Feasibility, Safety, and Clinical Utility of Proton Magnetic Resonance Spectroscopy in the Presence of Deep Brain Stimulators (DBS) for Parkinson's Disease (PD)

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Introduction: Parkinson's Disease (PD) and Alzheimer's Disease (AD) are both neurodegenerative disorders during the course of which elderly patients may develop dementia. Early diagnosis of dementia, and defining the underlying disease(s) will have an important impact on effective treatment and its outcome[1]. Magnetic Resonance Spectroscopy (MRS) and Magnetic Resonance Imaging (MRI) are important new tools which can assist in diagnosis of AD and PD and differentiate between them[2]. New treatments of PD, including deep brain stimulation (DBS) bring with them the promise of not merely treatment but cure[3]. An important aspect of a curative treatment such as DBS will be the ability to identify and reverse developing dementia. MRS is the ideal diagnostic tool for this task Although it is known that MR is safe for patients with DBS under well described conditions[4], it is unknown whether MRS is feasible due to possible effects of the electrodes used in DBS.

Methods: Twenty controls and fifteen patients with well-defined PD were examined. Furthermore, two PD patients were examined before and one year after implantation of bilateral DBS (Medtronics, Minnesota). The study was approved by the IRB of Huntington Memorial Hospital and informed consent was obtained from both patients. All data was acquired on a 1.5T clinical MR scanner using the standard RF head coil. Specific absorption rates (SAR) of all sequences fell below guidelines of 0.1 W/kg. The neurosurgeon was available throughout. Prior to the post-surgical exam, DBS were set to amplitude of 0 and switched off. Patients were instructed prior to MRI to report any unusual sensations and were continually monitored visually and verbally. After the exam, the DBS were evaluated for functionality and were activated.

T2w FSE imaging was used to localize the striatum of the basal ganglia. A voxel was placed in the left basal ganglia (BG) as well as the posterior cingulate gyrus (PCG) and anterior white matter (WM) as shown in Figure 1. The initial exam was planned with the neurosurgeon to ensure that the initial voxel could be replicated in the follow-up exam without including any portion of the electrode. Special care was taken in the follow-up exam to ensure that the positions of all the voxels were replicated in all three planes by utilizing images of voxel placement from the initial exam. BG spectra were acquired with PRESS (TE=35ms, TR=1500ms) and a voxel size of 13x15x15 mm^3 with 256 averages. Spectra from the PCG and WM were acquired using the same PRESS parameters but with a voxel size of 20x20x20 mm^3 and 128 averages. Aside from standard reconstruction, no additional data processing of the spectra was necessary.

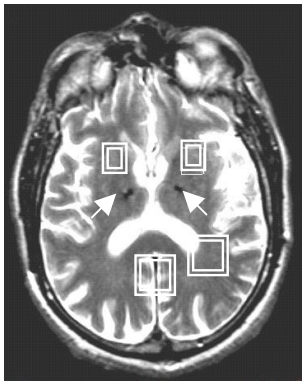

Figure 1. MRS voxel positions. Arrows indicate DBS implants.

Results: ^{1}H MRS between PD and control demonstrated significantly increased Cho/Cr and mI/Cr in the basal ganglia. Although significantly decreased NAA/Cr was found in both PCG and WM, these changes were not as dramatic as those found in AD[5]. Metabolite ratios in the two DBS patients were not significantly different from the PD (P>0.05). There were no ill effects felt by the patient during or after the MRS exams. Neurostimulators were fully functional after the exam. Spectra obtained from the PCG and WM were highly reproducible before and after surgical implantation of the DBS (Figure 2). Spectra acquired in the basal ganglia were minorly impacted by the presence of the electrodes resulting in susceptibility artifacts after 3.6 ppm. However, NAA, Cr, Cho, and Glx peaks were free from artifact and also highly reproducible (Figure 3). There was no presence of lactate and NAA/Cr was not significantly reduced in the post-DBS exams indicating that DBS surgery and therapy did not damage neurons.

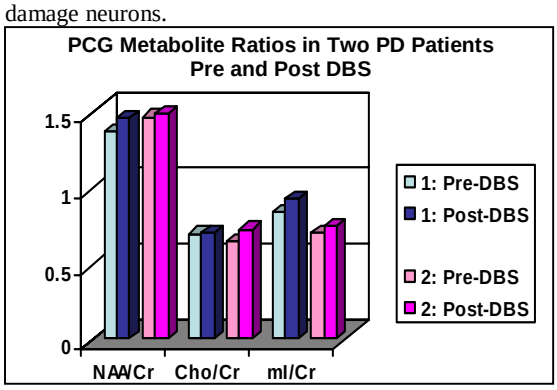

Figure 2. PCG metabolites before and after DBS

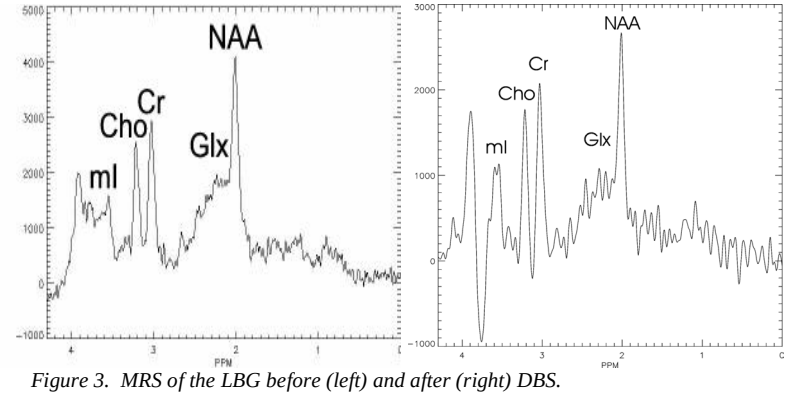

Figure 3. MRS of the LBG before (left) and after (right) DBS.

Conclusion: 1) MRS effectively and safely monitors neuronal health in patients with PD who are undergoing DBS. 2) Adjacent DBS electrode placement did not damage neurons. 3) No neuronal damage was associated with continuous DBS over 1 year. 4) Potential for long-term evaluation of dementia in PD and therapeutic benefits of DBS can be determined with ^{1}H MRS.

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