Imaging of Cartilage in the Athlete

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KEYWORDS

• MRI • Cartilage injury • Cartilage repair

KEY POINTS

- MRI is the optimal test for identification of cartilage injuries and for evaluating these patients after cartilage repair surgery.
- Standard MRI evaluation allows for a morphologic cartilage evaluation addressing the cartilage thickness, intrinsic cartilage signal, and subchondral bone.
- Compositional MRI techniques specifically quantify the quantity of particular molecules within the extracellular cartilage matrix and may allow for an earlier diagnosis of cartilage injury before morphologic changes manifest.

INTRODUCTION

Articular cartilage lesions represent a growing class of injuries in collegiate, professional, and recreational athletes with limited intrinsic healing capacity.[1] Due to the prevalence of these injuries and their associated sequela, diagnosis with noninvasive imaging modalities is extremely helpful to be able to appropriately treat these patients and determine their long-term prognosis. This article discusses imaging of cartilage injuries in athletes and the imaging of surgical cartilage repair techniques, with an emphasis on MRI.

MRI remains the ideal imaging technique for evaluation of articular cartilage, as it allows for direct visualization of the cartilage and the subchondral bone. MRI uses nonionizing radiation and therefore avoids the associated health risks caused by ionizing radiation, which is particularly relevant for this class of injuries that may involve younger patients with multiple imaging studies. MRI is also ideal because it can be obtained in multiple planes and provides exquisite soft tissue contrast. Additionally, MRI provides an ideal evaluation of the other soft tissue structures around the joint that may be injured. Radiographs and computed tomography (CT) provide an evaluation of the cartilage indirectly by evaluating the joint space thickness and associated

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bone changes, but have limited ability to directly visualize the cartilage tissue. Contrast arthrography using radiographs and CT allow for a more detailed evaluation of the cartilage surface, but still do not provide the same level of detail that MRI provides when evaluating the cartilage tissue and include the risks associated with ionizing radiation.

Although MRI is the ideal imaging examination in patients suspected of having an articular cartilage injury, this modality can be contraindicated, particularly when the patient has a pacemaker or other implanted medical device that is not safe for MRI. In these cases, alternative examinations, such as CT arthrography, may be able to provide adequate evaluation of the cartilage. Direct consultation with a radiologist is helpful in these situations to determine the most appropriate alternative imaging modality.

MRI evaluation using standard sequences provides high-resolution, high-contrast techniques that will allow for imaging in multiple planes, yet also be completed in a timely fashion. Technological advances in MRI have led to the development of a variety of imaging techniques that allow for a compositional evaluation of the articular cartilage, which can potentially evaluate molecular changes to the cartilage before morphologic changes, including techniques such as delayed gadolinium-enhanced MRI of cartilage (dGEMRIC), T2 mapping, and T1 rho. Adequate evaluation of the articular cartilage requires high–spatial resolution imaging because of the small thickness of articular cartilage, with imaging performed in 3 orthogonal planes. High resolution is accomplished by the use of a surface coil over the joint of interest. Field strengths of 1.5 T can generally provide adequate signal for morphologic evaluation of the articular cartilage. MRI units with 3.0-T field strengths allow for improved signal to noise ratio (SNR), thereby allowing for higher spatial resolution and shorter imaging times. Use of 3.0-T MRI has shown higher diagnostic accuracy compared with 1.5 T for the evaluation of cartilage in the knee.[2] A field strength of at least 1.0 T is recommended for cartilage evaluation and field strengths of 0.20 T have been shown to be inadequate to reliably evaluate cartilage.[3,4] Limitations of 3.0-T units include increased metallic susceptibility artifact compared with 1.5 T, particularly in the postoperative patient or patient with implanted hardware.

When evaluating articular cartilage, the normal hyaline cartilage will demonstrate an intermediate signal with a trilaminar pattern of stratification on T2-weighted or proton density (PD)-weighted sequences (**Fig. 1**). The surface layer of cartilage should have low signal intensity, the intermediate layer should have high signal intensity, and the deep layer should have low signal intensity. This is often most evident in thicker cartilage, such as the patellar cartilage.[5] The signal pattern in each layer of cartilage remains related to the orientation of collagen fibrils in that layer and the distribution of chondrocytes.

MORPHOLOGIC CARTILAGE EVALUATION

The sequence selection needs to provide adequate soft tissue contrast to differentiate between the joint fluid and cartilage along with differentiation between the cartilage and the subchondral bone. Attention should be paid to the intrinsic signal within the cartilage, the presence of fissuring, and the presence of partial-thickness or full-thickness cartilage loss. The presence of fibrillation or irregularity of cartilage surface should be addressed. Focal fissuring is identified, as focal linear or wedge-shaped regions of increased signal extending to the lamina splendens. Focal cartilage damage should be described as either partial thickness or full thickness extending to the