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NEUROSURGERY: TECHNOLOGY INNOVATIONS

Advancing the Use of Novel Technology in the Operating Room

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Image 1: Joshua B. Bederson, MD, and his team using a surgeon-driven robotic visualization system.

Over the past several years, the Mount Sinai Department of Neurosurgery has established itself as a leader in the development and use of innovative imaging, simulation, and augmented reality technologies to improve patient outcomes and solve neurosurgical challenges. Through novel technologies that were developed in house or were the result of collaborations with industry partners, today's Mount Sinai neurosurgical patients are able to see 3D representations of their vascular and cranial nerves before surgery, and their surgeons have a vast array of increasingly sophisticated pre- and intraoperative tools to achieve greater outcomes.

Surgeon-Driven Robotic Visualization

The effort is being led by Joshua B. Bederson, MD, Professor and Chair of Neurosurgery for the Mount Sinai Health System and Clinical Director of the Neurosurgery Simulation Core, where there has been considerable investment in next-generation microscopy. Mount Sinai became one of the first health systems nationwide to use the ZEISS KINEVO® 900 microscope, a surgeon-driven robotic visualization system that not only streams 3D optical, navigation, and simulation information in 4K resolution into the microscope's eyepiece, but also projects those data on large monitors in the operating room. This technology is combined with sophisticated 3D rendering of patient images, intraoperative navigation, and microscope integration. The 3D glasses provide an enhanced visualization of neuroanatomy. Mount Sinai also uses a micro-inspection surgical tool, the ZEISS QEVO®, which is engineered with an angled design, allowing the neurosurgeon to look around complex structures that are out of the microscope's range.

The result is an augmented virtual reality tool that provides detailed, real-time information about critical structures that enhances a surgeon's ability to remove difficult tumors with increased safety and efficiency. "Our goal is to integrate multiple information streams for surgeons to use with optical data, navigation, and simulation information all streaming into the surgeon's viewpoint in a way that is not distracting and helps ensure the safety of the patient," says Dr. Bederson.

Robotically Controlled Digital Microscope

The Mount Sinai Hospital, a *U.S. News & World Report* Honor Roll hospital, is also one of the first to adopt Modus V™ in the operating room. The cornerstone of Synaptive Medical, Inc.'s BrightMatter™ platform, Modus V is a hands-free, robotically controlled digital microscope that is capable of integrating and projecting navigation and data analytics on larger monitors. Moreover, the technology's planning platform incorporates diffusion tensor imaging tractography, which enables surgeons to map out eloquent and non-eloquent areas of the brain during the approach phase and the resection using navigation.

"This is a powerful alternative to traditional microscopy technology," says Constantinos G. Hadjipanayis, MD, PhD, Chair of Neurosurgery at Mount Sinai Union Square and Director of Neurosurgical Oncology for the Mount Sinai Health System. "Using this system during surgery, we can magnify tissue images to delineate tumors, and robotically adjust the arm position to achieve better visualization during tumor removal and avoid important nerve pathways that control movement and speech."

Dr. Hadjipanayis says the resulting high-definition images of brain tractography and central nervous system fibers significantly enhance his ability to navigate each patient's brain during surgery. "It is also ergonomically more comfortable to use because I can visualize the patient's anatomy on a screen directly in front of me instead of looking down into the microscope. It sets the stage for the next generation of digital image-based neurosurgery."

Image 2: Left screen: Modus V high-definition visualization of a glioblastoma tumor resection. Right screen: BrightMatter overlay of brain tractography with MRI neuronavigation in a glioblastoma patient.

Advanced Circuit Therapeutics Enhancing Deep Brain Stimulation

Mount Sinai's Center for Advanced Circuit Therapeutics, headed by founding Director Helen S. Mayberg, MD, Mount Sinai Professor in Neurotherapeutics, and Professor of Neurosurgery, Neurology, Psychiatry, and Neuroscience, at the Icahn School of Medicine at Mount Sinai, is also enabling advances in tractography-guided targeting to test high-tech multimodal imaging tools that enhance deep brain stimulation (DBS) therapy. One such advance, StimVision, a software tool developed in collaboration with the McIntyre Lab at the Case Western Reserve University School of Medicine, enables real-time visualization of brain tracts and neural computational modeling of volume of tissue activated to facilitate more precise targeting and validation of electrode implantation targets among patients with depression.

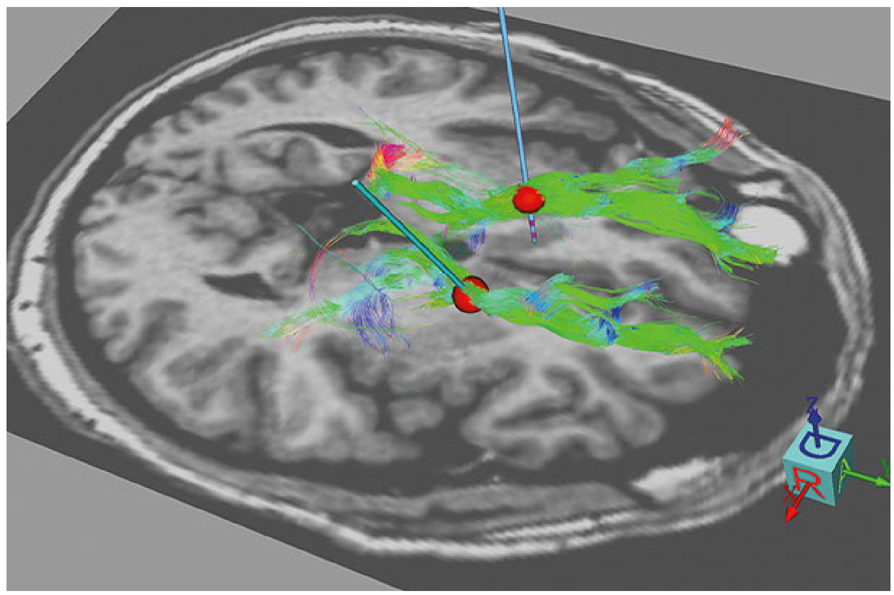

Image 3: Individualized model of DBS target (red dot) for obsessive-compulsive disorder and impacted circuit and associated fiber bundles. Red dot represents the volume of tissue activated by estimated therapeutic stimulation dose.

"Conventional anatomical imaging does not enable identification of the optimal DBS electrode target—subcallosal cingulate," says Ki Sueng Choi, PhD, who leads the Center's Imaging Core and is an Assistant Professor of Radiology, and Neurosurgery, at the Icahn School of Medicine. "Using StimVision, we can visualize the white-matter pathways and remote connections of DBS stimulation settings in real time, enabling us to find and validate the optimal target in the operating room."

The result has been an increase in clinical efficacy from 43 percent to 80 percent. Based on these results, the goal now is to extend the use of StimVision to patients with obsessive-compulsive disorders and movement disorders. For these efforts, Dr. Mayberg is collaborating closely with the clinical Center for Neuromodulation, led by Brian H. Kopell, MD, Professor of Neurosurgery, Neurology, Neuroscience, and Psychiatry. "We envision that using this technology will result in more precise targeting based on functional and structural connectivity, and enable us to visualize brain anatomical and functional changes with acute and chronic stimulation," says Dr. Kopell. "Using that information, we will be able to minimize the adverse effects of DBS to the benefit of our patients."

Constantinos G. Hadjipanayis, MD, PhD, receives compensation as a consultant for Synaptive Medical, Inc.