

Chapter 28

Neurosurgical Operations Using Navigation Microscope Integration System

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ABSTRACT

The use of intraoperative navigation systems in neurosurgery has increased rapidly. The Neuronavigation Microscope Integration (NMI) system consists of a microscope (Zeiss, Germany) combined with the StealthStation (Medotronic, U.S.A.) including light emitting diodes, a dynamic reference frame with light emitting diodes, an optical digitizer with camera array and a computer workstation. The aim of this study was to determine the usefulness of the NMI system for neurosurgical operations. Between April 2003 and March 2011, the authors used the NMI system in 367 patients undergoing neurosurgical operations at Kagawa University Hospital. Because the navigational informations could be superimposed onto the microscope view, accurate locations of tumor and normal anatomical structures could be obtained before skin incision. During the operations, the surgeons did not need to turn away from the surgical field or to use a bulky pointer. Catheter applications along the tumor borderline guided by the NMI system could be useful for glioma surgery. Deep seated lesions including intraventricular or intra-axial tumors could be removed through accurate and minimal corticotomy. For transsphenoidal surgery, pituitary tumors could be safely removed without X-ray imaging. For the skull base surgery, the navigational information was not affected by the brain shift during the operations. The registration assessment deviations were within 2 mm and the real anatomical deviations were within 3 mm. The authors' findings suggest that the NMI system can provide valuable and reliable intraoperative navigational informations during neurosurgical operations.

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INTRODUCTION

The use of intraoperative navigation system in neurosurgery has increased rapidly (Brinker, 1998; Enchev, 2009; Germano, 1999; Golfinos, 1995; Roessler, 1997; Samii, 2000; Sipos, 1996; Takizawa, 1993; Uluc, 2009; Watanabe, 1991; Yoshikawa, 2006). Computer-assisted neuronavigation for the intraoperative viewing of anatomical landmarks is increasingly used for the surgical removal of intracranial lesions. Neuronavigation simultaneously represents a complex, multimodal, information-based, highly adaptable technique, method, or device using frameless stereotaxy for precise intraoperative guidance, orientation, and localization, with consequently greater surgical precision and possibilities for preoperative virtual simulation and postoperative analysis of the surgical procedures (Enchev, 2009). The Neuronavigation Microscope Integration (NMI) system is composed of a microscope (Zeiss, Germany) and the StealthStation® (Medtronic, U.S.A.) that includes light emitting diodes, a dynamic reference frame with light emitting diodes, an optical digitizer with a camera array and a computer workstation. The aim of the study was to evaluate the suitability and usefulness of the NMI system for neurosurgical operations.

BACKGROUND

Operating microscopes have improved tremendously since they first entered the operating room. Today they offer good magnification without significant aberrations, sufficient illumination without excessive heat, and satisfying stability without sacrificing operational flexibility. Modern microscopes have already started to combine multiple visualization techniques (Uluc, 2009). These microscopes can display intraoperative navigation informations simultaneously.

In contrast, neuronavigation simultaneously represents a complex, multimodal, information-

based, widely adaptable technique, method, or device using frameless stereotaxy for precise intraoperative guidance, orientation, and localization, with consequently greater surgical precision as well as the potential for preoperative virtual simulation and postoperative analysis of the surgical procedure.

MAIN FOCUS OF THE CHAPTER

Registration of the Neuronavigation Microscope Integration (NMI) System

Intraoperative image guidance was achieved using a NMI system composed of a microscope (Zeiss, Germany) and StealthStation® (Medtronic, USA). Accuracy in image-guided surgery directly depends on how well the radiographic images and surgical anatomy of the patient is correlated. The process of establishing a computer map between all locations on the images and the corresponding anatomical locations in the surgical field is called *registration*. Registration is initiated using the disposable skin fiducial markers (Medtronic, U.S.A.) and surface landmarks, which correlate with the same points on the three-dimensional CT/MRI surface reconstruction of the skin. The StealthStation system (Medtronic, U.S.A.) employs two different methods for achieving object alignment and transformation: PointMerge™ registration and SurfaceMerge™ registration. PointMerge registration is the primary method and must be used for each surgery. SurfaceMerge registration is a secondary method employed in the spinal application as a refinement to the PointMerge method. Both methods attempt to find the best coordinate system transformation between image space and surgical space by aligning the user-defined objects contained within them. The difference between the methods lies in how the computer represents the objects internally and how the computation of the 'best' alignment changes with this representation (Figure 1).

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