'Nano-scissors' laser shows precise surgical capability

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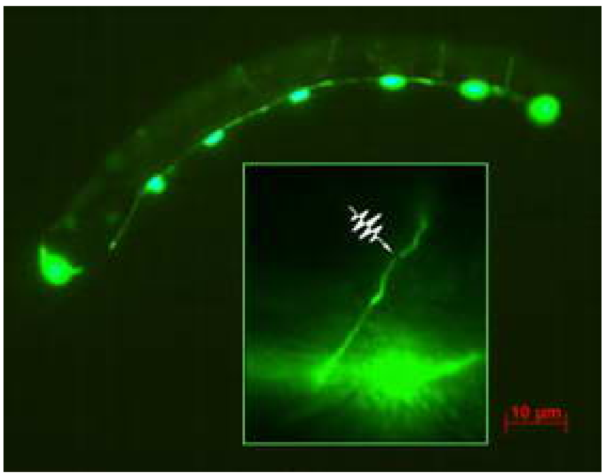

An ultra-short pulse laser that can perform extremely precise surgery on tiny roundworms may be the key to understanding nerve regeneration and is an important step toward treatment of human neurological disease, according to research published in the Dec. 16 issue of Nature.
Dr. Adela Ben-Yakar, an assistant professor of mechanical engineering at The University of Texas at Austin, led the development of the technique. It acts like a pair of tiny "nano-scissors," able to cut, for example, nano-sized units like nerve axons, the parts of nerve cells that carry nerve impulses away from the cells to muscles or to other cells.

Image: The background shows a C. elegans roundworm. The bright green *dots are neurons, and the thin green lines extending from the neurons are axons. The inset demonstrates where the laser severs the axon. Photo: H. Cinar and Y. Jin*

“This tool opens up a new frontier for biologists studying nerve regeneration,” says Ben-Yakar. “We can also apply it to many other studies that require nanosurgery, so it’s a very versatile tool.”

The beauty of this laser, she says, is its ability to cut organelles (parts of cells—they are what organs are to organisms) precisely, without damaging surrounding tissue. Usually, conventional lasers used in surgery heat the area to be cut, then cut it, but this heightens the risk for tissue damage.

Ben-Yakar’s nanosurgery technique used a series of low-energy “femtosecond” laser pulses to partially sever the axons of several anesthetized C. elegans, a widely studied type of roundworm about one millimeter long. A femtosecond is one millionth of a billionth of a second.

“The time is very important here,” she says. “Because it happens so fast, there isn’t enough time for heat to diffuse out, so we don’t damage anything. The pulse’s very short length makes the photons in the laser concentrate in one area, delivering a lot of power to a tiny, specific volume without damaging surrounding tissue.”

Once cut, the axons vaporized, and no other tissue was harmed.

To assure the axons were actually cut, and their disappearance wasn’t caused by discoloration by the laser, the researchers cut axons they knew would impair the worms’ backward motion. The worms couldn’t move backwards after surgery. But within 24 hours, most of the severed axons regrew and the worms recovered backward movement—confirming that the precision of the laser's cut didn't damage surrounding tissue and allowed the neurons to grow a new axon to reach the muscle.

Until now, researchers have only been able to investigate nerve regeneration in mice and zebrafish, which have complex nervous systems. This laser allows researchers to study nerve cells at their most basic evolutionary form, opening the door to other experiments on genetic and molecular factors that determine whether damaged nerve cells regrow.

Ben-Yakar developed the femtosecond laser surgery technique using the laboratories and equipment of Dr. Robert Byer, a Stanford University professor, while doing post-doctoral work. The paper's other co-authors are Mehmet Fatih Yanik at Stanford, Hulusi Cinar, Hediye Nese Cinar and Andrew D. Chisholm at the University of California at Santa Cruz and Yishi Jin of UC Santa Cruz and the Howard Hughes Medical Institute.