-functional balance) is considered as the goal of surgery for all these patients.[6]

Insula is located at the depth of Sylvian fissure and is hidden by the frontal, temporal, and parietal lobes. It is in close vicinity of

Key words
- Awake craniotomy
- Brain mapping
- Cortical stimulation
- Insula
- Insular glioma
- Glioma

Abbreviations and Acronyms

DES: Direct electrical stimulation
DTI: Diffusion tensor imaging
LAIR: Fluid-attenuated inversion recovery
fMRI: Functional magnetic resonance imaging
HGG: High-grade glioma
LGG: Low-grade glioma
MEP: Motor-evoked potential
MRI: Magnetic resonance imaging

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the internal capsule and basal ganglia and is adjacent to the speech centers in the dominant hemisphere. Thus, radical resection of insular gliomas can be associated with major morbidity.

It is suggested that brain-mapping techniques can be used to detect the eloquent areas of the brain with acceptable precision intraoperatively so that the extent of tumor removal is maximized and postoperative morbidities are minimized.[7-11]

In this article, we present our experience with application of intraoperative functional mapping of motor and speech functions for surgical resection of cerebral gliomas and evaluate its precision and accuracy.

MATERIALS AND METHODS

Patient Population

We have consecutively enrolled patients with gliomas of the dominant insular lobe who had no history of surgery or chemoradiation from February 2015 until October 2016. All patients underwent complete neurologic, psychologic, and neuroradiologic evaluations before the operation. This study has been approved by the ethics committee of the Neurosurgery Department of the Tehran University of Medical Sciences.

Patients with gliomas of the eloquent regions are not suitable candidates for intraoperative brain mapping. Therefore, patients with severe cognitive or psychologic disturbances and those with difficulty in communication were excluded from this study.

Patients who were older than 75 years, severely obese patients, and those with difficult airways for intubation and severe cardiovascular or respiratory diseases are not suitable for awake craniotomy technique according to the American Society of Anesthesiologists physical status classification.[12,13]

Imaging and Neurophysiologic Tests

The topography of the tumor was assessed with preoperative magnetic resonance imaging (MRI; T1-weighted images before and after Gd enhancement, T2-weighted and fluid-attenuated inversion recovery [FLAIR] images in 3 orthogonal planes and volumetric sequences). Magnetic resonance spectroscopy was performed for all patients to obtain a multivoxel magnetic resonance spectroscopic map of the tumor. We performed functional MRI (fMRI) for motor and language tasks for all patients, and interpreted fMRI images for hemispheric dominance and surgical planning. All patients underwent diffusion tensor imaging (DTI) tractography of the white matter fiber tracts involved in motor (corticospinal tract) and language functions (i.e., arcuate fasciculus, inferior and superior longitudinal fasciculus, uncinate fasciculus, and inferior fronto-occipital fasciculus). The imaging data were coregistered in the neuronavigation system and used for preoperative planning and to guide the intraoperative functional mapping.

Intraoperatively, direct electrical stimulation (DES), electromyography, electrocorticography, and motor-evoked potential (MEP) were performed for neurophysiologic monitoring.

We recorded electrocorticography continuously during the entire duration of surgery using subdural strip electrodes with 4–8 contacts from the cortex near the mapping area to monitor occurrence of electrical seizures and after-discharges during

Table 1. Clinical Features and Outcome Measures of the Patients

Patient Number	Age (years)	Sex	Clinical Presentation	Tumor Volume (cm^3)	Histopathology	Extent of Resection (%)	Early Postoperative Neurologic Deficit	Neurologic Outcome (3 months)
1	47	Male	Seizure (medical refractory)	88	LGG	100	3 episodes of seizure	Significant improvement of seizure control
2	58	Male	Hemiparesis, speech disturbance (mostly expressive)	125	HGG	92	None	Deteriorated expressive aphasia, hemiparesis unchanged
3	36	Male	Seizure	72	LGG	80	None	None
4	26	Female	Seizure	100	LGG	90	Intermittent dysphasic episodes	None
5	63	Female	Seizure	120	HGG	70	None	None
6	30	Female	Seizure, Speech disturbance (mostly Wernicke)	104	LGG	86	Deteriorated Wernicke aphasia	Speech returned to preoperative status
7	70	Female	Seizure (medical refractory)	134	HGG	90	Transient global aphasia	No improvement in seizure control
8	43	Male	Seizure (medical refractory), memory disturbance	108	LGG	93	Mild dysphasia	No seizure occurred during follow up
9	28	Female	Speech disturbance (conductive)	96	LGG	88	None	Nearly normal speech
10	35	Female	Seizure (medical refractory)	130	LGG	73	None	Improvement in seizure control

LGG, low-grade glioma; HGG, high-grade glioma.