Laser surgery probe targets individual cancer cells

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Mechanical engineering Assistant Professor Adela Ben-Yakar at The University of Texas at Austin has developed a laser "microscalpel" that destroys a single cell while leaving nearby cells intact, which could improve the precision of surgeries for cancer, epilepsy and other diseases.

"You can remove a cell with high precision in 3-D without damaging the cells above and below it," Ben-Yakar says. "And you can see, with the same precision, what you are doing to guide your microsurgery."

Femtosecond lasers produce extremely brief, high-energy light pulses that sear a targeted cell so quickly and accurately the lasers' heat has no time to escape and damage nearby healthy cells. As a result, the medical community envisions the lasers' use for more accurate destruction of many types of unhealthy material. These include small tumors of the vocal cords, cancer cells left behind after the removal of solid tumors, individual cancer cells scattered throughout brain or other tissue and plaque in arteries.

A commercially available femtosecond laser system and microscope was developed recently for LASIK and other eye surgeries, but the system's bulk limits its usefulness. Ben-Yakar's laboratory has overcome technological challenges to create a microscope system that can deliver femtosecond laser pulses up to 250 microns deep inside tissue. The system includes a tiny, flexible probe that focuses light pulses to a spot size smaller than human cells.

Ben-Yakar's experimental system and its use to destroy a single cell within layers of breast cancer cells grown in the laboratory is described in the June 23 issue of *Optics Express*.

Within a few years, Ben-Yakar expects to shrink the probe's 15-millimeter diameter three-fold, so it would match endoscopes used today for laparoscopic surgery. The probe tip she has developed also could be made disposable -- for use operating on people who have infectious diseases or destroying deadly viruses and other biomaterials.

To develop the miniature laser-surgery system, Ben-Yakar worked with co-author Olav Solgaard at Stanford University's Electrical Engineering Department to incorporate a miniaturized scanning mirror. Ben-Yakar and her graduate student Chris Hoy, another co-author, also used a novel fiber optic cable that can withstand intense light pulses traveling from an infrared, femtosecond laser. To make the intensity more manageable, they stretched the light pulses into longer, weaker pulses for traveling through the fiber. Then they used the fiber's unique properties to reconstruct the light into more intense, short light pulses before entering the tissue.

For the study, Ben-Yakar directed laser light at breast cancer cells in three-dimensional biostructures that mimic the optical properties of breast tissue. She has since studied laboratory-grown, layered cell structures that mimic skin tissue and other tissues.

Ben-Yakar is also investigating the use of nanoparticles to focus the light energy on targeted cells. In research published last year, she demonstrated that gold nanoparticles can function as nano-scale magnifying lenses, increasing the laser light reaching cells by at least an order of magnitude, or 10-fold.

"If we can consistently deliver nanoparticles to cancer cells or other tissue that we want to target, we would be able to remove hundreds of unwanted cells at once using a single femtosecond laser pulse," Ben-Yakar says. "But we would still be keeping the healthy cells alive while photo-damaging just the cells we want, basically creating nanoscale holes in a tissue."

Source: University of Texas at Austin