



Comprehensive Analysis of Motor Deficits after Glioma Surgery having Integrated Exoscopic Neuronavigation, fMRI and DTI at Punjab Institute of Neurosciences, Lahore

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ABSTRACT

Objective: To determine the frequency of motor deficits following glioma surgery using integrated exoscopic neuro-navigation, fMRI, and DTI, assessed by the MRC power scale at a tertiary care hospital in Lahore. **Study Design:** Descriptive longitudinal study. **Study place & Duration:** Department of Neurosurgery unit 2, Punjab Institute of Neurosciences, Lahore from March 25, 2025 to June 25, 2025. **Methodology:** A total of 64 patients were enrolled and their demographics were recorded. Following admission, baseline investigations and necessary preoperative workup were conducted. Functional MRI and Diffusion Tensor Imaging were performed. After obtaining anesthesia clearance, patients were scheduled for elective surgery in the neurosurgery operating theater. Surgeries were carried out by the neurosurgical team under neuronavigation guidance, with careful attention to preserving critical tracts and motor eloquent areas. On the first postoperative day, motor power was evaluated using the Medical Research Council (MRC) power scale. **Results:** The mean age of the patients was 31.20 ± 8.99 years. There were 30 (46.9%) male and 34 (53.1%) female patients. The mean MRC score on the first day was 4.75 ± 0.73 , which improved to 4.87 ± 0.57 by the end of the first month. On the 1st month follow-up, motor deficit was observed in 4 (6.25%) patients glioma surgery with integrated exoscopic neuro-navigation, fMRI, and DTI. **Conclusion:** It was concluded that the chances of motor deficits by using the MRC power scale after glioma surgery.

INTRODUCTION

Brain tumours may be the result of distant cancers spreading, or they may be the result of neuronal components within the brain. About half of all occurrences of intracranial neoplasms are primary brain tumours, which originate from the CNS tissue.¹ Although the pathogenesis of glial tumours is diverse, the extent of resection (EOR) has a significant impact on the prognosis of these patients regardless of the histological grade or genetic classification.^{2,3}

Gliomas, which are neuroepithelial tumours of the supporting glial cells in the nervous system, are among the most prevalent primary intracranial tumours. WHO divides tumours into grades according to histological characteristics like nuclear atypia, anaplasia, microvascular proliferation, and necrosis. WHO grade II tumours are classified as low grade gliomas, whilst WHO grade III and IV tumours are classified as high grade.⁴ Optimising the EOR while maintaining or even raising quality of life is the primary goal of glioma surgery.⁵ The

only alternatives for definitive treatment are chemotherapy, surgical resection, or a combination of the two. The possible advantages of the treatment must be carefully balanced against any possible risks associated with it in cases of this kind of brain tumour, which has a long survival and a generally favourable prognosis.⁴

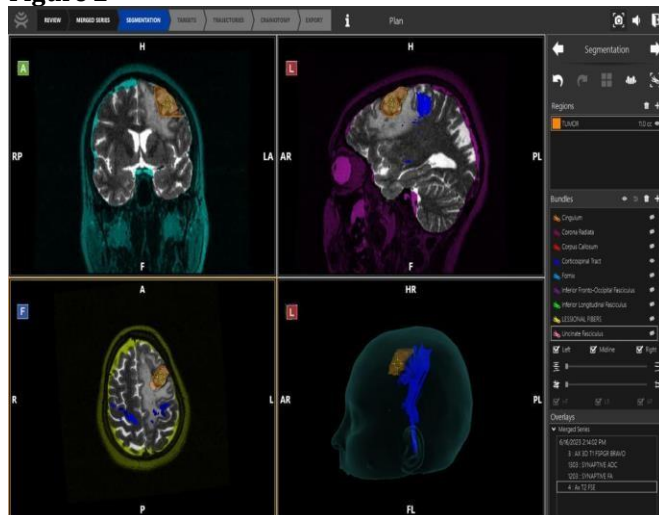
A noninvasive magnetic resonance imaging technique called diffusion tensor imaging (DTI) shows the likely position and orientation of subcortical white matters tracts in vivo. This allows for the revelation of several elements of the tumor-tract relationship. When designing a surgical trajectory, this knowledge is essential to prevent harm to the eloquent tissue.⁶ Similarly, the emergence of intraoperative MRI has started a new era in brain tumor resection. The recent intraoperative motor mapping with functional MRI or FMRI has been used to localize sensorimotor areas during awake craniotomy. FMRI works by identifying changes in blood flow and metabolic activity when performing neuronal activity, and complicated surgical procedures is essential for successful

Figure 1



Notwithstanding its drawbacks, this technology may help with the removal of brain tumours in eloquent individuals. For example, DTI may be used to identify the pyramidal tracts in patients with gliomas close to expressive brain tissue, like the motor cortex, when paired with 3-dimensional intraoperative guidance-neuro navigation.⁷ Based on these oncological considerations, image-guided resection became more and more developed. For surgical selection and planning, it first relied on structural MRI and then on preoperative functional neuroimaging, which includes functional MRI (fMRI), magnetoencephalography, diffusion tractography imaging (DTI), and transcranial magnetic stimulation.^{8,9}

Figure 2



Without the need for a stereotactic frame, neuro-navigation is a method that allows the tip of a pointer to be calibrated to an image space by displaying the tip of an instrument in relation to corresponding CT or MRI images. Although guided technology has various clinical uses, the most common use in neurosurgery now is for the localization of tiny brain tumors. Additionally, it lowers morbidity by enabling the surgeon to determine how the tumor relates to significant neighboring structures, such as motor regions.¹⁰

Figure 3



Our study aimed to identify and record the frequency of motor deficits in patients that have undergone excision gliomas with the use of FMRI, DTI tractography and neuro navigation guidance, so that we may assess the benefits of such equipment in our tertiary care setup.

MEHODOLOGY

After approval from the ethical review board, this descriptive longitudinal study was carried out at Punjab Institute of Neurosciences, Lahore from March 25, 2025 to June 25, 2025. The MRC power scale was used to assess motor deficits. It is a scale that assesses motor power in a range of 1-5. In our study 5 were considered as having no motor deficit while any value below 5 was recorded as having a motor deficit. Motor power was assessed at 1st post-operative day and at 1 month follows up. Functional MRI is an MRI that determines the "Blood Oxygen Level Dependent (BOLD)" changes in MRI signals that occur when specific tasks are performed. In this study, when the patient performs motor activity, the MRI signal change was used to determine which area of the patient's brain engages in his activity. Neuro-epithelial glial cell tumors of the brain were diagnosed based on MRI findings: intra-axial, irregular, unmarked masses with variable contrast enhancement (no contrast enhancement in low grade and heterogenous in high grade), having surrounding angioedema with or without a necrotic core. The calculated sample size was 64 by taking incidence of brain tumors in Pakistan, population proportion = 28.4% (gliomas per total number of brain tumors)¹¹. The confidence interval for this calculation was 95% and 5% was the margin of error. All the patients were enrolled by applying non-probability consecutive sampling technique.

Inclusion

Patients having an age range between 16-50 years of both genders, patients presenting with low grade gliomas, in the frontal lobe, operated via craniotomy and excision under FMRI, DTI tractography and neuro navigation guidance and cooperative patients able to follow the commands required in FMRI were included.

Exclusion

Patients with low pre-operative GCS (<15), patients with pre-op motor deficits, patients with inability to follow

fMRI commands and patients unfit for surgery were excluded.

After meeting selection criteria, informed consent and demographic detail was taken from all the patients. The patients were admitted, baseline investigations and workup was performed. Functional MRI and DTI were done, mapping the patient's motor areas by asking him/her to perform commands during fMRI. The changes in brain signal while performing these commands were guide as a map to motor areas that need to be preserved when tumor was excised. Programming was done, delineating the tumor and its relation to the motor areas and the important fiber tracts as imaged by DTI. This programmed image was synchronized with the neuronavigation equipment to guide in real time the dimensions in which the tumor should be excised. Patients were prepared for surgery after anesthesia fitness. Patients were operated in elective neurosurgery theatre by the surgical team under neuronavigation guidance, taking special care to spare the important tracts and functional motor eloquent areas. On 1st post-operative day patient's motor power was assessed according to MRC power scale and was defined as having no deficit or deficit. All the data was analyzed via SPSS v.27. Motor deficit was estimated as frequency (%). Data was stratified for age of patients, sex, ASA status, and size of glioma. Post-stratification, Chi-square test was applied to compare motor deficit in stratified groups. *P*-value ≤ 0.05 was considered as significant.

RESULTS

Sixty-four patients with glioma were included with the mean age of 31.20 ± 8.99 years. Among all, 30 (46.9%) were females and 34 (53.1%) were males. ASA physical status classification revealed that 36 (56.3%) patients were categorized as ASA I, while 28 (43.8%) were classified as ASA II. The average glioma size measured 20.92 ± 8.98 mm. The mean MRC score on the first day 4.75 ± 0.73 , which improved to 4.87 ± 0.57 by the end of the first month. 9 patients (14.0%) had motor deficit on the first day of assessment while only 4 patients (6.25%) had motor deficits on 1 month follow up. (Table 1)

Table 1
Basic Demographics and Clinical Parameters of Enrolled Patients (n = 64)

Variables	Frequency
Age (Years)	31.20 ± 8.99
Sex	Females 30 (46.9%)
	Males 34 (53.1%)
ASA	I 36 (56.3%)
	II 28 (43.8%)
Size of glioma (mm)	20.92 ± 8.98
Motor Deficit at day 1	9 (14.0%)
MRC score at day 1	4.75 ± 0.73
Motor deficit at 1 month	4 (6.25%)
MRC score at 1 st month	4.87 ± 0.57

Figure 1
Frequency Distribution of Motor Deficit at 1st Day

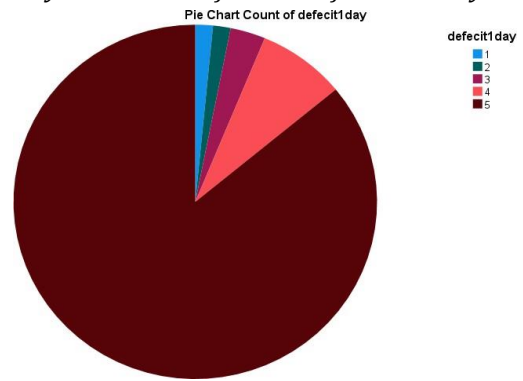
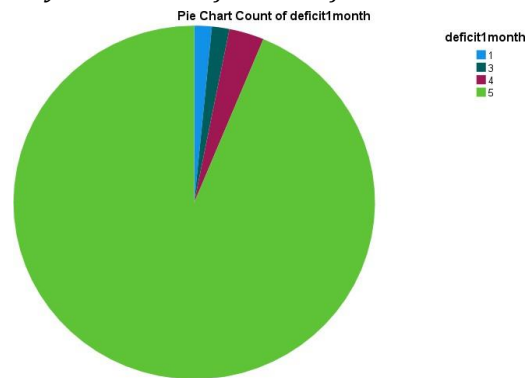


Figure 2
Frequency Distribution of Motor Deficit at 1 Month



At the first month of follow-up, motor deficit was detected in 1 patient who had age ≤ 40 years while in 3 patients who had age >40 years ($p = 0.052$). Among male patients, motor deficit was present in 1, whereas in female patients, it was seen in 3 (29.4%) ($p = 0.373$). Regarding ASA classification, the motor deficit was noted in 2 patients with ASA I status and in 2 patients with ASA II status. Similarly, in patients with a glioma size ≤ 20 mm, motor deficit was observed in 1 compared to 3 in those with a glioma size >20 mm ($p = 0.23$). (Table 2)

Table 2
Comparison of Motor Deficit at 1st Month between Age Groups Gender, ASA and Size of Glioma

Variables	Motor Deficit at 1 st Month		p-value
	Yes (n = 4)	No (n = 60)	
Age of patients	≤ 40 years 1 (2.22 %)	44 (97.7%)	0.238
	>40 years 3 (15.7%)	16 (84.2%)	
Gender	Male 1 (2.94%)	33 (97.05%)	0.373
	Female 3 (10%)	27 (90%)	
ASA	I 2 (5.6%)	23 (94.4%)	0.740
	II 2 (7.14%)	26 (92.8%)	
Size of Glioma	≤ 20 mm 1 (2.7%)	36 (97.3%)	0.283
	>20 mm 3 (12.2%)	24 (88.8 %)	

DISCUSSION

The most common and dangerous brain tumors in humans are gliomas, which have a poor prognosis and a high rate of morbidity. Significant deficits in motor function could result from gliomas entering the motor system, which could harm the white matter architecture to varying degrees. ¹²⁻¹⁴ In this study, on the 1st month follow up motor deficit was observed in 4 (6.25%) patients with glioma surgery with integrated exoscopic neuro-

navigation, fMRI, and DTI. An excellent EOR can be obtained without adversely affecting the patients' outcome, according to a group from the University of California, San Francisco that published their experience with surgery for tumors primarily located within the motor cortex. This suggests that the tumors are indeed amenable to resection and shouldn't be classified as unresectable. 49 patients with gliomas in the motor cortex who underwent surgery for resection were included in their series. Although just 4% of the 49 patients were deemed severe, 60% of them experienced a new motor impairment and 20% experienced a persistent new deficit.¹⁵

Surgical resection carries the risk of leaving the patient with post op deficits such as motor or sensory deficits, therefore mapping the cortex before and during tumor resection is of great importance to minimize the risk of postoperative neurological sequelae. According to a study conducted in Jaipur, India. 34 patients were operated under DTI guidance out of which 4 (11.7%) developed post-operative motor deficits.⁶ According to Mamani et al., 82% of patients had motor strength between 4 and 5 on the MRC motor scale; in the immediate postoperative term, that percentage fell to 61%. Within the first month of the follow-up period, 79% of patients regained their motor capability, and 79% of patients scored 4 or 5 on the motor scale after a 6-month follow-up.¹⁶

According to Mamani et al.'s findings, the EOR for gliomas close to the motor tract did not significantly affect the patients' ultimate motor outcome, as was determined in the earlier series.^{16,17,18} According to the Medical Research Council assessment, Shams et al. showed that approximately 37% of patients had preoperative motor function abnormalities when they first arrived. When comparing groups, the superior part of the tracts' profiles showed the most non-overlapping diffusion MRI

differences. As apparent diffusion coefficient axial diffusivity and radial diffusivity rise, fractional anisotropy and fibre density fall.¹²

According to another study by Gong et al., the cingulate gyrus had a higher prevalence of low-grade gliomas (LGGs) (69.47%). Overall, the most frequent histological diagnosis was diffuse astrocytoma (40.00%). Midcingulate cortex glioma was the most common sub-regional tumor (54.74%), followed by anterior cingulate cortex glioma. EOR > 90% was obtained by 83 patients (87.37%) out of all participants. EOR ≥ 90% was obtained by 58 patients (87.88%) in the LGG group. There was a strong correlation between survival and EOR attainment (P = 0.006). Short-term morbidity in either language or motor function was substantially linked to Midcingulate cortex instances (P = 0.02). Nearly 90% of anterior cingulate cortex cases were free of permanent morbidity, and the majority (80.65%) were devoid of any short-term impairments.¹⁹

CONCLUSION

Based on the findings of this study, it can be concluded that at the one-month follow-up, motor deficits—evaluated using the MRC power scale—were observed in 34.38% of patients who underwent glioma surgery with integrated exoscopic neuro-navigation, fMRI, and DTI at the Punjab Institute of Neurosciences, Lahore.

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