Evaluation of an advanced navigation approach for intraoperative MRI by retrospective analysis of neurosurgical procedures

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Purpose

Evaluation of an advanced navigation approach for intraoperative MRI guidance by retrospective analysis of neurosurgical cases with respect to procedural safety, radicality of resections, diagnostic yield of biopsies, time exposure, and potential benefit of the additional use of fMRI information.

Patients and Methods

Image guidance for our open 0.5T MRI (Signa SP/i, GE Medical Systems, Milwaukee, WI) was available (1) in the standard mode (GE guidance), based on continuous MR scans where image quality relies on a trade-off between SNR and frame rate, but images are up-to-date with surgery and deliver dynamic information (insertion of tools, brain tissue shift) and (2) in the advanced mode (LOCALITE guidance, LOCALITE GmbH, Bonn, Germany), based on interpolated images from reference data, delivering high quality images in real time with optional data fusion, requiring extra effort and final control scans because image data is static only. A total of 110 cases in 109 patients were performed over 3.5 years, 96 cases performed by just 3 neurosurgeons were included for analysis (Tab. 1). To exclude a possible bias between operators we also compared only the resection data for the 'leading' surgeon with the majority of cases. The completeness of resection was assessed by MR, the accuracy of the biopsies by their histological evaluation. In 16 cases, additional fMRI information after data fusion was used for craniotomy. Post-operative neurological situation and deficits were rated as either worse, same, or better compared to the pre-operative status. The period of time between initial and final control scans was used as a measure for the time requirements and is given as median and range. The time to availability of the reference data imposed by their extraction from the host data base and subsequent transfer to the navigation workstation was calculated from the individual process times and recorded number of transfers.

Results

Two intracranial hemorrhages (2.1%) occurred, one in each group. Using LOCALITE guidance, resections were classified as 38% total, 48% subtotal and 14% partial, compared to 39% total, 43% subtotal and 17% partial resections with GE guidance (Fig. 1). The time requirements for the advanced mode, 4:35 (2:18-7:55) hrs, was not significantly longer than that observed for scan-guided resections, 4:22 (2:27-5:41) hrs, despite the time-consuming reference data access of the new approach (Fig. 2). Intraindividually, resections were more radical (Fig. 3) and even slightly faster - 4:05 (2:47-6:55) hrs vs. 4:08 (2:27-5:35) hrs - compared to GE guidance. Post-op neurological status with functional information was worse in 21.4%, same in 57.1%, and better in 21.4% of the cases, in comparison with 31.8%, 54.5%, and 13.6%, respectively, under GE guidance only. Biopsies taken from tumor entities of comparable size - 22.2 (0.5-59.6) ml vs. 22.9 (1.6-91.6) ml - resulted in a higher diagnostic yield (94% vs. 77%) and required 2:10 (1:21-4:30) vs. 1:38 (1:14-2:28) hrs (Figs. 4 and 5). The time to availability of the reference data on the navigation PC contributed an average of almost 20 min for each resection and more than 10 min for each biopsy. The average processing time for fMRI data fusion was 13 min.

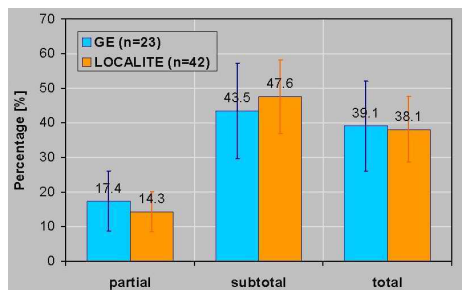|	GE	LOCALITE	
Resections	23	42	= 65
Biopsies	13	18	= 31

▲ **Tab. 1** Summary of neurosurgical cases under intraoperative MRI guidance

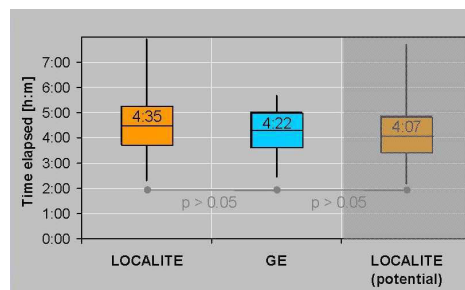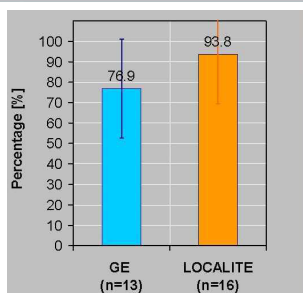► **Fig. 1** Radicality for three surgeons
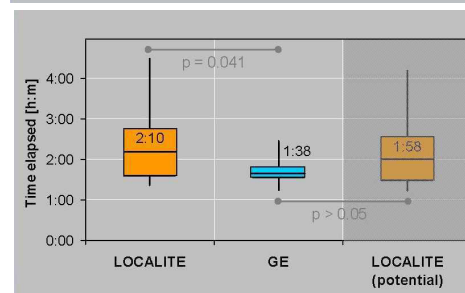
►► **Fig. 2** Time requirements for resections
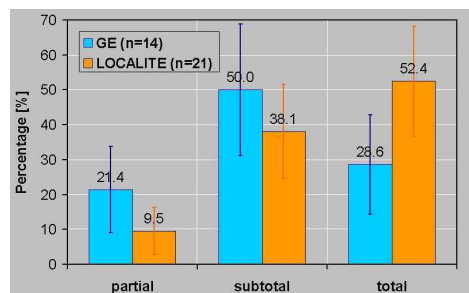
▲ **Fig. 3** Radicality for 'leading' surgeon

▲ **Fig. 4** Diagnostic yield of biopsies

▲ **Fig. 5** Time requirements for biopsies

Discussion

Resections under LOCALITE guidance showed a slightly higher radicality at comparable time exposures. This effect was more pronounced for the 'leading' surgeon. Biopsies had a higher diagnostic yield but took 32 min longer. Potentially, the LOCALITE-guided interventions, in particular those requiring frequent intraoperative control imaging may be performed even faster by improving the availability of the reference data currently acquired and stored on the MR host computer only. In conclusion, we believe that our approach is safe and highly effective for neuronavigation. It combines the advantages of intraoperative MRI guidance with those of conventional (functional) neuronavigation. Our data suggest that the integration of fMRI information might have a beneficial effect for the immediate development of the neurological situation. All reported improvements, however, were not statistically significant. Also, the new approach is an add-on rather than a substitute for GE guidance, because all interventional maneuvers still need to be verified by actual MR scans.

References

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