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 intraoperative 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 preoperative navigated transcranial magnetic stimulation (nTMS) and nTMS-based diffusion tensor imaging (DTI) as an adjunct to awake surgery.

Methods
Sixty consecutive patients (83.3% 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 (Figure 2), followed by awake surgery for tumor resection. Both nTMS language mapping and DTI 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.

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).

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, 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.

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: Extent of resection
Figure 1 shows an example of a patient with left-hemispheric glioma. 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.

Figure 3: Language deficits during follow-up
Figure 2 shows an example of a patient with left-hemispheric glioma. 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.

Figure 4: Language deficits during follow-up
Figure 3 shows an example of a patient with left-hemispheric glioma. 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.