Utility of 7T Imaging for Deep Brain Stimulation Surgery

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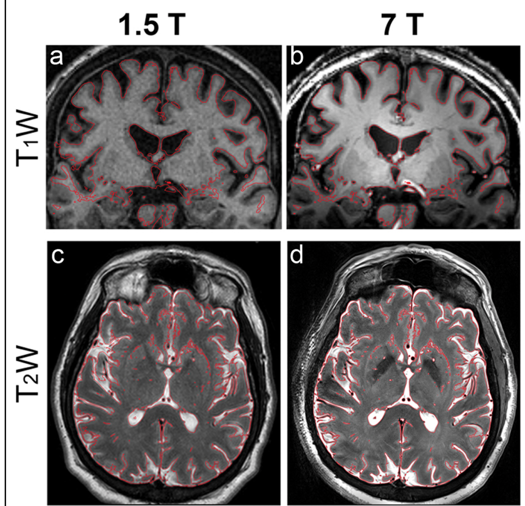
Introduction

Structural brain MR images acquired at 7 Tesla exhibit rich informational content with potential utility for clinical applications (Abosch et al, 2010). However, (1) substantial increases in susceptibility artifact, and (2) possibility of geometrical distortion at increased magnetic field strength, would be detrimental for stereotactic procedures such as DBS surgery, which typically use CT and/or 1.5T MR images for surgical planning. We previously addressed these two issues from a technical standpoint, demonstrating sub-millimetric distortion and absense of artifact in the midbrain region (Duchin et al, 2012). Here, we supplement technical findings with the clinical aspects of our investigation.

Methods

Seven candidates for DBS (8 electrodes) to treat Parkinson’s disease were scanned preoperatively on a standard clinical 1.5T, and 7T MRI scanner. Qualitative and quantitative assessments of global and regional distortion were evaluated based on anatomical landmarks and transformation matrix values, and postoperative electrode location assessed. Intraoperatively, 7T images were merged with stereotactic CT, and accuracy of the registration verified by windowing between datasets. Segmentations of STN SN, and RN on axial, coronal, and sagittal SWI and T2-weighted images at 7T, were used to generate 3D renderings of these structures. Postoperative CT and 1.5T MRI were then fused to preoperative datasets, and used to assess postoperative location of active electrode contacts based on DBS programming.

Fig. 1. Qualitative assessment of co-registration accuracy between 1.5 and 7T MRI



High degree of correspondance between 7T red iso-contour lines, superimposed on 1.5T images for T1 (fig a and b) and T2 (fig c and d), indicating minimal distortion.

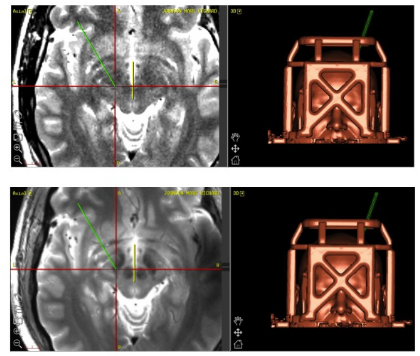
Results

Our analysis here demonstrates (1) successful co-registration between 1.5T and 7T images (Fig 1 and 2), and (2) demonstrates correspondance between intraoperative microelectrode recording data and postoperative analysis of DBS electrode location on preoperative 7T images (Fig).

Conclusions

7T MR images of the midbrain region yield comparable distortion to that observed at 1.5T. Clinical applications targeting structures such as the STN, are *feasible* and *clinically useful* with the enhanced informational content provided by 7T imaging.

Fig. 2. Intraoperative Neuronavigation Comparison of 1.5 vs. 7T



T2-weighted 1.5 (above) and 7T (below) images from the intraoperative imaging platform, showing electrode trajectory to target (green line). Note the enhanced image resolution of RN and STN at 7T compared to 1.5 T. Accuracy of co-registration was assessed qualitatively by windowing between 1.5 and 7T images.

Table 1. MER data for tracks in Fig. 4.

SubjCntr	Pos	Med	Lat	Ant
16-R	4.7	0	0NT	NT
26-L	D Cells	D	4.8	4.8

Learning Objectives

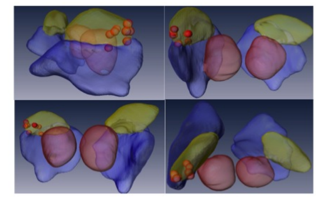
By the conclusion of this session, participants should be able to discuss the importance of high-field imaging on resolving deep brain structures.

References

1.Abosch A, et al. Assessment of current brain targets for DBS surgery with SWI imaging at 7T. Neurosurgery 67(6):1745-56, 2010.

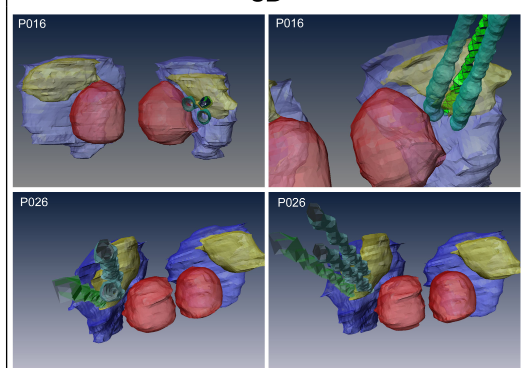
2. Duchin Y, et al. Feasibility of using ultra-high field (7T) MRI for clinical surgical targeting. PLoS ONE, May 2012, 7(5): e-37328.

Fig. 3. Composite 3D Active Contact Location



3-D location of active electrode contacts in each subject, mapped onto a single STN. Clockwise from left: sagittal, coronal-1, axial, coronal-2 STN, yellow; SN, purple; RN, red.

Fig. 4. Microelectrode Recording Tracks with DBS Electrode Location in 3D



Microelectrode recordings tracks plotted onto 3D renderings of STN, SN, and RN, with postoperative DBS electrode location. Note correspondance between MER track data (Table 1) and track locations in 3D relative to STN.