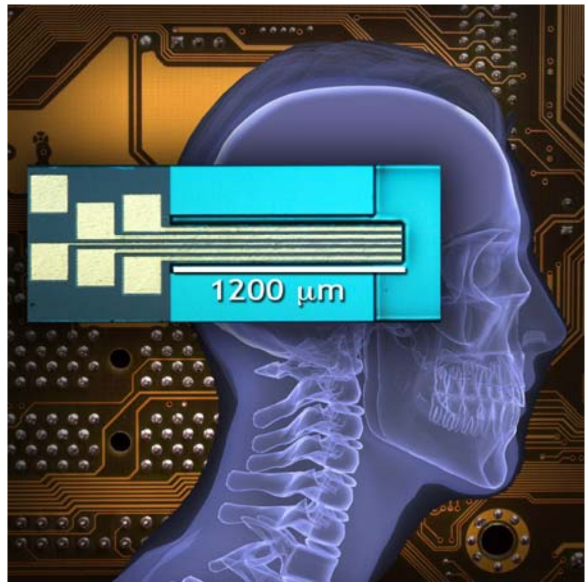
Tiny Neural Clamps Make Connections

Active nerves enable limbs to move, the bladder to empty at appropriate times, and hundreds of other bodily feats that we take for granted. Thanks to girls' hair barrettes, researchers at Arizona State University have developed a device that may revolutionize ways to communicate with the peripheral nervous system, the body's nerve network that sends messages to and from the brain and spinal cord. The neural clamp, which resembles a tiny circuit board, could impact how electrical systems are used to record or stimulate nerve activity to restore limb movement in people with spinal cord injuries, amputees, and others with neurological movement disorders.

A Case of Open and Shut

Dr. Ranu Jung, co-director of the Center for Adaptive Neural Systems at Arizona State University's Biodesign Institute, got the idea for the neural clamp after observing that girls quickly reposition locks of their hair with barrettes that easily pop open or shut with slight bending. Jung, along with collaborator Stephen Phillips, chair of ASU's Department of Electrical Engineering, determined that temperature changes would cause the clamp to open or shut. At body temperature, the device closes. Add a squirt of saline and the clamp opens.



The active neural clamp for spinal nerve roots may improve movement for individuals with spinal cord injuries or those recovering from stroke. Gold wire bond pad contacts for 5 electrodes can be seen on this clamp. These can provide nerve stimulation or feedback to refine movement.
Image courtesy of Dr. Ranu Jung, Biodesign Institute, Arizona State University.

The key to the clamp is its ability to directly connect to nerves as they first emerge from the spine. These nerves or rootlets are about as thick and as long as a standard paper staple. During implantation surgery a surgeon would fit the neural clamp onto the spinal roots and reposition it as needed until a robust nerve signal emerges. Electronic circuitry connected to electrodes on the clamp would record on-going nerve activity or stimulate missing nerve activity.

No Bulky Electrodes

The neural clamp would be a vast improvement over currently available systems used to activate nerve function lost to stroke and spinal cord injuries. Often multiple electrodes are placed on the skin to stimulate movement in those with spinal cord injuries. Electricity delivered via the electrodes prompts nerves to signal muscle movement. But multiple attachments make them awkward to use and it is difficult to reliably place all the electrodes at the same location again and again.

Implanted electrodes overcome these problems but the devices used today are large and often hand made. However, because Jung's neural clamp relies on fabrication techniques used to mass produce computer chips, large quantities of the micro-component can be readily made.

Refining Movement

Current systems to control movement in people with spinal cord injuries or prostheses of amputees also lack adaptive capabilities needed for smooth or precise actions. The temperature-sensitive clamp could provide an effective interface between nerves and electronic control systems. A system for recording nerve activity based on neural clamps would provide feedback about the status of the nervous system by sensing signals coming from the spinal roots. These signals would be used for adaptive stimulation of nerves and muscles downstream from the spinal roots for people with spinal cord injuries or adaptive control of the motors of artificial limbs for amputees, adjusting stimulation accordingly. Over time as a person recovers from incomplete spinal cord injury or improves their ability to control prostheses, feedback of neural signals recorded with the clamps would provide less stimulation.

Dr. Ranu Jung

A Bionic Future?

Dr. Jung and her colleagues hope to start testing the neural clamp this year in animal models. The team still must find a way to make the clamp durable and unlikely to damage nerves. Jung notes that the clamp's design may be altered to improve durability and make it flexible enough to provide long-term electrical connections with nerves without damaging them in the process. Human testing is still another 10 or more years away.

The potential for this device to revolutionize rehabilitative medicine helps keep the research team on task. "We are very much driven by the needs of the patients. We are trying to find ways to repair or replace lost neural function using adaptive interfaces. The bottom line is, 'Can we get function back?'" Dr. Jung says.

Will this research lead us on a path to realizing the fictional bionic woman or six-million- dollar-man whose artificial parts gave each super powers? "We are all bionic more or less," says Dr. Jung. "Many of us have pacemakers, hip replacements or insulin pumps. We are becoming more and more integrated with technology. Why not take advantage of the capabilities of advanced technology to help us get back or improve function?"

Development of the neural clamp is supported by the National Institute of Biomedical Imaging and Bioengineering and spinal cord injury research support is provided by the National Institute of Child Health and Human Development.

Reference

Venkatasubramanian, G., R. Jung, J. D. Sweeney. "Functional Electrical Stimulation", In: The Wiley Encyclopedia of Medical Devices and Instrumentation, 2nd Edition, Editor. J. G. Webster, Wiley, March 2006. ISBN: 0-471-26358-3; 3666 Pages