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Application of MRI-safe robot for stereotactic intracranial procedures: feasibility and accuracy in a cranial phantom model in the intraoperative MRI suite.

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Introduction

Stereotactic procedures targeting intracranial structures are common neurosurgical procedures and include needle biopsies, placement of DBS electrodes, laser ablation of metastatic lesions, or hippocampal laser ablation for epilepsy treatment. Navigation systems rely on preoperative imaging, affecting the accuracy due to shifts in the brain after the dural opening. This system adds real time validation of the target[1-10] . We report the results of feasibility and accuracy of the MRI-safe robot for intracranial stereotactic procedures with real time MRI imaging in a skull phantom.

Methods

A 3-degree of freedom (DoF) MR-safe robotic system [14] that is electricity free, is actuated by pneumatic motors[15], uses light for the position sensors, and does not include any conductive, metallic, and magnetic materials was used. The 18G needle is manually inserted through the guide and the depth of the needle is set by a 1-DoF needle depth driver after orientation. The robot was fixed to the table, and the mockup was fixed to the head holder. MR image set was acquired. Targets were selected in the images relative to the robot. After each targeting, additional images were

Conclusions

We demonstrate the feasibility of the use of the MRI compatible robot for Stereotactic procedures with real time imaging. We also demonstrate accuracy of this robotic-assisted procedure when targeting pre-determined locations based on real-time imaging.

Learning Objectives

To demonstrate the feasibility and accuracy of the use of an MRI-safe robot for stereotactic intracranial procedures.

Results

The robot was mounted successfully in the arm of the Mayfield cranial fixation system (Figure 1) in a way that if perfectly fit in the bore of the intraoperative MRI (Figure 2). Points in the intracranial grid in the skull phantom were chosen as targets after MRI. The robot was aimed at the coordinates set in the MRI images and the needle was placed intracranially (Figure 3). Targeting accuracy was 1.6 mm and precision was 0.81mm with 12 trials.

References

[1]F. Cardinale, M. Cossu, L. Castana, G. Casaceli, M. P. Schiariti, A. Miserocchi, et al., "Stereoelectroencephalography: surgical methodology, safety, and stereotactic application accuracy in 500 procedures," Neurosurgery, vol. 72, pp. 353-66; discussion 366, Mar 2013.
[2]D. Markowitz, D. Lin, S. Salas, N. Kohn, and M. Schulder, "Compact Intraoperative MRI: Stereotactic Accuracy and Future Directions," Stereotact Funct Neurosurg, vol. 95, pp. 197-204, 2017.
[3]M. Bot, P. van den Munckhof, R. Bakay, G. Stebbins, and L. Verhagen Metman, "Accuracy of Intraoperative Computed Tomography during Deep Brain Stimulation Procedures: Comparison with Postoperative Magnetic Resonance Imaging," Stereotact Funct Neurosurg, vol. 95, pp. 183-188, 2017.
[4]A. Y. Chan, D. K. Tran, A. S. Gill, F. P. Hsu, and S. Vadera, "Stereotactic robot-assisted MRI -guided laser thermal ablation of radiation necrosis in the posterior cranial fossa: technical note," Neurosurg Focus, vol. 41, p. E5, Oct 2016.
[5]S. Hunsche, D. Sauner, F. E. Majdoub, C. Neudorfer, J. Poggenborg, A. Gossmann, et al., "Intensity-based 2D 3D registration for lead localization in robot guided deep brain stimulation," Phys Med Biol, vol. 62, pp. 2417-2426, Mar 21 2017.
[6]S. C. Park, C. S. Lee, S. M. Kim, E. J. Choi, and J. K. Lee, "Comparison of the Stereotactic Accuracies of Function-Guided Deep Brain Stimulation, Calculated Using Multitrack Target Locations Geometrically Inferred from Three-Dimensional Trajectory Rotations, and of Magnetic Resonance Imaging-Guided Deep Brain Stimulation and Outcomes," World Neurosurg, vol. 98, pp. 734-749 e7, Feb 2017.
[7]P. Pezeshkian, A. A. DeSalles, A. Gorgulho, E. Behnke, D. McArthur, and A. Bari, "Accuracy of frame-based stereotactic magnetic resonance imaging vs frame-based stereotactic head computed tomography fused with recent magnetic resonance imaging for postimplantation deep brain stimulator lead localization," Neurosurgery, vol. 69, pp. 1299-306, Dec 2011.

References (Continued)

[8]J. K. Scheer, T. Hamelin, L. Chang, B. Lemkuil, B. S. Carter, and C. C. Chen, "Real-time Magnetic Resonance Imaging-Guided Biopsy Using SmartFrame(R) Stereotaxis in the Setting of a Conventional Diagnostic Magnetic Resonance Imaging Suite," Oper Neurosurg (Hagerstown), vol. 13, pp. 329-337, Jun 01 2017.
[9]C. E. Tatsui, C. N. G. Nascimento, D. Suki, B. Amini, J. Li, A. J. Ghia, et al., "Image guidance based on MRI for spinal interstitial laser thermotherapy: technical aspects and accuracy," J Neurosurg Spine, vol. 26, pp. 605-612, May 2017.
[10]S. Vadera, A. Chan, T. Lo, A. Gill, A. Morenkova, N. M. Phielipp, et al., "Frameless Stereotactic Robot-Assisted Subthalamic Nucleus Deep Brain Stimulation: Case Report," World Neurosurg, vol. 97, pp. 762 e11-762 e14, Jan 2017.
[11]G. Srimathveeravalli, C. Kim, D. Petrisor, P. Ezell, J. Coleman, H. Hricak, et al., "MRI-safe robot for targeted transrectal prostate biopsy: animal experiments," BJU Int, vol. 113, pp. 977-85, Jun 2014.
[12]D. Stoianovici, C. Kim, D. Petrisor, C. Jun, S. Lim, M. Ball, et al., "MR Safe Robot, FDA Clearance, Safety and Feasibility Prostate Biopsy Clinical Trial," IEEE/ASME Transactions on Mechatronics, 2016.
[13]D. Stoianovici, C. Kim, G. Srimathveeravalli, P. Sebrecht, D. Petrisor, J. Coleman, et al., "MRI-safe robot for endorectal prostate biopsy," IEEE/ASME Transactions on Mechatronics, vol. 19, pp. 1289-1299, 2014.
[14]D. Stoianovici, C. Jun, S. Lim, P. Li, D. Petrisor, S. Fricke, et al., "Multi-Imager Compatible, MR Safe, Remote Center of Motion Needle-Guide Robot," IEEE Transactions on Biomedical Engineering, 2017.
[15]D. Stoianovici, A. Patriciu, D. Petrisor, D. Mazilu, and L. Kavoussi, "A New Type of Motor: Pneumatic Step Motor," IEEE ASME Trans Mechatron, vol. 12, pp. 98-106, Feb 01 2007.

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