Brain probe that softens after insertion causes less scarring

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A hard probe inserted in the cerebral cortex of a rat model turns nearly as pliable as the surrounding gray matter in minutes, and induces less of the tough scarring that walls off hard probes that do not change, researchers at Case Western Reserve University have found.

In the first test of the nanocomposite probe inspired by the dynamic skin of the sea cucumber, the immune response differed compared to that of a metal probe, and appeared to enable the brain to heal faster.

The findings, which provide insights to the brain's responses to the mechanical mismatch between tissue and probe, are described in the online edition of the Journal of Neural Engineering.

Brain probes are used to study and treat neurological disorders. But, wires or silicon materials being used damage surrounding tissue over time and accumulate scarring, because they are far harder than brain matter.

In this test, "The scar wall is more diffuse; the nanocomposite probe is not completely isolated in the same way a traditional stiff probe is," said Dustin Tyler, a professor of biomedical engineering and leader of the experiment.

The result may prove beneficial. Studies by others in the field indicate the greater the isolation, the less effective the probe is at recording and relaying brain signals.

Tyler worked with James P. Harris, a graduate student in biomedical engineering and the lead author on the paper; Biomedical Engineering Professor Jeffery Capadona; Stuart J. Rowan, professor of macromolecular science and engineering, and former graduate student Kadhiravan Shanmuganathan; Robert H. Miller, professor of neurosciences at Case Western Reserve School of Medicine; Christoph Weder, formerly a professor of macromolecular science and engineering at Case Western Reserve and now at the University of Fribourg; and Harvard Neurology Professor and Research Fellow Brian C. Healy.

The new probe material is inspired by the skin of the sea cucumber, which is normally soft and flexible, but becomes rigid for its own defense within seconds of being touched. These changing mechanical properties may improve our interaction with our brain, Tyler said.

In the nanocomposite, short polymer chains are linked together in a network mesh to make the material rigid, which is necessary for insertion into the cortex. In the presence of water, the mesh begin unlinking in seconds, changing to a soft, rubbery material designed to cause less damage to surrounding brain tissue over time.

To test the effects of the changing mechanical properties, metal probes were coated in a think layer of nanocomposite materal. When both were implanted into the brain, the chemical properties as seen by the brain were these same, but the mechanical properties were very different.

Four weeks after implantation, the density of neuronal nuclei adjacent to the new probe was significantly higher than surrounding the traditional probe.

At eight weeks, the density of nuclei had increased around the wire probe to equal the density around the flexible probe, which remained unchanged.

"One hypothesis is that the soft material allows the brain to recover more quickly," Tyler said. "Both probes cause the same insult to the tissue when inserted."

But, testing for scar components at 8 weeks showed that although the thickness of scar surrounding the metal probe had shrunk, the scar was denser and more complete than that around the nanocomposite probe. This dense scar separated the stiff probe from the brain more than the loose tissue around the more flexible probe.

The researchers are now comparing the impacts of the two probes at longer time intervals and testing for more indicators of the immune response, Harris said.

"We're trying to better understand the nuances regarding the response to the nanocomposite and how it would improve recordings."

More information: stacks.iop.org/1741-2552/8/066011

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