Anatomically Guided Neuronavigation:
Sample Applications of the SulcusEditor in a Clinical Setting

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Summary. The clinical use of the SulcusEditor (SE) on an everyday basis for preoperative analysis of 3D MRI data sets of neurosurgical patients is reported. The SE is applied to MRI data sets of patients with tumors in the central and the temporal region of the brain in order to trace the individual sulcal pattern. This leads to a better understanding of the topographical relationships between the tumor and the surrounding tissue. Hence the operating neurosurgeon is provided preoperatively with detailed knowledge concerning the area of interest, eventually leading to a reduction of the operating trauma. Three cases of patients with tumors in the central region are shown examplarily.

Key words: Neuronavigation, brain tumors, magnetic resonance imaging

1 Introduction

To provide the operating neurosurgeon with knowledge concerning the topography of a brain tumor is an important goal of preoperative magnetic resonance imaging. Yet the neurosurgeon has to create a three-dimensional 'mental image' of the anatomical relationships by looking at plane MR slides. Although workstations for neuronavigation using correlated triplanar displays support the surgeon, an automatical detection of eloquent cortical regions is not yet feasible. Since functional aspects are closely related to morphology a sensitive detection of anatomical structures is needed. There is, however, a substantial lack of exact lesion site definition with regard to the 'functional environment' of the tumor. Although the SulcusEditor (SE) essentially uses a morphological approach, it provides detailed information concerning the exact localization of a mass and its relationship to the surrounding functionally intact nervous tissue. So far 41 patients underwent the SE procedure.

2 Methods

For SE analysis T1-weighted 3D FLASH data sets were acquired using a Magnetom 1.5T imaging system (Siemens Medical Systems, Erlangen, Germany, SL=1.6 mm) as well as a Gyroscan T5-NT (Philips Medical Systems, Best, The Netherlands, SL=

3.0 mm, Easy-Guide MR scan protocol). The results of the SE procedure had to be made available to the neurosurgeons within a period of 48 hours after acquisition of the MR sequence including bidirectional data transfer. The individual tumor site was scrutinized by identifying and interactively labelling 10 to 12 sulci neighbouring the lesion. The selection of the sulci took into account the intended trepanation site as well as the eloquent areas that had to be bypassed during operation.

3 Results

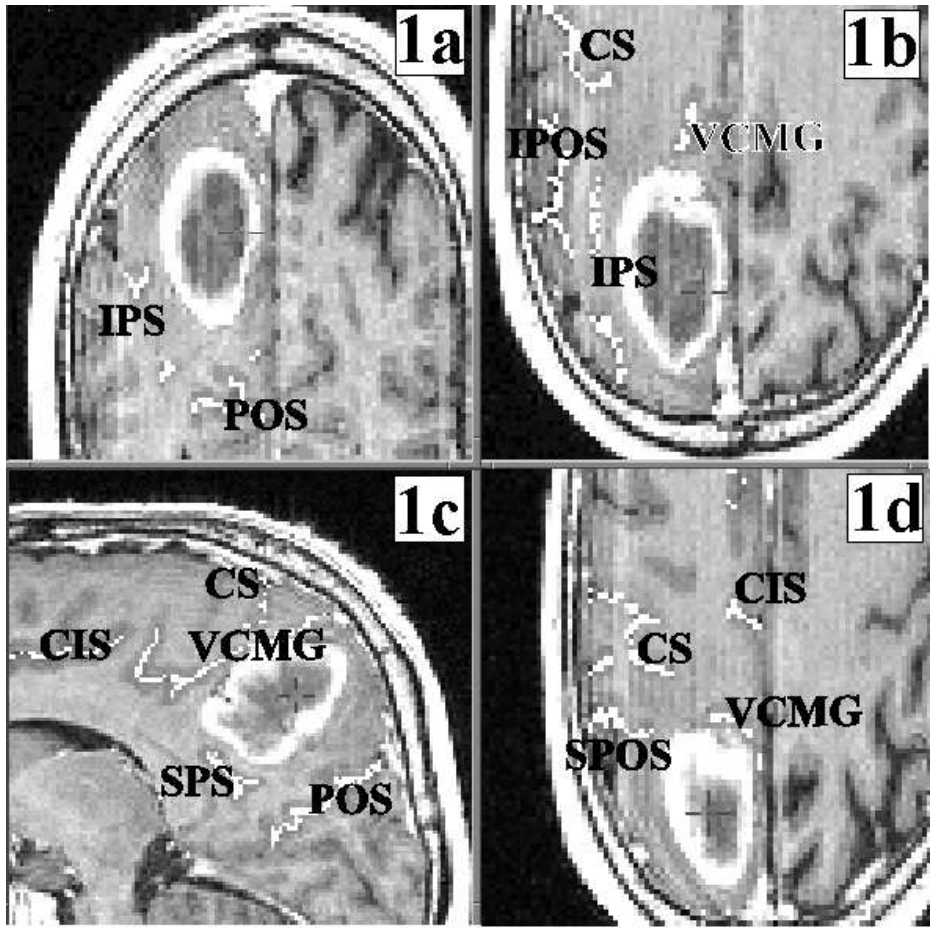
Case p0056: A 65-year-old female presenting with an isolated right-sided hemiparesis (power 4/5). Initial MRI scanning was interpreted as a left-sided centrally located contrast enhancing lesion with surrounding edema. Preoperative SE analysis showed that the tumor was situated posterior to the central sulcus within the postcentral gyrus and also embraced the dorsal tip of the superior postcentral sulcus. The vertical branch of the cingulate sulcus was displaced posteriorly. In its medial aspect the tumor was confined to the paracentral lobule. During operation the SE findings were confirmed. Histological analysis showed a metastasis of an adenocarcinoma.

Case 179: A 50-year-old male who presented with a loss of consciousness, a left-sided hemiparesis, and a hemihypesthesia. Initial CT and subsequent MR imaging both showed parietal postcentral atypical bleeding, suspectible for a tumor. Further investigation revealed a mass with a rim enhancement and a diameter of 3-4 cm that was located in the parietal region. SE analysis showed that the vertical branch of the cingulate sulcus was displaced anteriorly. The superior portion of the postcentral gyrus was also shifted rostrally. Concludingly the tumor was located in the precuneus. Since the interparietal sulcus passed the tumor laterally in its complete extent the tumor was solely situated in the superior parietal lobule [Fig.1]. During intraoperative preparation along the pseudo-membrane the rostral demarcation of the mass by the postcentral sulcus was corroborated. The tumor appeared to be reaching the midline. Postoperative histological workup revealed a glioblastoma.

Case 1131: A 33-year-old female who exhibited a seizure with loss of consciousness during work. Initial CT and MR imaging showed a huge mass with a right medial frontal location that compressed the anterior horn of the lateral ventricle. Preoperative analysis with the SE revealed that the huge tumor was situated in the superior and middle frontal gyri, displacing the superior and middle frontal sulcus laterally. Seen from the medial aspect the cingulate sulcus traversed the tumor area although the corpus callosum was displaced ventrally. Thus the tumor additionally involved the cingulate gyrus. During operation the neurosurgeon removed the tumor - histologically a grade II astrocytoma - essentially from the superior frontal and cingulate gyri. However in the area of the posterior margin the brain tumor interface was not clearly visible.

Figure 1. *Case 179***.** Example of the tracing results in correlated triplanar display. Frontal (1a), axial (1b), and sagittal (1c) view. Sulci labelled: cingulate sulcus (CIS), central sulcus

(CS), inferior postcentral sulcus (IPOS), interparietal sulcus (IPS), superior postcentral sulcus (SPOS), subparietal sulcus (SPS), vertical branch of cingulate sulcus (VCMG)



4 Discussion

Interactive definition of the sulcal topography of a tumor in a triplanar correlated display has several advantages. The labelling procedure enables initial definition of segments of a sulcus which can unequivocally be defined in a slice. Using these definitions as starting points 3D continuity detection of the sulcus even in unfavourable section planes is possible. Thus reviewing the data set a definite recognition of the structure in every section plane is possible. Unravelling the cortical landscape the tumor is embedded in enables a specific detailed verbal representation of its topography. This verbal representation complements the surgeon's 'mental image' with detailed information for the minimally invasive neurosurgical approach.

5 References

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