5. Workshop Automatisierungstechnische Verfahren für die Medizin vom 15.-16. Oktober 2004 in Saarbrücken

„Intraoperative imaging for updating neuronavigation“

C. Nimsky, O. Ganslandt, B. von Keller, R. Fahlbusch
Department of Neurosurgery, University Erlangen-Nürnberg, Erlangen, Germany
E-Mail: nimsky@nch.imed.uni-erlangen.de

Band: „Tagungsband, Automed 2004“
Editors: W. I. Steudel
ISBN: 3-00-013509-X
Pages: 13-14

Intraoperative imaging for updating neuronavigation

C. NIMSKY, O. GANSLANDT, B. VON KELLER, R. FAHLBUSCH

Department of Neurosurgery, University Erlangen-Nürnberg
Schwabachanlage 6, 91054 Erlangen

E-Mail: nimsky@nch.imed.uni-erlangen.de

INTRODUCTION

Brain shift, which is caused by tumor removal and loss of cerebrospinal fluid during surgery, results in a decreasing reliability of neuronavigation systems. Intraoperative image data reflect the actual 3-D-structure of the brain during surgery. So these can be used for an update of neuronavigation systems [Nimsky2000]. However, patient registration with intraoperative image data, e.g. by the application of bone fiducials around the surgical field, proved to be cumbersome. The aim of this study was to localize tumor remnants by updating the neuronavigation system with intraoperative image data without repeated patient registration.

METHODS

A 1.5T Magnetom Sonata (Siemens Medical Solutions, Erlangen, Germany) in combination with microscope-based neuronavigation was used for pre- and intraoperative imaging [Nimsky2004]. The intraoperative image data are send via intranet (100MBit) from the scanner to the planning station of the navigation system. Pre- and intraoperative images are registered using the ImageFusion Software (IPlan cranial 1.0, BrainLab, Heimstetten, Germany), which performs a semi-automatic rigid registration, i. e. after a rough alignment by the user the images are registered by the software using a rigid registration algorithm applying an intensity based pyramidal approach using mutual information [Studholme1996], [Thevenaz1996]. Then the remaining tumor is segmented manually. Due to the registered images this contour is displayed on pre- and intraoperative images. All image data are then transferred to the navigation system without altering the patient registration file, so that a restoring of the previous patient to image registration (which was done at the beginning of surgery with the preoperative image data only) can be performed. This is possible due to a negligible positional shift between the initial registration and the updating, because of a rigid head fixation with a defined relative position of the head in the fixation clamp to the reference star, which is tracked by the navigation cameras.

RESULTS

Between April 2002 and July 2004 394 patients underwent intraoperative high-field MRI. In 149 of the 178 craniotomy cases microscope-based neuronavigation was applied, in 81 with integrated further multimodal data from fMRI, MEG, diffusion tensor imaging, or MR spectroscopy. In 32.9 % (49/149) intraoperative imaging revealed some remaining tumor that could be further resected, so that the intraoperative image data were used to update the navigation system. The tumor remnants could be localized reliably in all cases, thus increasing the extent of resection. In Fig. 1 an illustrative case of co-registered pre- and intraoperative images is depicted.

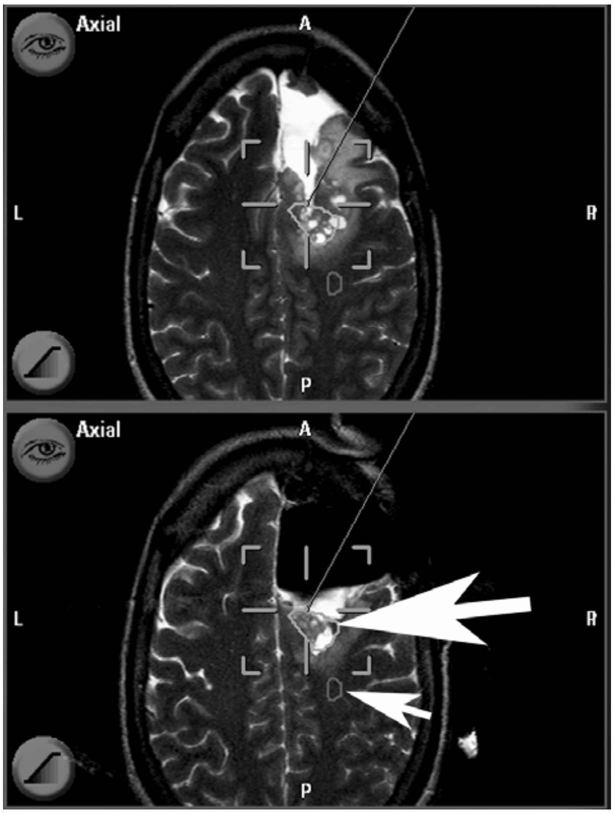

Fig. 1: Recurrent right frontal astrocytoma WHO III in a 33 years-old female patient; co-registered T2-weighted axial images (upper: pre-, lower: intraoperative), the large white arrow depicts the segmented tumor remnant adjacent to the pyramidal tract (small arrow) identified by diffusion tensor imaging.

DISCUSSION

Registered pre- and intraoperative images could be navigated simultaneously, improving the interpretation of intraoperative image changes. Updating of the navigation by registration of pre- and intraoperative image data and restoring the initial patient registration proved to be very efficient and time-consuming. This update procedure is much more comfortable, than the methods that were established before, which needed a re-registration of the patient, which was often complicated due to the restricted surgical field. Now preservation of functional markers during updating seems workable, as well as further image processing of intraoperative image data, which can directly be used during the same operation, seems to be possible. This opens new possibilities of updating the navigation system with various data, i. e. not only an intraoperative anatomical update, but also updating function, pathways, and metabolism, integrated by fMRI, diffusion tensor imaging, and MR spectroscopy, respectively.

CONCLUSION

Updating of neuronavigation systems with intraoperative image data allows a reliable localizing of tumor remnants, compensating for the effects of brain shift. Intraoperative high-field MR imaging offers the additional possibility to obtain intraoperative functional data which are otherwise lost by the update procedure.

REFERENCES

[Nimsky2000]
C. Nimsky, O. Ganslandt, S. Cerny, P. Hastreiter, G. Greiner, R. Fahlbusch, "Quantification of, visualization of, and compensation for brain shift using intraoperative magnetic resonance imaging" *Neurosurgery* Vol 47, p 1070-1080, 2000

[Nimsky2004]
C. Nimsky, O. Ganslandt, B. v. Keller, J. Romstöck, R. Fahlbusch, "Intraoperative high-field strength MR imaging: implementation and experience in 200 patients", *Radiology* Vol 233, 2004

[Studholme1996]
C. Studholme, D. Hill, D. Hawkes, "Automated 3-D-registration of MR and CT images of the head", *Medical Image Analysis* Vol 1, p 163-175, 1996

[Thevenaz1996]
P. Thevenaz, M. Unser, "A pyramid approach to sub-pixel image fusion based on mutual information" in *Proc. IEEE International Conference on Image Processing* 1, p 265-268, 1996