Preoperative fiber tracking (FT) enables visualization of white matter pathways. However, the intraoperative accuracy of preoperative image registration is reduced due to brain shift. Intraoperative FT is currently considered the standard of anatomical accuracy, while intraoperative imaging can also be used to correct and update preoperative data by Intraoperative MRI-based elastic fusion (IBEF). However, the use of intraoperative tractography is restricted due to the need for additional acquisition of diffusion imaging in addition to scanner limitations, quality factors, and setup time. Since IBEF enables compensation for brain shift and updating of preoperative FT, the aim of this study was to compare intraoperative FT with IBEF of preoperative FT.

Preoperative MRI (pMRI) and ioMRI, both including diffusion tensor imaging (DTI) data, were acquired between February and November 2018. Anatomy-based DTI FT of the corticospinal tract (CST) and the arcuate fascicle (AF) was reconstructed at various fractional anisotropy (FA) values on pMRI and ioMRI, respectively. The intraoperative DTI FT, as a baseline tractography, was fused with original preoperative FT and IBEF-compensated FT, processes referred to as rigid fusion (RF) and elastic fusion (EF), respectively. The spatial overlap index (Dice coefficient [DICE]) and distances of surface points (average surface distance [ASD]) of fused FT before and after IBEF were analyzed and compared in operated and nonoperated hemispheres.

Seventeen patients with supratentorial brain tumors were analyzed. On the operated hemisphere, the overlap index of pre- and intraoperative FT of the CST by DICE significantly increased by 0.09 maximally after IBEF. A significant decrease by 0.5 mm maximally in the fused FT presented by ASD was observed. Similar improvements were found in IBEF-compensated FT, for which AF tractography on the tumor hemispheres increased by 0.03 maximally in DICE and decreased by 1.0 mm in ASD.

Preoperative tractography after IBEF is comparable to intraoperative tractography and can be a reliable alternative to intraoperative FT [1)].

Tractography is a useful technique that is standardly applied to visualize subcortical pathways. However, brain shift hampers tractography use during the course of surgery. While intraoperative MRI (ioMRI) has been shown to be beneficial for use in oncology, intraoperative tractography can rarely be performed due to scanner, protocol, or head clamp limitations. Elastic fusion (EF), however, enables adjustment for brain shift of preoperative imaging and even tractography based on intraoperative images. The authors tested the hypothesis that adjustment of tractography by ioMRI-based EF (IBEF) correlates with the results of intraoperative neuromonitoring (IONM) and clinical outcome and is therefore a reliable method.

Methods: In 304 consecutive patients treated between June 2018 and March 2020, 8 patients, who made up the basic study cohort, showed an intraoperative loss of motor evoked potentials (MEPs) during motor-eloquent glioma resection for a subcortical lesion within the corticospinal tract (CST) as shown by ioMRI. The authors preoperatively visualized the CST using tractography. Also, IBEFs of pre- and intraoperative images were obtained and the location of the CST was compared in relation to a subcortical lesion. In 11 patients (8 patients with intraoperative loss of MEPs, one of whom also showed loss of MEPs on IBEF evaluation, plus 3 additional patients with loss of MEPs on IBEF evaluation), the authors examined the location of the CST by direct subcortical stimulation (DSCS). The authors defined the IONM results and the functional outcome data as ground truth for analysis.

Results: The maximum mean ± SD correction was 8.8 ± 2.9 (range 3.8-12.0) mm for the whole brain and 5.3 ± 2.4 (range 1.2-8.7) mm for the CST. The CST was located within the lesion before IBEF in 3 cases and after IBEF in all cases ($p = 0.0256$). All patients with intraoperative loss of MEPs suffered from surgery-related permanent motor deficits. By approximation, the location of the CST after IBEF

could be verified by DSCS in 4 cases.

Conclusions: The present study shows that tractography after IBEF accurately correlates with IONM and patient outcomes and thus demonstrates reliability in this initial study [2)].

1)
Zhang W, Ille S, Schwendner M, Wiestler B, Meyer B, Krieg SM. Tracking motor and language eloquent white matter pathways with intraoperative fiber tracking versus preoperative tractography adjusted by intraoperative MRI-based elastic fusion. J Neurosurg. 2022 Feb 25:1-10. doi: 10.3171/2021.12.JNS212106. Epub ahead of print. PMID: 35213839.
2)
Ille S, Schroeder A, Wagner A, Negwer C, Kreiser K, Meyer B, Krieg SM. Intraoperative MRI-based elastic fusion for anatomically accurate tractography of the corticospinal tract: correlation with intraoperative neuromonitoring and clinical status. Neurosurg Focus. 2021 Jan;50(1):E9. doi: 10.3171/2020.10.FOCUS20774. PMID: 33386010.