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Larissa Ptak ECE 340

Deep Brain Stimulation Correct Electrode Placement Within the Brain

How to more accurately place electrodes on the brain to increase the success of surgery and minimize risks to the patient.

Deep brain stimulation (DBS) is a modern surgical procedure meant to treat movement disorders such as Parkinson's, tremors, muscle spasms, or symptoms of obsessive-compulsive disorder and epilepsy. The surgical procedure places electrodes on the left and right hemispheres of the brain that are responsible for body movement trough small holes in the skull. The electrodes are then connected to a stimulator device, similar to a pacemaker. The neurostimulator then regulates brain activity through electric pulses. Where the electrodes are placed depends on which symptoms are being treated, and accuracy is essential.

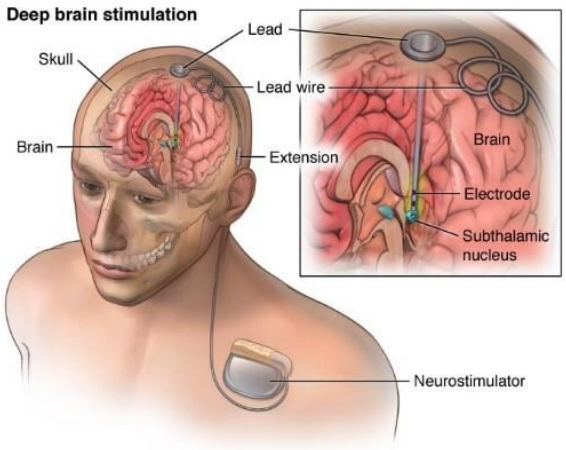

Figure 1 This is an imagine depicting where electrodes are placed during DBS

Correct electrode placement is crucial to a successful surgery. However, accurate electrode placement is difficult to achieve due to brain shifts. Post-surgery the brain shifts, and therefore the electrodes shift marginally out of place, and are create more risk for the patient. The greatest direction of rotation in the brain is forward and toward the nose.

The brain will shift between preoperative imaging and the surgery, thus complicating the surgery. Through the use of interventional magnetic resonance (iMR) a model can be constructed to predict the direction and magnitude of the brain shift. This model can then be used to update preoperative MR scans, which aids the surgeon's accuracy. Current clinical methods can be enhanced by a model-based shift correction of DBS surgery using sparse.

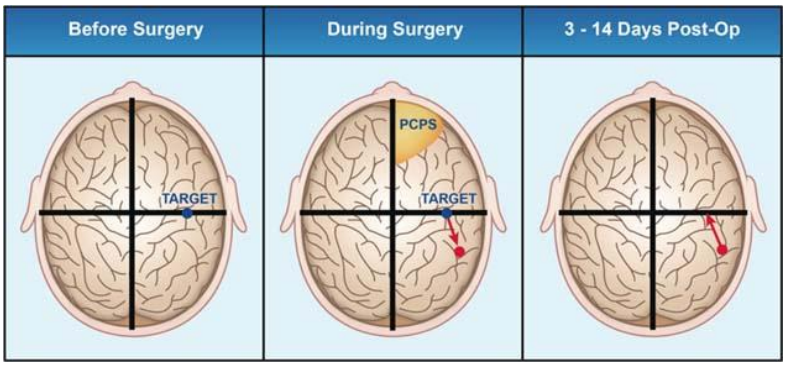

Figure 2 Visualizes where electrodes should be placed with the blue target dot. The red dot signifies how far off the electrodes end up after surgery.

In addition to image guidance, robot assisted surgery has progressed. Robot assisted techniques allows for more accurate electrode placement then by a surgeon. DBS is traditionally preformed by a surgeon on an awake patient. However, preforming asleep DBS with robots cuts down on expensive operating room times and allows for better electrode placement. Asleep DBS relies on iMR to plan the surgical procedure. Then CT scans during the surgery are fused with preoperative MRIs to verify electrode placement.

Stereotactic systems can be classified as frame-based, frameless, and iMRI-guided systems. A systematic literature study of electrode placement methods has shown that targeting accuracy of DBS electrode implantation is shown to have increased to 1-2mm. The iMRI-guided ClearPoint SmartFrame achieved the best targeting accuracy at 0.6 ± 0.5 mm. The use of frameless systems continues to increase over time. Stereotactic systems also continue to diversify. It has been recorded that targeting error generally is decreasing over time as a result. Within the last few years, targeting error has decreased toward 1mm.

Deep brain stimulation (DBS) is a surgical procedure that can treat movement disorders. Where the electrodes are placed depends on the symptoms being treated. These regions are very deep in the brain, and therefore electrode placement is difficult, but accuracy is essential for success in the surgery, to only target problem areas. Image guidance and robotic assisted surgery techniques improve electrode placement accuracy, in addition being able to better verify electrode placement after the surgery.

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