Robotic Placement of Intracranial Depth Electrodes for Long-Term Monitoring: Utility and Efficacy

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Introduction: To investigate the utility and efficacy of robotic stereotactic assistance in the placement of intracranial depth electrodes for invasive monitoring in patients with intractable focal epilepsy

Methods: From November 2010 to January 2012, 33 patients underwent robotic assisted stereotactic placement of depth electrodes for long term monitoring. All patients were considered to have medically refractory focal epilepsy. ROSA device(Medtech, Montpellier, France) was used for planning and implantation guidance in all procedures. Implantation time, efficacy in mapping the epileptogenic zone, and complications were analyzed.

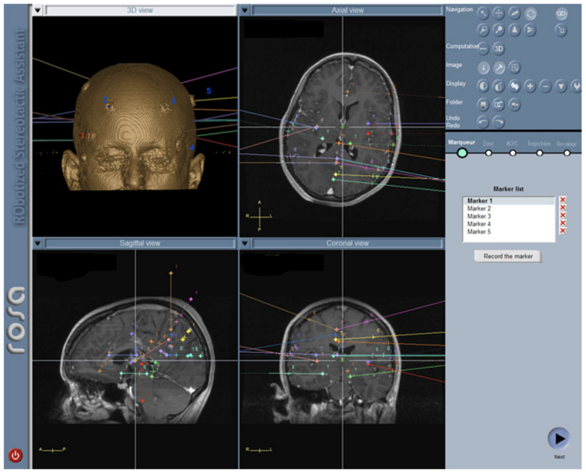

Figure 2: Tailored implantation schema viewed in the robotic software interface. Demonstrated is the planning for bilateral electrode placement, with multiple non-orthogonal trajectories. The nature of the robotic interface and planning software allows for implantation of multiple orthogonal and non-orthogonal trajectories. These may be implanted, bilaterally, without changing components of the robotic arm. The process is the same irrespective of trajectory side or angulation. This feature facilitates avoidance of vascular structures and the use of a single electrode to target multiple specific areas, thus increasing efficiency during both planning and implantation stages of the procedures.

Figure 4: The robotic arm automatically moves the working platform to the appropriate location in stereotactic space for each trajectory, eliminating the use of numerical coordinates.

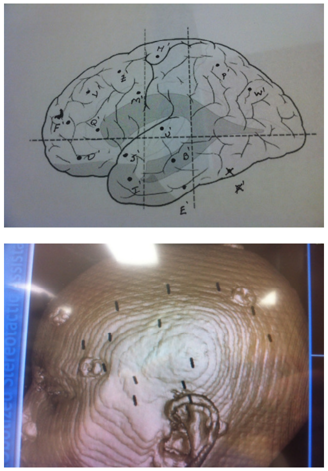

Figure 1: a) Initial plan of implantation schema. b) Translation of initial schema to preoperative 3-D reconstruction.

Figure 3: Automated laser based surface registration . When positioning needs dictate that the face be inaccessible to to the robotic arm, fiducial based registration can alternatively be used.

Results:
Mean age was 30 years-old (4 to 59 years). Mean duration of the epilepsy syndrome was 13.8 years (0.83 to 52 years). 438 electrodes were implanted. Proprietary ROSA software facilitated an efficient trajectory planning stage. 19 patients underwent unilateral implantation. 14 patients underwent bilateral implantation. The mean OR time during implantation was approximately 2 hours. The robotic implantation was successful in localizing the electrophysiological epileptogenic zone in 31 patients (94%). Asymptomatic subdural hemorrhage occurred in 2 patients. A small intracranial contusion resulting in temporary leg weakness occurred in 1 patient. The complication rate per electrode was 0.68%.

Discussion:
Planning times were reduced by the robot's adaptability to the use of multiple variably angled trajectories. Implantation efficiency increased with the automated movement of the robotic arm platform to the appropriate working position in stereotactic space. Utility was increased by facilitating placement of electrodes in patients thought to require more complex electrode schema, while reducing overall planning and operative time. A randomized trial comparing standard methods of implantation versus robotic implantation is necessary to confirm these conclusions.

Conclusions:
Robot assisted placement of intracranial depth electrodes streamlines the electrode implantation process, without sacrificing safety, in patients with intractable focal epilepsy.