Placement of Deep Brain Stimulator Electrodes Using Real Time Image Guidance

A. Martin[1,2], P. Larson[3], K. Sootsman[4], N. Lindsey[3], P. Talke[5], O. Weber[1], J. Meyers[3], P. Starr[3]

[1]Radiology, University of California - San Francisco, San Francisco, CA, United States, [2]Philips Medical Systems, Cleveland, OH, United States, [3]Neurosurgery, University of California - San Francisco, San Francisco, CA, United States, [4]Image Guided Neurologics, Melbourne, FL, United States, [5]Anesthesia, University of California - San Francisco, San Francisco, CA, United States

Introduction

Placement of deep brain stimulators (DBS) within structures such as the sub-thalamic nucleus (STN) or globus pallidus is an increasingly popular therapy for patients with neurological movement disorders such as Parkinson's disease. Due to the extreme precision with which these devices must be placed, DBS electrodes are delivered with stereotactic techniques and monitored with micro-electrode recordings. The latter is used to infer the true probe position during surgery and requires an awake, cooperative patient. However, multiple brain penetrations may be necessary in order to achieve an acceptable micro-electrode signature. In this study, we investigate the use of direct real time image guidance as a means of delivering DBS electrodes. The technique may be performed on anesthetized patients and does not require either stereotaxy or microelectrode recordings.

Methods

Imaging was performed on a 1.5 T magnet (Philips Intera, Best, The Netherlands) in a suite equipped with an in-room console. All patients signed an informed consent form that was approved by the university's committee on human research. Patients were anesthetized and locked to the MR table-top by a head frame. An RF coil consisting of two 20 cm diameter circular loops was placed bilaterally against the patients head. A burrhole was created and a trajectory guide (Nexframe, Image Guided Neurologics, Melbourne, FL) was attached to the skull. A fluid filled 14 cm long "stem" was inserted into the trajectory guide to indicate its orientation.

Patients were then transferred to magnet isocenter and high resolution T_2-weighted spin echo images were acquired to delineate the STN and establish the pivot point of the trajectory guide. The path between the selected target in the dorsolateral STN and the pivot point of the trajectory guide represented the desired insertion path for the DBS lead. Trajectory guide alignment was achieved with a fluoroscopic acquisition in a scan plane perpendicular to and centered on the desired trajectory. This scan plane was positioned approximately 10 cm from the patient's skull, where only the tip of the fluid filled stem would be visible. The neurosurgeon then reached into the magnet and adjusted the trajectory guide until the stem was centered in this imaging plane. The trajectory guide was then locked and two orthogonal acquisitions were performed along the desired trajectory to assure correct orientation of the guide.

Following alignment of the trajectory guide, the fluid filled stem was removed and a peel away introducer sheath with a titanium stylet was advanced to the STN. Confirmation scans along the desired trajectory were performed during this introduction process. After confirmation of successful placement in the dorsolateral STN, the stylet was removed and a 28 cm long DBS lead (DBS lead model 3389, Medtronic, Minneapolis, MN) was advanced to the target through the sheath. The high resolution T_2-weighted spin echo sequence was then repeated to confirm lead placement and rule out hemorrhage. Finally, the peel away sheath was removed and the lead was anchored to the skull.

Results

To date, six DBS electrodes have been inserted in four patients with this approach. In 33% of procedures there was appreciable brain shift in the ipsilateral frontal lobe following burrhole access. Since definition of the target within the STN was performed only after burrhole access, however, this did not affect our targeting accuracy. Since the desired target would not be immediately identifiable on all our acquisitions, we used the high resolution T_2-weighted scans to determine the 3D coordinates of the target in the dorsolateral STN. These coordinates were subsequently used to mark the desired target in acquisitions where the contrast or scan plane did not allow optimal visualization of the STN. Similarly, the 3D coordinates of the trajectory guide's pivot point were noted; however, this point was easily visualized on all acquisitions. In all cases it was possible to accurately align the trajectory guide towards the intended target (Figure 1a).

Insertion of the titanium stylet was monitored in three stages, each separated by approximately a third of the distance from entry to the STN (Figure 1b-d). These scans were used to confirm that the prescribed trajectory was being followed and to check for hemorrhage. A final high resolution acquisition was performed once the target had been reached, the stylet removed and DBS lead inserted (Figure 1e). Acceptable positioning within the STN was achieved on the first pass in 5/6 cases, with two passes required in one case. Mean error from the intended target was 1.0 mm +/- 0.6 mm (range = 0.1mm – 1.9 mm). There were no intraoperative or post-operative complications.

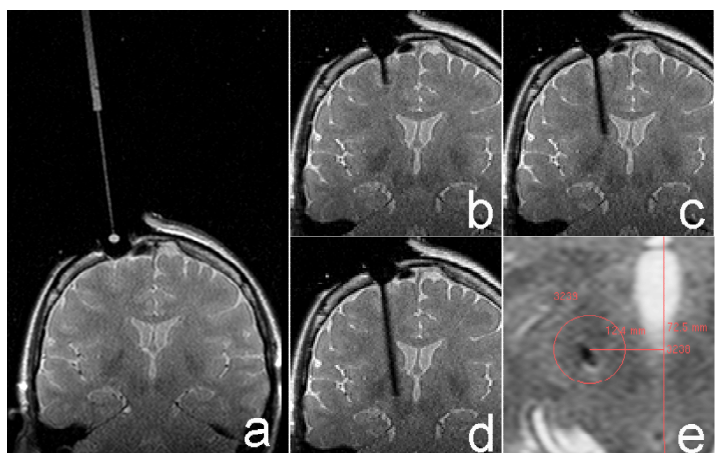

Figure 1: The orientation of the trajectory guide is demonstrated following alignment (a). Insertion of a rigid titanium stylet is monitored to confirm its trajectory and screen for hemorrhage (b-d). Following placement, stylet position is compared with the intended target, which is indicated by the center of the red circle (e).

Conclusions

Our initial experience with the delivery of DBS electrodes with real-time image guidance indicates that the approach is both feasible and practical. It has the benefits of being able to determine the anatomic target following burrhole access, efficiently align a trajectory guide, and monitor insertion to assure appropriate placement prior to completing surgery. Moreover, it can be done on anesthetized patients without need for stereotactic frame placement, micro-electrode recordings or withholding anti-Parkinsonian medications.