Commentary & Perspective

Commentary on an article by Richard B. Frobell, PhD: “Change in Cartilage Thickness, Posttraumatic Bone Marrow Lesions, and Joint Fluid Volumes After Acute ACL Disruption. A Two-Year Prospective MRI Study of Sixty-one Subjects”

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The anterior cruciate ligament (ACL) is an important stabilizer of the knee joint. At the time of ACL disruption, the “bone bruise” sustained during pivot shift and tibial translation has been recognized as a transchondral fracture of varying severity. Little is known, however, about the risk factors of osteoarthritis following initial ACL injury, or the effect on cartilage morphology following the initial transchondral fracture. Because of its direct multiplanar capabilities and superior soft-tissue contrast, as well as the availability of reproducible, standardized, and surgically validated cartilage pulse sequences, magnetic resonance imaging (MRI) is an extremely well-suited tool to provide objective longitudinal evaluation of cartilage changes following ACL disruption. In a young cohort of patients (mean age, twenty-six years) who sustained an ACL tear, the investigators performed a longitudinal, comprehensive, prospective MRI analysis, using standardized three-dimensional pulse sequences to evaluate morphologic changes and cartilage thickness as well as the extent of subchondral bone marrow edema pattern and joint fluid volume. The patients were captured from a prior randomized controlled trial comparing delayed versus acute ACL reconstruction with a clinical rehabilitation regimen alone. The investigation disclosed significant cartilage thickening in the central portion of the medial femoral condyle, associated with an older age at the time of the ACL tear, as well as cartilage thinning in the trochlear sulcus, particularly in male patients who were younger at the time of injury. The initial bone marrow edema pattern largely resolved within six months, but new bone marrow edema patterns in the lateral compartment were discovered in one-third of the knees. None of the factors tested, including age and treatment regimen, were associated with development of the new bone marrow edema patterns.

The investigators are to be congratulated for a comprehensive MRI analysis, capturing multiple data points in this cohort. The group of subjects is, however, somewhat heterogeneous. Exclusion criteria included a full-thickness cartilage defect at the time of the initial MRI, but there was no clarification of the extent of high-grade partial preexisting lesions, particularly in the patellofemoral joint. Further, patients treated with either partial meniscectomy or small (<10-mm) meniscal repair were included. It is well established that loss of functional meniscal tissue may result in an accelerated rate of articular cartilage degeneration and may be associated with an increasing risk of development of osteoarthritis following ACL injury. In addition, the means of reconstruction are somewhat heterogeneous, including autologous patellar tendon and hamstring reconstruction, as well as conservative treatment. No specifics regarding the ACL footprint were made. Current trends toward a more “anatomic” femoral footprint of the ACL reconstruction may arguably overconstrain the lateral compartment, potentially leading to the development of increasing contact pressures over the lateral femorotibial joint and the development of the observed new bone marrow edema lesions. The finding of swelling or increased thickness of cartilage of the central aspect of the medial femoral condyle is likely associated with shifts of water from the extracellular compartment from early depletion of matrix, possibly due to proteoglycan loss.

Quantitative MRI techniques that predominantly target proteoglycan have been used to study small cohorts of ACL-injured patients, and this information is complementary to the observed morphologic changes in the current study. Tiderius et al. utilized delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) indices to assess a group of patients following ACL injury, demonstrating relative depletion of the glycosaminoglycan index over the bone marrow edema pattern lesions of the lateral femoral condyle, as well as the medial femoral condyle, an area unaffected by the initial bone bruise. T1 rho is an additional technique that has been used to target proteoglycan, as it predominantly assesses low-frequency interactions between hydrogen molecules in macromolecules (such as the glycosaminoglycan chains in proteoglycan) and free water. Li et al. applied such techniques to a small cohort of ACL-injured patients and found prolongation of T1 rho, reflective of the depletion of proteoglycan in the superficial layers of the medial compartment, one year following ACL injury. These data, combined with the swelling of the medial femoral condylar cartilage in the current study, suggest that the initial transchondral fracture sustained at the time of pivot shift may result in an overall change in regional cartilage homeostasis, imparting a deleterious effect on compartments that are presumably unaffected at the time of the initial injury and undetected by the initial postinjury MRI with use of standardized morphologic pulse sequencing.
The finding in the current study of significant cartilage thinning in the trochlear sulcus two years after injury suggests that there was an adverse effect on the patellofemoral joint, possibly due to the fact that the mechanics of the knee joint were not fully restored in the patients treated both conservatively as well as with ACL reconstruction.

There are increasing groups of data suggesting that the chondral injury sustained at the time of ACL injury is not an inconsequential bone bruise, but is a clinically relevant injury that not only affects cartilage morphology but also results in depletion of extracellular matrix over the area of the initial bone bruise, potentially resulting in a deleterious effect on cartilage homeostasis throughout the remaining knee joint. Further evaluation in select cohorts of ACL-injured patients will be necessary, with longer imaging follow-up, to more comprehensively assess and define the risk factors associated with more rapid progression of osteoarthritis. Advances in MRI provide a well-suited vehicle by which to study these events, both on a morphologic and biochemical basis.

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*The author received no payments or services, either directly or indirectly (i.e., via her institution), from a third party in support of any aspect of this work. Neither the author nor her institution has had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, the author has not had any other relationships, or engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete Disclosures of Potential Conflicts of Interest submitted by the author of this article are available with the online version of this article at jbjs.org.

References