Medical Xpress

Stanford researchers develop the next generation of retinal implants

December 10 2009, By Janelle Weaver

(PhysOrg.com) -- A team of Stanford researchers has developed a new generation of retinal implants that aims to provide higher resolution and make artificial vision more natural.

This could be a boon to the several million people in the United States who are blind or visually impaired as a result of retinal degeneration. Every year, 50,000 people in the United States become blind, according to the National Federation of the Blind. But only a couple of dozen Americans have retinal implants.

The team, consisting of ophthalmology Associate Professor Daniel Palanker, electrical engineering Assistant Professor Peter Peumans and neurobiology Assistant Professor Stephen Baccus of Stanford, and biophysics Assistant Professor Alexander Sher of the University of California-Santa Cruz, presented their research Dec. 9 at the International Electron Devices Meeting in Baltimore.

Retinal implants are arrays of electrodes, placed at the back of the eye, which partially restore vision to people with diseases that cause their light-sensing photoreceptors to die. Typically, a camera embedded in glasses collects visual information and sends it to a computer that converts the images to electrical signals, which are then transmitted to the implant and interpreted by the brain. There are several private companies and universities working on different versions, but most people with implants can only make out fuzzy borders between light and dark areas.

Analogous to high-definition TV

The Stanford implant would allow patients to make out the shape of objects and see meaningful images. "A good analogy is high-def TV," Baccus said. "If you only have a few pixels of stimulation, you're not going to see much. One clear advantage of our implant is high resolution." The Stanford implant has approximately 1,000 electrodes, compared to 60 electrodes commonly found in fully implantable systems.

What's more, patients would not have to move their heads to see, as they do with older implants. Although we don't notice it, images fade when we do not move our eyes, and we make several tiny eye movements each second to prevent fading. With older retinal implants, the camera moves when the head moves, but not when the eyes move.

The Stanford implant, on the other hand, retains the natural link between eye movements and vision, Palanker said. A patient would wear a video camera that transmits images to a processor, which displays the images on an LCD screen on the inside of patient's goggles. The LCD display transmits infrared light pulses that project the image to photovoltaic cells implanted underneath the retina. The photovoltaic cells convert light signals into electrical impulses that in turn stimulate retinal neurons above them.

As patients move their eyes, the light falls on a different part of the implant, just as visible light falls on different parts of the retina. "The Palanker group has developed a device that actually allows patients to see infrared light on the implant and visible light through the normal optics of the eye," Baccus said.

"It's a sophisticated approach," said Shelley Fried, a research scientist working on the Boston Retinal Implant Project. "It should definitely be helpful."

This is also the first flexible implant, and it makes use of a material commonly used in computer chips and solar cells. Peumans and his team at the Stanford Nanofabrication Facility engineered a silicon implant with tiny bridges that allow it to fold over the shape of the eye. "The advantage of having it flexible is that relatively large implants can be placed under the retina without being deformed, and the whole image would stay in focus," Palanker said. A set of flexible implants can cover an even larger portion of the retina, allowing patients to see the entire visual field presented on the display.

"It's really a very interesting idea," Fried said. "The ability to get all the electrodes to sit perfectly on the retina would be a very nice advantage." He said that a spring technology allows their device to conform to the contour of the eye, maintaining close contact between electrodes and neurons.

The tiny crevices between the bridges serve a useful function. Distant retinal cells migrate to the implant and fill in the spaces between the electrodes. Previously, one major challenge was to get cells close enough to the device to receive signals, Fried said. "If we can find a way to bring the retinal neurons closer to the electrode, that would have a huge advantage," he said.

Implanted under the retina

The Stanford device is implanted under the retina, at the earliest possible stage in the visual pathway. "In many degenerative diseases where the photoreceptors are lost, you lose the first and second cells in the pathway," Baccus said. "Ideally you want to talk to the next cell that's still there." The goal is to preserve the complex circuitry of the retina so that images appear more natural.

"With most of the current devices, we are replicating only very few elements of normal retinal signaling," Fried said.

To further enhance the naturalness of restored vision, Baccus and Palanker are developing software that performs functions that the retina normally performs. For example, cells in the retina tend to enhance the appearance of edges, or boundaries between objects. What's more, objects that we focus on are seen in better detail than objects that appear at the corners of our eyes.

The researchers hope to incorporate these features in the next generation of retinal implants. Baccus envisions a day when patients will be able to adjust their implants to see objects better, just like an optometrist adjusts the lens while we read a letter chart.

Palanker and his team will test the ability of animals with retinal diseases similar to those in humans to use the implant to discriminate visual patterns.

One of the major challenges is to understand how the retina works, especially after it is damaged. "We operate on the assumption that the photoreceptors are gone, but otherwise it's a normal retina," Baccus said. "This is almost certainly not true."

Future devices should learn, patient by patient, the new language needed to communicate with the altered circuitry of the damaged retina, he said. Even if the retinal circuitry were unaltered, the brain would still have to learn how to interpret the signals. By mimicking normal vision, retinal implants may overcome these obstacles and bring enhanced vision to blind patients.

Provided by Stanford University (news : web)