

TEMPERATURE MEASUREMENTS OF DEEP BRAIN STIMULATOR LEAD TIP IN PHANTOM WITH MR BODY COIL RF TRANSMIT

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TARGET AUDIENCE: Medical Physicists, MR Scientists, Neuroradiologists, Neurosurgeons

PURPOSE: Manufacturer guidelines (Medtronic) for MR scanning of patients with implanted deep brain stimulators (DBS) prohibit scanning with receive-only head coils (using body coil transmit) and specific absorption rates (SAR) above 0.1 W/kg. However, manufacturers of MR-guided systems for DBS planning and implantation may only provide a receive-only head coil to be used during the procedure. One such system (MRI Interventions-ClearPoint) is FDA cleared, however the clearance does not include scans of DBS components with the receive-only head coil. During the procedure, to verify proper targeting, an MR-safe ceramic stylet is inserted into the desired position of the DBS primary lead tip. The proper position is confirmed with an MR scan. The neurosurgeon then replaces the ceramic stylet with the DBS primary lead. It is possible that the position of the DBS tip could deviate from that of the MR-safe ceramic stylet tip. Consequently, it is advantageous to perform a final MR verification with the DBS primary lead (and insertion stylet) while the patient is still in surgical position in case modification of lead tip position is required. Furthermore, some patients with already existing DBS systems could benefit from MR-guided implantation of a second DBS system or additional leads. These DBS MR scans, however, are contraindicated with receive-only head coils. The purpose of this study is to measure heating of DBS lead tip in phantom at high and low SAR levels under various DBS component configurations with body RF transmit / receive-only head coil.

METHODS: Measurements of DBS lead tip heating during MR scanning were made in a phantom built according to ASTM F2182-09 [1]. Six fluoroptic temperature probes (Luxtron-LumaSense) were placed in the phantom with 4 probes at the lead tip, 1 at the pulse generator and 1 in background material in the head of the phantom (Figure 1). The DBS components (Medtronic Soletra 7426 pulse generator, 3389-40 primary lead, and 7482A-51 lead extension) were arranged in three different configurations: full system, primary lead only (no extension, no pulse generator), and primary lead only with lead insertion stylet. In primary lead only and lead+stylet configurations, the lead or lead+stylet was oriented at different angles exiting the phantom to simulate clinical and "worst-case" situations (Figure 2). The scanning was performed on a Siemens Espree scanner with 15-minute high SAR (2.5-3 W/kg) and low SAR (0.03-0.06 W/kg) sequences. Recorded temperature histories (sampled at 1-second intervals) were used to determine maximal temperature increase over scan duration. Measurements were repeated using body coil and transmit-receive (T/R) head coil RF transmit.

RESULTS: Maximal temperature increases recorded at DBS lead tips (RF-heating) are shown in the table below. Body coil RF-transmit and T/R head coil RF-transmit resulted in similar RF-heating at the lead tip. RF-heating due to high SAR sequences was approximately 14 C while that due to low SAR sequences was approximately 0.2 C (full DBS system). Maximal temperature increases were recorded during scanning of the full DBS system (14.4 C) as compared to primary lead only (0.5 or 1.8 C) or lead+stylet (1.2 or 3.2 C) configurations. When positioned along the z-direction and angled 45 degrees up, RF-heating of the lead+stylet was 1.2 C as compared to 1.8 C for lead only configuration. A "worst case" alignment in which the lead+stylet was positioned towards the side of the bore and 45 degrees up resulted in increased RF-heating (3.2 C) compared to lead+stylet aligned along bore (1.2 C). Minimal temperature increases were observed for primary lead only and lead+stylet during all low SAR scans.

DISCUSSION and CONCLUSIONS: MR-guided targeting, planning and placement of DBS systems offers advantages to certain patient populations by allowing general anesthesia to be used and patients to remain on medications. Guidance systems may only include receive-only head coils, which are contraindicated by the DBS manufacturer. As MR-guided DBS implantation systems become more widely available there will be increased interest in obtaining final MR verification scans with the DBS primary lead in place while the patient is in the surgical suite and the lead can be easily repositioned [2]. Currently, there is no FDA-cleared method of MR scanning of patients with the primary lead only (extending outside the head) or lead+stylet configurations in place. The FDA-cleared approach to confirm DBS lead tip position via MR involves fully completing the DBS surgery, closing the surgical site, bringing the patient out of anesthesia or moving the sleeping patient attached to anesthesia to a location that supports scans with T/R head coil. If the DBS lead tip needs to be repositioned, the patient must return to surgery which, as results of this study and of reference [3] suggest, could add arguably greater risk than that of scanning a DBS lead+stylet with a receive-only head coil. In this study, body coil RF-transmit of DBS primary lead only and DBS lead + insertion stylet in clinically motivated geometries at low SAR resulted in temperature increases below 0.1 C. However, significant risks remain for MR scans on patients with DBS [4] especially when techniques outside manufacturer safe scanning guidelines are used. The MR community must remain extremely cautious when utilizing any off-label scanning technique.

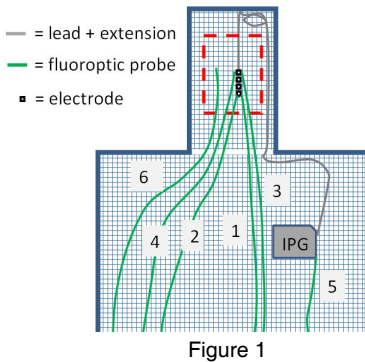


Figure 1

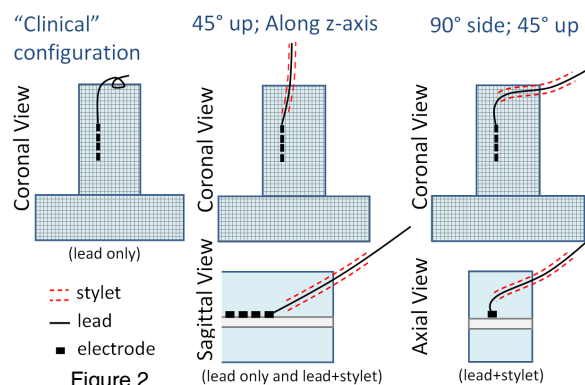


Figure 2

	Lead Tip Heating (Deg C)			
	Transmit coil:	Head		Body
SAR (W/kg):	3.0	0.06	2.5-2.8	0.03
Component - Config.				
Full DBS system	14.1	0.2	14.4	0.25
Lead Only - "Clinical" config.	1.1	< 0.1	0.5	< 0.1
Lead Only - "45° up along Z"	-	-	1.8	-
Lead+Stylet - "45° up along Z"	-	-	1.2	< 0.1
Lead+Stylet - "90° side, 45° up"	-	-	3.2	< 0.1

Table 1 ("-" indicates measurement not made)

REFERENCES: [1] ASTM Designation: F2182-09; [2] Larson, et. al. Stereotact Funct Neurosurg 2008;86:92-100; [3] Lin, et. al. <http://www.aapm.org/meetings/2012am/PRAbs.asp?mid=68&aid=17948>; [4] Finelli, et. al. Am J Neuroradiol 23:1795.