Brain Implant Aims to Restore Movement After Stroke

In the United States, someone has a stroke every 40 seconds. Often, these victims have long-term physical disabilities—the inability to use an arm and hand properly, for example. While rehabilitation can restore some function, improvements typically plateau well short of full recovery. Seeking to help stroke patients gain a fuller return-to-function, a research group led by assistant professor of neurology **Mijail Serruya, MD, PhD**, has begun a clinical trial of a brain implant and motorized robotic brace that could enable greater mobility. The work represents a convergence of disciplines, including computer science, fashion design, mechanical engineering, neurology, physics and rehabilitation medicine.

In this trial, a recovering stroke patient has had electrodes implanted in the brain. The electrodes are connected to a mechanical brace intended to help replicate normal movement and restore physical abilities. "The electrodes send signals originating in brain neurons to an arm brace that then controls movement," explains Dr. Serruya. Bioengineer and visiting professor **Alessandro Napoli, PhD**, led development of the computer software that translated the patient's brain signals into control commands for the arm brace.

Most previous research on such "brain-computer interface" (BCI) systems has focused on individuals with extensive disability, such paraplegia resulting from spinal cord injury. However, the Jefferson study is striving to help the majority of stroke victims, who have significant but less extensive disability. "The current trial serves as a proof of concept that our electrodes can effectively convey neuronal signals to a mechanical device that guides and supports arm movements for stroke patients," Dr. Serruya says. "We view this trial as a bridge to implanting wireless electrodes that can convey those signals to an effective device."

Perhaps most notable, "This study is the first to implant electrodes in a patient who can walk and still live semi-independently," says Dr. Serruya. "What we're studying is much more relevant to all of the people who live with disability from stroke. But for that reason, it's also more challenging." While the brains of most patients who previously participated in BCI studies are relatively healthy (because their injuries occur in the spine or lower brain), Jefferson researchers have implanted electrodes adjacent to the stroke-damaged area. "As a result, we must regularly adjust and refine the artificial intelligence algorithms that interpret brain signals in order to have movement that best reflects a patient's intention. But we believe this work will inform all future BCI trials for fully implantable and wireless devices," notes Dr. Serruya.

Dr. Serruya works closely with the patient to adjust the brain-computer interface.

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Neurosurgeon **Robert Rosenwasser, MD, MBA**, led the electrode-implantation surgery for the patient in the current Jefferson trial, accompanied by neurosurgery colleagues **Ash Sharan, MD** and **Chengyuan Wu, MD**. "We have long seen stroke patients go home and struggle with simple daily tasks like picking up a cup of coffee or brushing their teeth. But this approach, which helps restore function, could in coming years be a game changer for our patients," says Dr. Rosenwasser, chair of neurological surgery and president of the Vickie and Jack Farber Institute for Neuroscience at Jefferson Health. "Fully implantable BCI electrodes are being developed by a number of companies, and this trial will pave the way for a future in which a patient with permanent disability from stroke can get an implant, train with rehab and artificial intelligence experts to use it, and go home with finer control of a mechanized brace."

The clinical trial's success depended on the diverse types of knowledge and skills of an interdisciplinary team that—beyond Drs. Rosenwasser, Napoli and Serruya—included an occupational therapist, physical therapist, neuroradiologist, stroke specialist neurologist, multiple biophysicists, and associate professor of fashion design **Anne Hand**, who created a customized coat for the patient to wear when using the mechanical brace outdoors in cold weather. Several Jefferson medical and occupational therapy students were also involved in the effort. ■