Penn scientists develop a new way to re-grow cartilage

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Every day the world over, runners hit the streets, pounding the pavement. Their knees are taking a pounding, too.

As runners well know, cartilage, the shock absorber within the joint, wears down over time and when an injury occurs, it is unable to heal itself. Traumatic injury can cause small tears on the cartilage surface that never heal, and get worse with time. Trauma and arthritis are the primary culprits for sidelining jogging enthusiasts and weekend warriors alike.

When aspirin and rest no longer do the trick, it may be time for surgery. And while bone-grafting procedures have been used for decades, cartilage repair with new therapies is rapidly expanding. Minimally invasive cartilage repair and regeneration involves harvesting healthy cartilage from one site and transplanting the tissue to the defective area. Another approach involves growing new cartilage cells in a lab and re-injecting the cells to replace worn cartilage.

A group of Penn scientists working across disciplines—in this case engineering and medicine—has developed a novel way to allow patients to re-grow cartilage in their own bodies, using their own cells, directly in the site that has been damaged through injury or disease.

Penn Engineering Associate Professor Jason Burdick says the breakthrough represents a new way of thinking about tissue regeneration. The work could lead to new, more effective therapies that offer longer-lasting results.

Additionally, because the cells are taken directly from the patient, they don't cause an immune response, unlike current grafting and repair technologies, so there is no risk the body will reject the implanted cells.

"We're thinking about materials that can actually interact with the stem cells, whereas most people are thinking about inert materials that can provide only a framework" for new tissue to grow, Burdick says. "Our lab is interested in making new materials that can give us new functionality that is not currently available."

A key first step to the growing pursuit of new biomaterial solutions begins with developing a fundamental understanding of the material properties of cells that make up cartilage. Since coming to Penn in 2005, Burdick and his team have looked at how the ingredients of cartilage change with time.

Working with Penn Associate Professor of Orthopaedic Surgery Robert Mauck in the McKay Orthopaedic Research Laboratory, they've studied the mechanical properties of these tissues, as well as the influence of mechanical loading on cells. Now, they are moving to the next phase: applying what they've discovered to translational therapies.

"A lot of our projects are based on a fundamental understanding of how cells interact with their surrounding microenvironment and using synthetic materials as a mimic for those interactions," Burdick explains. "Being able to control the synthetic materials allows us to probe questions about microenvironment chemistry, mechanical properties and other cues."

Experiments in ovine models are being pursued with adult stem cells, usually taken from bone marrow, and mixed with a hyaluronic acid hydrogel solution and injected into the troubled joint, where the stem cells are biologically instructed to regenerate into cartilage-forming cells. An ultraviolet light source is needed to form the material in the defect, but visible light works as well. The process is similar to how dentists fill tooth cavities.

Burdick cautions that it will likely be several years before the process is ready for clinical testing in humans.

Of one thing he is certain: As the active baby boomer generation ages, there will be great demand for new cartilage replacement therapies.

"One of the things that I really like about this field is that there are so many people with personal stories about how this could help," he says. "I think many of us can appreciate the widespread application of such technology."

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