Medical Xpress

Study shows how cartilage interacts with the joints in our bodies

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Cartilage is a fascinating substance. It coats the ends of our bones, allowing them to glide by one another at joints like our elbows and our knees. The surface it creates is about five times more slippery than ice on ice.

Exactly how cartilage manages this near-frictionless, shock absorbing function is not fully understood. It is generally accepted that it depends on interactions between fluid in the joint and the molecules that make up the tissue, known as the extracellular matrix (ECM). Studying these subtle dynamics at the microscopic level has long been a goal of scientists.

In a new study, researchers using ultrabright X-ray beams at the Advanced Photon Source (APS), a U.S. Department of Energy (DOE) Office of Science user facility at DOE's Argonne National Laboratory, have taken direct measurements of the movement of cartilage at the nanoscale for the first time. The novel employment of a technique called X-ray photon correlation spectroscopy (XPCS) allows for insights into cartilage mechanics, potentially setting the stage for the development of new treatments for everything from common osteo-related diseases to sports injuries.

"Using the APS, we are able to look at the dynamics of the extracellular matrix at scales that people in the field have never done before, which is very exciting," said Principal Researcher Kyle D. Allen, an associate professor of biomedical engineering at the University of Florida. "The more we understand these interactions of the cartilage, the more possible it is to, for instance, develop new synthetic materials or biological tissue implants that can replace the function for someone who has osteoarthritis."

Allen and his university colleagues joined forces with the scientists at Argonne's X-ray Science Division (XSD). Half-moon-shaped cartilage samples were collected from the rounded ends of cow femurs. At the APS' 8-ID-I beamline, the cartilage was exposed to different conditions, inserted into a specimen holder, and examined using ultrabright X-ray beams.

The group published the study in the journal *Osteoarthritis and Cartilage*. The findings suggest that smaller ECM components are more mobile than larger components, dehydration slows mobility, and ECM dynamics are faster the closer they are to the cartilage surface. The report also shows that this X-ray technique can be used to effectively measure ECM dynamics simultaneously at larger scales—below one micron, or 70 times smaller than the width of a human hair—and at smaller ones, down to nanometers, or the amount your fingernails grow each second. This study demonstrates the use of this technique and opens the door to studies of how such tissues are affected by various parameters or conditions.

"The insights that we can gain from biological materials using X-rays at the APS are unique compared to any other probes," said Qingteng Zhang, an assistant physicist at XSD. "With the XPCS technique, one can look at the inner structure of the cartilage or dynamics that are on the nanometer scale in its native environment without damaging or cutting open the structure. It is something that only high-energy, laser-like X-rays are capable of."

Taken together, these results advance the understanding of cartilage dynamics and demonstrate a valuable new research tool.

"This study is really about achieving a fundamental understanding," Allen said. "While we have a high-level idea of how cartilage functions, there are still a lot of mysteries. The work we've done allows us to finally investigate some of those questions that are left unanswered."

More information: B.D. Partain et al, Spatially-resolved nanometer-scale measurement of cartilage extracellular matrix mobility, *Osteoarthritis and Cartilage* (2021). DOI: 10.1016/j.joca.2021.05.059

Provided by Argonne National Laboratory

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