DBS Electrode Positioning Accuracy in the STN and GPi with Intraoperative MR Guidance

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Introduction

Deep brain stimulation (DBS) is a therapy that is presently applied to patients with movement disorders and is being investigated for use under other conditions, including epilepsy and depression. DBS is achieved by placing an electrode at specific locations in the brain via surgical intervention and connecting this electrode to an implanted pulse generator. The clinical benefit afforded by DBS is highly dependent on electrode positioning and thus targeting accuracy during electrode implantation is crucial. We have previously described a technique for utilizing intra-operative MR to implant DBS electrodes (1) and more recently developed an optimized system (2) in collaboration with a corporate partner (ClearPoint, MRI Interventions, Irvine, CA). In this abstract we report on the accuracy achieved with the new system and contrast this to our prior findings. We further evaluate whether accuracy is affected by the selected deep brain structure.

Methods

The optimized DBS implantation system consists of a trajectory guide that can be remotely actuated and control SW that visualizes the procedure and provides instructions on where to penetrate the skull and how to achieve alignment with a selected deep brain structure. The trajectory guide contains a linear fluid filled alignment indicator with an open central lumen through which devices can be inserted. Initial course alignment is achieved with prospective stereotaxy methods, and fine adjustments are subsequently achieved by fitting the signal from the alignment indicator to a linear function and projecting that into the brain. Adjustments are made to the trajectory guide until this projection closely intersects the intended target (within 0.3mm). Once alignment is achieved a rigid ceramic mandrel within a peel-away sheath is inserted through the guide’s central lumen to the specified depth. If acceptable positioning is achieved, the mandrel is withdrawn, leaving the sheath as a placeholder. The electrode is inserted through this sheath, which is subsequently peeled away.

Patients undergoing MR guided DBS implantation were anesthetized and their skull secured to the MR tabletop (Philips Achieva 1.5T). A special sterile drape is employed that permits motion between the rear opening to the magnet, where skull penetration and trajectory guide mounting are performed, and magnet isocenter, where the implantation procedure is actually performed. The RF coil is an array of two 19cm diameter open circular surface coils that are placed laterally on the patient’s head.

Results

A total of 20 patients (37 electrodes) have undergone DBS implantation with the new system. The STN was targeted in 11 PD patients (22 electrodes), while the GPi was targeted in 3 PD patients (5 electrodes) and 6 dystonia patients (10 electrodes). PD patients averaged 63.5 years old while dystonia patients averaged 19.2 years old. Acceptable placement was achieved with a single brain penetration in 36/37 (97%) electrodes implanted with this approach. The magnitude of the targeting error was 0.7±0.4mm when the STN was targeted and 0.7±0.4mm when the GPi was targeted. On average, the electrode position was 0.2mm posterior and 0.1mm medial to the intended target for both the STN and GPi. This implies that our errors are scattered around the intended target and minimal bias is evident (statistically insignificant at this point). The similarity in targeting results implies that accuracy for different deep brain structures is relatively constant with this approach. Our results compare favorably with our initial study, which achieved a targeting accuracy of 1.0±0.6mm and had a single brain penetration in 84% of cases (n=82 electrodes).

Conclusions

An optimized DBS implantation system is able to achieve consistently high targeting accuracy and permits electrode positioning with a single brain penetration in a very high percentage of cases. Accuracy was not affected by the selected deep brain target and minimal bias is evident. Initial results demonstrate improvement over our prior findings.