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Setup presentation and clinical outcome analysis of treating language-eloquent gliomas via preoperative navigated transcranial magnetic stimulation and tractography

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Purpose

Awake surgery combined with intra-operative direct electrical stimulation (DES) and intraoperative neuro-monitoring (IONM) is considered the gold standard for the resection of highly language-eloquent brain tumors. Different modalities such as functional magnetic resonance imaging (fMRI) or magnetoencephalography (MEG) are commonly added as adjuncts for preoperative language mapping but have been shown to have relevant limitations. Thus, the present study presents a novel multimodal setup consisting of pre-operative navigated transcranial magnetic stimulation (nTMS) and nTMS-based diffusion tensor imaging fiber tracking (DTI FT) as an adjunct to awake surgery.

Methods

Sixty consecutive patients (63.3% men, 47.6 ± 13.3 years; Table 1) suffering from language-eloquent left-hemispheric low-grade glioma (LGG) or high-grade glioma (HGG) underwent preoperative nTMS language mapping (Figure 1) and nTMS-based DTI FT (Figure 2), followed by awake surgery for tumor resection. Both nTMS language mapping and DTI FT data were available for resection planning and intraoperative guidance. Clinical outcome parameters, including extent of resection (EOR), language deficits, and Karnofsky performance status (KPS) score were evaluated.

Patient characteristics		
Age (in years; mean ± SD & range)		47.6 ± 13.3 (23.9 – 73.9)
Gender (% of patients)	Male	63.3
	Female	36.7
Tumor entity (% of patients)	WHO °I	1.7
	WHO °II	21.7
	WHO °III	30.0
	WHO °IV	46.6
Maximum tumor diameter (in cm; mean ± SD & range)		3.7 ± 1.4 (1.4 – 7.4)
Time to follow-up (in months; mean ± SD & range)		21.3 ± 16.0 (3.0 – 63.6)

Table 1: Patient characteristics
SD: standard deviation, WHO: World Health Organization.

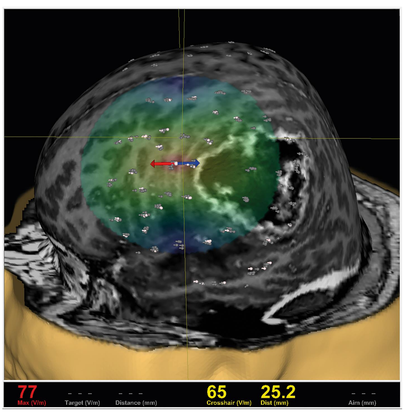

Figure 1: Preoperative language mapping by nTMS
This figure depicts preoperative nTMS language mapping in an example case of a patient with an angular glioma. Both language-negative nTMS spots (grey) and language-positive nTMS spots (white) are displayed. The colored arrow represents one selected stimulation point and the localization of the induced electric field during stimulation.

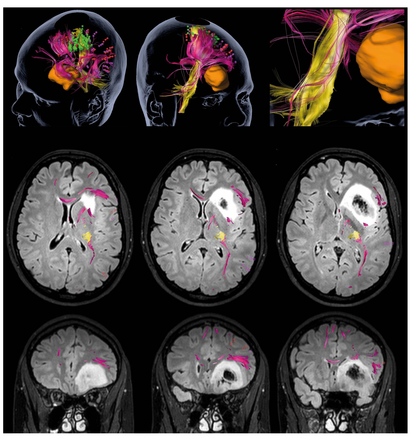

Figure 2: Preoperative nTMS-based DTI FT
This figure shows nTMS-based DTI FT, with language-positive nTMS spots (red & purple) serving as seed regions for tractography. Language-related fibers (red & purple) are displayed in relation to the tumor volume (orange) in this example case of a patient suffering from an insular glioma.

Results

Regarding the EOR according to postoperative evaluation, 28.3% of patients showed tumor residuals (Figure 3), whereas new surgery-related permanent language deficits occurred in only 8.3% of patients (Figure 4). KPS scores remained unchanged (median preoperatively: 90; follow-up: 90).

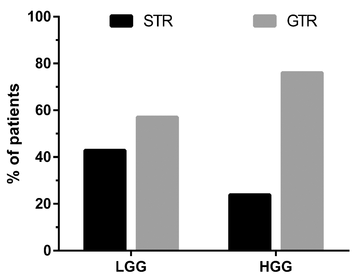

Figure 3: Extent of resection
STR: subtotal resection, GTR: gross total resection, LGG: low-grade glioma, HGG: high-grade glioma.

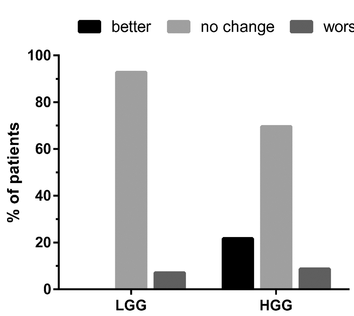

Figure 4: Language deficits during follow-up (3 months after tumor removal)
LGG: low-grade glioma, HGG: high-grade glioma.

Conclusion

This is the first study to present a clinical outcome analysis of the modern approach of combined preoperative nTMS language mapping and nTMS-based DTI FT, which is increasingly applied in neuro-oncological centers worldwide. Although the human language function is a highly complex and dynamic cortico-subcortical network, the presented approach offers excellent functional and oncological outcomes in patients undergoing surgery of lesions affecting this network, represented by high fractions of GTR combined with low rates of permanent language deficits.