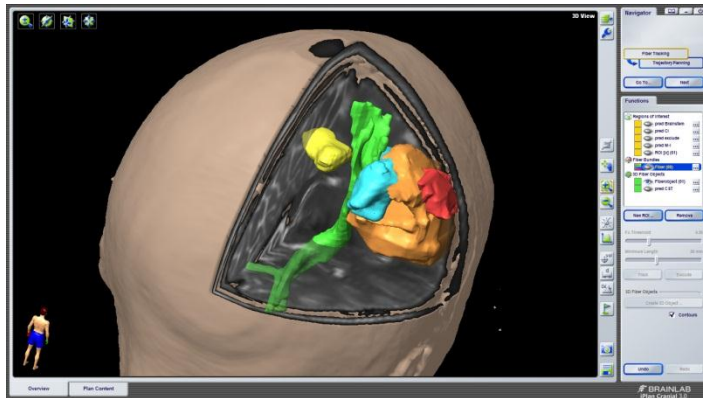


# FULL UTILIZATION OF BRAINLAB PRODUCT PORTFOLIO IN GLIOMA SURGERY

Clinical Case Report By D. Netuka, O. Bradáč, S. Ostrý, ÚVN Military Hospital, Prague

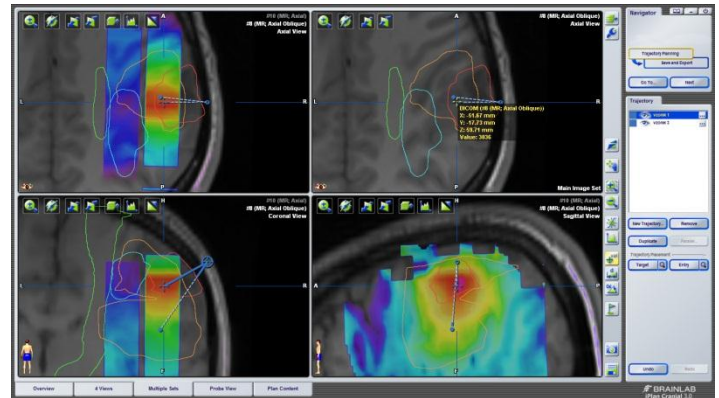
A 37 year old female was presented with an epileptic seizure. MR imaging showed an expansive intra-cerebral lesion in the right fronto-parietal area with collateral edema and a 2 mm midline shift toward the left side. The central part of the lesion was contrast enhancing. We suspected the lesion to be a secondary high grade glioma. The tumor was assumed to be close to or infiltrating the cortico-spinal tract (CST), according to anatomical landmarks on the pre-operative MR scan. The neurological status before surgery was normal. Our pre-operative planning protocol consisted of a navigation MR study (MR T1 with contrast), diffusion tensor imaging (DTI), functional MRI (fMRI) with motor tasks and Spectroscopic Imaging (CSI). All datasets were fused and post-processed in iPlan Cranial version 3.0.



**Figure 1**  
3D preoperative image plan with coloured objects: high grade glioma (red), low grade glioma (orange), CST (green), fMRI hand activation (blue), fMRI foot activation (yellow)

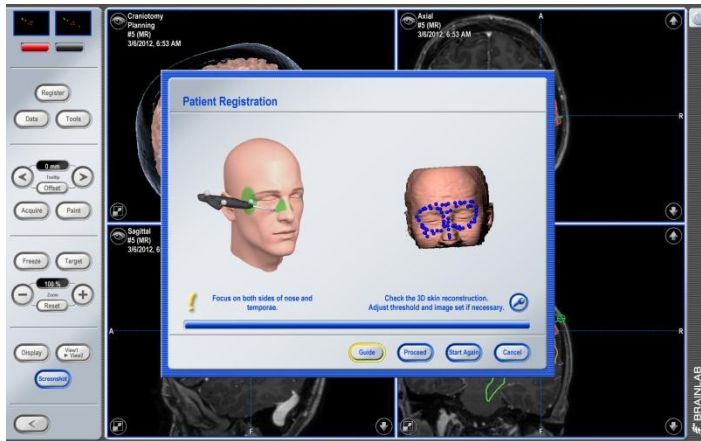
Both parts of the tumor were outlined: the non-enhancing part (suspected low-grade glioma [LGG] marked in orange) and the enhancing part (high-grade glioma [HGG] in red). The cortico-spinal tract (CST) is displayed in green. The MR T1 revealed infiltration of the CST by the LGG, whereas the HGG only compressed the tract (see **Figure 1**). The minimal distance between HGG and the border of CST was 12.6 mm. This was measured in all axes and documented via screenshots in iPlan 3.0.

The Spectroscopic Imaging (CSI) data was measured using 2D PRESS-CSI sequence and processed by jSIPRO software. Metabolite images of Creatin/Choline, Creatine/N-acetyl aspartate and Choline/N-acetyl aspartate have been calculated and exported in DICOM format for iPlan import. Points of maximum metabolite ratios were identified and two trajectories for a biopsy from these 'hot spots' were prepared (see **Figure 2**). The pre-operative surgical plan was to resect only the high-grade part of tumor radically, as the resection of the LGG would have led to destruction of the CST, which would have caused a hemiparesis, at the very least.



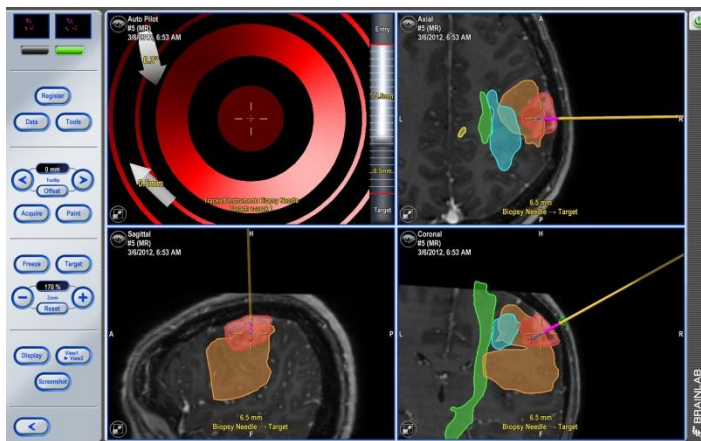
**Figure 2**  
Pre-operative plan showing MR Spectroscopy (CSI) data over an anatomical MR: Two trajectories were planned based on the spectroscopic information for biopsy before resection. The target area lays within the 'hot spot', which can be identified in red (center of the HGG)

For surgery, the patient was positioned supine; the patient's head was turned to the left. Surface matching registration with Softouch was used (see **Figure 3**). Detailed visual accuracy checks on several landmarks confirmed good accuracy in the Cranial Navigation software version 2.1. Softouch registration became a standard technique of registration in our department. We prefer not to use fiducials since they may fall off and extra shaving is required and, in some cases, the scan necessary for navigation is performed the day prior to surgery. In these instances fiducials are not very convenient for the patient. Landmark registration may be useful in selected cases, but less precise. Softouch becomes superior to Z-touch when patients are positioned in prone or a significant amount of recording cables are connected to the patient's head. After registration, a linear incision was made and a craniotomy over the lesion was performed.



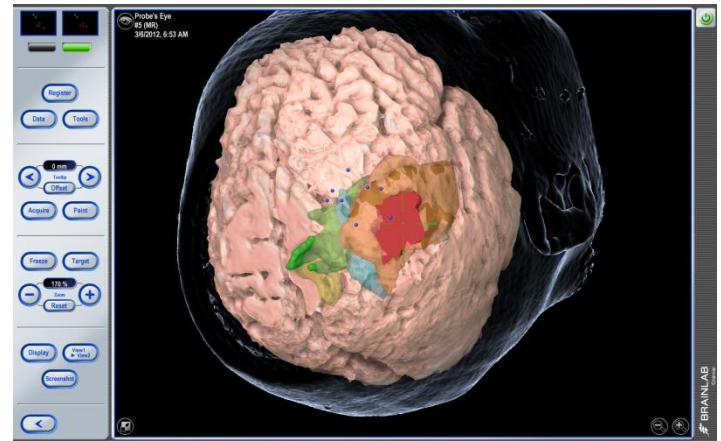
**Figure 3**  
Surface matching registration process with Softouch. The guide mode allows for optimal support. It takes certain landmarks like the lateral canthi and nasion into account and allows for continuous point acquisition.

After craniotomy, biopsies along two pre-planned trajectories were performed through one small dural opening using VarioGuide (see **Figure 4**). During every pass, several samples were taken from each 'hot spot' for further histopathological evaluation.



**Figure 4**  
Biopsy with VarioGuide and pre-calibrated biopsy needle (needle shown in yellow, biopsy window in pink). First target point was planned within the HGG (red object).

After durotomy, the central sulcus (CS) was identified by median nerve somatosensory evoked potential phase reversal (SEP-PR). The median nerve was stimulated with constant current on the contra-lateral wrist. Cortical mapping was performed to directly identify the primary motor cortex (PMC) using a 6-pole strip electrode placed over suspected central region on the cortical surface. Position of the strip was changed several times until phase reversal pattern was achieved<sup>1</sup>. The stimulation probe tip was incorporated into the navigation software through tool calibration (see **Figure 5**). The stimulation technique was monopolar (anodal) with reference on the scalp (Fpz). The stimulus was constant current, square monophasic delivered as fast short train (5 pulses, 500Hz, pulse width 400µs, stimulation frequency 0.8Hz)<sup>2,3</sup>.



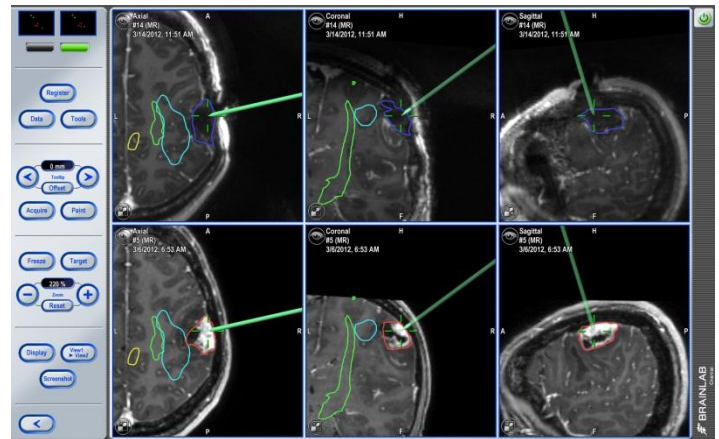
**Figure 5**  
Cortical mapping. Actual position of navigated stimulation probe (large cross), Stimulation points before resection are displayed in blue.

Motor evoked potentials (MEPs) were recorded by pairs of stainless steel needle electrodes from a standardized set of muscles of the contralateral upper and lower extremities, regularly used in all supratentorial procedures with motor functions monitoring (abductor pollicis brevis [APB], abductor digiti quinti [ADV], extensor digitorum communis [EDC], biceps brachii [BB]; quadriceps [Q], tibialis anterior [TA], medial head of gastrocnemius [GC] and abductor hallucis [AH]). Stimulation parameters were: sensitivity 100 µV/div, timebase 10 ms/div, bandpass 50-1500 Hz and no averaging. The MEP threshold was set in each stimulation point. The MEP threshold was defined as stimulation current for eliciting consistent response from at least one of the muscles with minimal MEP amplitude 50µV. The entire opened cortical surface was mapped. PMC was evaluated as an area with the lowest MEP threshold and in context with SEP-PR. The strip electrode was replaced on the PMC. That strip contact placed over the area with the lowest MEP threshold was used as a stimulation electrode (anode) for continuous MEP monitoring (cont-MEP). The stimulation parameters were identical as used in cortical mapping. The stimulation intensity was near MEP threshold and the stimulation frequency was 0.15Hz to prevent galvanic damage. Cont-MEPs were monitored during the entire tumour resection. MEP threshold increase by 2mA was considered as a significant change, the surgeon was warned and the resection interrupted. Further MEP threshold increase or absence of MEP induced alarm, and further resection was stopped immediately.

The resection cavity was mapped repeatedly to assure resection safety, to identify and compare the MEP-mapped CST with tractography in the navigation and to adjust our surgical strategy accordingly. The stimulation probe used for subcortical mapping was identical to the one used for cortical mapping. Active electrode was switched to cathode. The stimulation and registration parameters remained identical to the ones used prior for cortical mapping. Each MEP threshold and probe tip position were matched and recorded in the cranial navigation software. Mapping of the cavity wall was performed several times during surgery depending on surgeon indication or cont-MEP monitoring abnormality. This was done both before and after the intra-operative MR scan (iMRI).

After the resection of the HGG and the mapping of the cavity, the surgeon ordered an intra-operative MR scan. The patient was prepared and transferred from OR to MR room using the Maquet shuttle. All steps were timely, convenient and well organized by the OR staff. The scanning process itself took 15 minutes, which included a MR T1 and a DTI sequence. Return transport to the surgical position was recorded with 7 min, most time consumed by "recabeling" the patient to the OR anaesthesia machine. Therefore, the complete process to perform an intra-operative MR scan took 32 minutes.

The intra-operative MR scan confirmed radical resection of high-grade part of the tumor (see **Figure 6**). The intra-operative MR scan was registered to the pre-operative data via automatic image fusion in cranial navigation 2.1. In this particular case no further resection, but new cortical and subcortical stimulation were performed in order to compare the electrophysiological data with the updated anatomical data from iMRI. Each stimulation point was acquired in the cranial navigation software and matched with MEP threshold current. The distance between the stimulation point and the CST border were measured offline post-operatively in iPlan v.3.0. Further analysis included correlation of the intra-operative CST to MEP.



**Figure 6**  
The navigation pointer position indicates the resection cavity (intra-op MR, upper row, blue outline) confirming a complete resection of the HGG (pre-op MR, lower row, red outline).

Pre-operative planning was helpful for the biopsies and to achieve the pre-surgical goal to radically resect the enhancing part of the tumor (HGG), leaving the LGG in place. Furthermore, planning was valuable for the primary surgical approach based on the provided CST and fMRI information to not harm these areas.

The postoperative course was uneventful. The patient showed no signs of paresis. The histological examination revealed anaplastic astrocytoma. As further patient treatment, radiotherapy and chemotherapy were applied. The follow-up MRI after 3 and 7 months did not show any contrast enhancing lesion and a reduction of the remaining lesion in the MR T2 weighted images was recorded. The Karnofsky score is 100.

#### References

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