Putting the Spring Back in Broken Hearts

Tel Aviv University

TAU researchers develop spring-like fibers to help repair damaged heart tissue

The threat from a heart attack doesn't end with the event itself. Blockage of blood flow to the heart can cause irreversible cell death and scarring. With transplants scarce, half the people who live through a heart attack die within five years. Scientists are trying to address this problem by engineering cardiac tissue to patch up damaged areas.

Now doctoral students Sharon Fleischer and Ron Feiner—under the supervision of Dr. Tal Dvir of Tel Aviv University's Department of Molecular Microbiology and Biotechnology and the Center for Nanoscience and Nanotechnology—have fabricated fibers shaped like springs that allow engineered cardiac tissue to pump more like the real thing. They reported their findings in the journal Biomaterials in August.

"Until now, when scientists have tried to engineer cardiac tissue, they've used straight fibers to support the contracting cells," says Dr. Dvir. "However, these fibers prevent the contraction of the engineered tissue. What we did was mimic the spring-like fibers that promote contraction and relaxation of the heart muscle. We found that by growing tissues on these fibers, we got more functional tissues.

Springing into Action

Cardiac tissue is engineered by allowing cells taken from the hearts of patients or animals to grow on a three-dimensional scaffold, which replaces the extracellular matrix, a collagen grid that naturally supports the cells in the heart. Over time, the cells come together to form a tissue that generates its own electrical impulses and expands and contracts spontaneously. The tissue can then be surgically implanted to replace damaged tissue and improve heart function in patients.

Dr. Dvir's Laboratory for Tissue Engineering and Regenerative Medicine focuses on engineering complex tissues for medical use. When it comes to the heart, the researchers are always looking for ways to build a scaffold that better replicates the extracellular matrix and so yields more functional tissue. Earlier this year, they published research on integrating gold particles [1] into cardiac tissue to optimize electrical signaling between cells.

More recently, the researchers identified spiral-shaped collagen fibers in the extracellular matrix of rat hearts. Seeing the potential for an advance, they set out to recreate them for the first time. After fabricating the spring-like fibers using advanced techniques, they subjected them to a variety of tests.

As the researchers predicted, the spring-like fibers showed better mechanical properties than straight fibers, with especially improved elasticity. And compared to tissue engineered with straight fibers, the tissue engineered with spring-like fibers contracted with greater force and less mechanical resistance.

"These properties are very important, because we want to transplant the tissue into the human heart, which expands and contracts constantly," says Fleischer.

Saving Lives

Heart disease is responsible for a third of all deaths in the United States, according to a 2013 American Heart Association report. The researchers in Dr. Dvir's lab hope that tissue engineered with spring-like fibers will help fight this epidemic, improving and prolonging the lives of millions of people.

But additional research is needed first. The researchers say the processes for fabricating the fibers and assembling them into a scaffold need to be refined. Most importantly, they say, the ability of the tissue to improve heart function after a heart attack needs to be tested in humans—something they plan to do in pre-clinical and then clinical trials.

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