

Changes in RF transmit gain before and after DBS lead placement in 36 consecutive patients

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Introduction: Safely obtaining MR head exams of patients who have implanted deep brain stimulator (DBS) leads presents an important clinical problem. MRI can be used intra-operatively to determine whether the leads have been placed in their desired locations and to assess for complications such as bleeds. Other uses of MRI for patients with implanted DBS leads include post-operative assessment to rule out infection, and the pre-surgical planning for the placement of additional leads. Deposition of excessive RF energy, however, can cause lead-tip heating that can result in injury or death of the patient [1-4]. Recommended maximum limits for specific absorption rate (SAR) have been determined from in vitro measurements of lead tip heating in phantom experiments [5-7]. These recommended SAR limits can be further tailored to the specific MRI system and to the individual patient with calibration methods [8-9]. Direct, in vivo, proton resonance frequency-based temperature measurements near the lead tip are not reliable because of the rapid spatial variation of susceptibility. Also, local SAR simulations generally do not account for conducting structures. Consequently, indirect methods, such as the one describe here, are useful.

It is generally well-accepted that MR head exams of patients with implanted DBS leads can be safe, *provided* that a specific imaging protocol is carefully followed. The protocol recommended by the manufacturer includes use of a transmit/receive (T/R) head coil at 1.5T and a maximum limit of 0.1 W/kg average head SAR [10]. (Note that this is average head SAR, and *not* whole-body SAR.)

The limit of 0.1 W/kg average head SAR can be restrictive. Direct measurement of the interaction between the DBS leads and RF field in vivo is difficult, but potentially could be useful for refining the recommended SAR limits. Some information can be inferred from the appearance of the MRI images themselves. The DBS leads do not produce any MR signal, but typically have minimal effect on MR image quality. The purpose of this work is to investigate potential indirect effects of the DBS leads on the RF field and RF subsystem. Specifically, the RF power level, as measured by the transmit gain (TG) level provided by auto-prescan, was analyzed for systematic changes in a group of patients before and after DBS lead placement.

Methods: 36 consecutive patients underwent DBS implantation in a two-room MR/OR suite [11]. Pre-surgical MR was performed with the standard birdcage T/R head coil on a 1.5T GE Healthcare scanner running 11.0 M4 software. Imaging series included a 3-plane localizer, volumetric T1-weighted imaging (IR-SPGR/MP-RAGE), and optional thin-slice T2-weighted FSE. For all exams in which the patient had one or more leads in place, the applied average head SAR was kept below 0.1 W/kg as determined by an MR Physicist. 28 patients had 2 leads and 8 patients had a single lead implanted (model DBS 3387, Medtronic, Minneapolis MN, USA). After surgical placement, the MR protocol was repeated, with the addition of a T2*-weighted gradient echo series. TG, as measured by auto-prescan was recorded for the 3-plane localizer before and after lead placement. All patients were fitted with a Leksell Model G head frame (Elekta, Stockholm, Sweden) for both exams. A specially-modified head coil platter with a groove insured consistent (to within a few mm) positioning of the head frame within the RF head coil from patient-to-patient, and between MR exams of the same patient. All pairs of MRI exams were performed on the same day, with a 2-4 hour gap between them.

Results: No adverse events resulted from the MR scanning. The change in transmit gain as measured and reported by auto-prescan was $\Delta TG = 0.111 \pm 4.65$ in units of 1/10 dB. In these units, 30 counts of TG corresponds to a factor 2 in RF power, so the fractional change in applied power was $\Delta P/P = 0.0026 \pm 0.11$. Figure 1 shows a histogram of the number of occurrences of each ΔTG value. Note the peak about $\Delta TG = 0$. Figure 2 shows a plot of ΔTG versus patient weight, with the "X" indicating placement of single lead. Paired t-tests indicate that the addition of DBS lead(s) does not have a statistically significant effect on ΔTG . For single lead placement $p > 0.42$ ($n = 8$), for double-lead placement $p > 0.38$ ($n = 28$), and for either number of leads $p > 0.89$ ($n = 36$).

Discussion and Conclusion: Placement of DBS leads does not significantly affect the RF power calibration, as measured by the change in transmit gain (TG) provided by auto-prescan. This suggests that the leads do not significantly detune the RF coil or significantly increase reflected power. Due to the small physical size of the lead tips, however, this does not imply that lead tip heating will be small. *Extreme caution during MR scanning of patients with implanted DBS leads remains warranted, and all of the manufacturer's recommendations should continue to be followed.* The data presented here, however, could be useful for refining SAR limits in the future.

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