Can Knee Osteoarthritis Be Prevented?

A multidisciplinary HSS research team aims to identify patients at higher risk after surgery in an effort to reduce knee OA incidence.

HSS BIOMECHANICAL ENGINEERS, quantitative imaging scientists and clinician-scientists are creating innovative technologies and harnessing them to study the mechanisms of osteoarthritis (OA) that affect an increasing number of patients after knee injury. Translating these advances to the clinic may help identify patients with a higher risk of developing knee OA, allowing for more tailored approaches to treatment and rehabilitation to improve outcomes. The tools may also provide more objective evidence than standard methods for determining when it's safe for athletes to return to play after recovering from knee injury or surgery.

We are striving to develop new treatments to prevent the development of OA

"Injuries to articular cartilage, ligaments or the meniscus are significant risk factors for the development of knee OA, but the underlying mechanisms have been unclear," says clinician-scientist Scott Rodeo, MD, a sports medicine surgeon and Vice Chair of Orthopaedic Research and Co-director of the Orthopaedic Soft Tissue Research Program at HSS. "Surgery can fix the initial problem of a torn ACL or cartilage and stabilize an injured knee, but we are striving to develop new treatments to prevent the development of OA."

Developing new treatments requires better understandings of the underlying mechanisms of knee OA and whether differences in tissue structures and distribution of forces across the joint can explain which patients have a higher risk of joint degeneration. HSS is uniquely positioned to conduct basic, translational and clinical research to advance learning in this field.

SUBSPECIALTY EXPERTISE

In addition to performing knee repair surgeries in the clinic, Dr. Rodeo conducts basic research into mechanisms of knee OA after anterior cruciate ligament (ACL) injury using mouse models. He collaborates with subspecialist researchers from other labs within the HSS Research Institute, including Hollis Potter, MD, Chairman of the Department of Radiology and Imaging and Coleman Chair in MRI Research, and Matthew Koff, PhD, associate scientist in the Department of Radiology and Imaging — MRI Division at HSS. Together, the team developed advanced quantitative magnetic resonance (MR) imaging techniques that can assess the health of internal knee structures. "We use background physics to create 3D images showing the biochemical composition of joint structures in much greater detail than is possible with standard 2D MR images," explains Dr. Koff.

Little data currently exist on how forces are distributed across the human knee joint. To help address this issue, HSS senior scientist Suzanne Maher, MD, Associate Director of the Department of Biomechanics and Co-Director of the Orthopaedic Soft Tissue Research Program, has developed working models using cadaveric knees to simulate the activity of walking on joint surfaces, allowing her to measure how injury to cartilage and ligaments changes movement mechanics.

"Data generated from these models showed that the distribution of forces across a knee joint varied quite a bit, with some heavily loading the menisci and others not so much," says Dr. Maher. To measure differences in individual knees in clinical research, she collaborated with Dr. Koff to design a specialized boot with an MR-compatible load cell that simulates a force on the knee joint equivalent to 50 percent body weight.

A NEW, SPECIALLY DESIGNED BOOT CAN SIMULATE A FORCE OF:

50%

body weight on the knee joint

IT TAKES A TEAM

Drs. Rodeo, Potter, Koff and Maher combined their innovations and research advances to create an integrated clinical platform for directly evaluating contact mechanics and assessing cartilage health. They tested the platform in a pilot study of five patients who underwent meniscal allograft transplantation.

Data collected before, during and after surgery revealed that meniscal transplantation provided a chondroprotective effect for most patients, as evidenced by decreased peak contact stress and increased contact area. T1ρ values for tibial articular cartilage in post-operative MR scans at three and six months were lower, suggesting an increase in proteoglycan. The investigators also found prolonged T2 values within the central cartilage-on-cartilage contact area of the tibial plateau, reflecting focal disruption of the collagen network.

This kind of collaboration across disciplines could only happen at HSS, where we work together with a keen focus on translating research techniques to patients

"Our study demonstrated that our clinical platform generated objective, concrete data to evaluate the efficacy of surgical procedures aimed at delaying the progression of OA," says Dr. Potter. "This kind of collaboration across disciplines could only happen at HSS, where we work together with a keen focus on translating research techniques to patients."

NEW DIRECTIONS IN KNEE OA RESEARCH

The team has several initiates underway that build on previous HSS advances in knee OA research. "Our ongoing efforts in the area of knee OA research will continue to leverage our strong multidisciplinary team, combining our state-of-the-art quantitative imaging with computational models of the knee, laboratory analyses of biospecimens from our patients, and patient-reported outcomes data from our clinical registries."

NIH GRANT FUNDS HSS CLINICAL RESEARCH

Dr. Maher and Dr. Rodeo are leading a research initiative testing the utility of the clinical platform among patients undergoing partial meniscectomy, a more common treatment for meniscal injury than meniscal allograft transplantation. The five-year study, which began in 2019, is funded by a grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases.

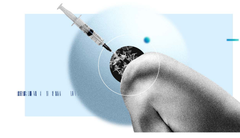
Dr. Maher, Dr. Rodeo and colleagues will evaluate whether the platform can identify the mechanical and clinical factors associated with the development of knee OA after partial meniscectomy, using their innovative tools to identify geometric features, tissue properties and kinematic characteristics that affect how forces distribute across the knees of patients who undergo arthroscopic partial meniscectomies compared to a control group with intact knees.

INFORMING RETURN-TO-PLAY DECISIONS

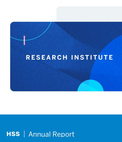
Our techniques may also prove useful as a biomarker in clinical trials testing the efficacy of novel agents targeting OA in the future

Drs. Potter and Koff are developing predictive models for return-to-play decisions for athletes who experienced knee injuries or had surgical interventions to treat them using quantitative MR techniques. "Scientifically rigorous evidence from noninvasive, quantitative MR will provide clinicians with much more robust information on whether athletes are ready to return to play or require more rehabilitation than basing decisions on how patients feel," says Dr. Potter. "Our techniques may also prove useful as a biomarker in clinical trials testing the efficacy of novel agents targeting OA in the future."

PLATELET-RICH PLASMA



Dr. Rodeo is leading a multi-institutional clinical study evaluating the use of platelet-rich plasma (PRP) injections as a potential treatment for reducing the risk of developing knee OA after ACL injury. The platelets in PRP, taken from the patient's blood, provide a rich source of anti-inflammatory chemicals and growth factors to stimulate repair processes. Researchers will analyze joint fluid over time to look for inflammatory markers. Additionally, they will evaluate quantitative MR data to detect biochemical changes in cartilage tissue within a year or two, much faster than changes observed via standard X-rays, which can take up to 15 years. They will also analyze small samples of each patient's PRP in the lab to look for common characteristics that help prevent the development of arthritis.



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