Magnetic Resonance Imaging of Cartilage Repair Procedures

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KEYWORDS

• Magnetic resonance imaging • Cartilage repair • Knee

KEY POINTS

- Current cartilage repair strategies in the knee.
- Magnetic resonance (MR) imaging appearance of cartilage repair procedures in the knee.
- Reporting MR imaging findings of cartilage repair in the knee.

Videos of microfracture procedure and autologous chondrocyte implantation procedure accompany this article at http://www.mri.theclinics.com/

INTRODUCTION

Articular cartilage lesions occur frequently and can be a common source of pain, especially in the knee. Up to 36% of athletic injuries have an associated chondral injury,[1,2] more so in women. A study of 31,516 arthroscopies identified chondral injuries in 63% of patients.[3] When left untreated, chondral lesions can accelerate the development of osteoarthritis and result in permanent dysfunction.[4,5] Mature articular cartilage has limited capability for repair because of poor vascularity, inability to recruit undifferentiated cells, and limitations on cell replication and migration by the dense extracellular matrix.[6] Some investigators have suggested that a subset of cartilage defects in humans may heal spontaneously,[7] and spontaneous cartilage repair has been shown in some animal models.[8,9] However, even in animal models, the repair tissue is imperfect and dependent on the age of the animal.[9,10] For these reasons, there has been intense research in the development of techniques to repair or restore articular cartilage surfaces.

Imaging plays an increasingly important role in both the initial detection of chondral lesions and the postoperative evaluation of chondral repair procedures. Magnetic resonance (MR) imaging, with its ability to directly image cartilage and chondral repair tissue, is particularly valuable and with proper use may help patients avoid unnecessary arthroscopic or even open surgery. Because an increasing number of cartilage repair procedures

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are being performed, the radiologist must have an understanding of the surgical techniques involved, the expected postoperative appearances of these repairs, and the possible complications associated with repair strategies. The basic approaches to the treatment of cartilage damage include nonoperative conservative measures, lavage and debridement, marrow stimulation techniques, synthetic scaffolds, biological tissue grafting, and cell-based therapies. Many cartilage repair techniques are not approved by the US Food and Drug Administration and are available only outside the United States or through clinical trials.

The following sections provide an overview of current cartilage repair strategies and their normal and abnormal MR imaging appearances. Guidelines for reporting postoperative imaging findings are discussed also.

NONOPERATIVE CONSERVATIVE THERAPY, LAVAGE, AND DEBRIDEMENT

Nonperative conservative treatments include symptomatic relief options such as nonsteroidal antiinflammatory drugs, braces, oral nutriceuticals such as chondroitin sulfate, intra-articular viscosupplementation with hyaluronic acid (HA), and injection with platelet-rich plasma (PRP). No studies have shown a significant improvement in the MR imaging appearance of chondral surfaces after HA or PRP injection.[11–13] This finding could, in part, relate to the short follow-up interval of these studies (1–2 years). In 1 randomized controlled study, clinical outcome scores were better for patients who underwent PRP injection than for those who received HA injection.[14,15]

Lavage and debridement are usually performed arthroscopically and involve the removal of unstable cartilage, loose bodies, and osteophytes. After debridement, lesions may appear larger and may have sharper margins on MR imaging. Some lesions may appear to fill, either from attempted self-repair or because of differences in slice position and partial volume averaging artifacts. MR imaging is usually performed after these therapies to assess the joint for progression of the cartilage defect or development of new structural damage.

SURGICAL TECHNIQUES FOR CARTILAGE REPAIR

All of the surgical techniques begin with complete removal of the damaged cartilage. This procedure may involve debridement of the cartilage to the calcified cartilage or subchondral bone. Bone and cartilage may also be removed en bloc or as a plug (as in osteochondral grafting). As a result, all tissue within a cartilage repair site represents either newly grown or implanted tissue. Tissue grafting techniques use autograft or allograft tissue to provide a more optimal hyaline or hyaline-like cartilage repair tissue. Cell-based therapies are 2-step procedures in which chondrocytes harvested from the patient are cultured and then reimplanted as cells or as cell-seeded scaffolds. Acellular scaffolds may also be implanted into prepared cartilage defects. Nonbiological therapies can provide partial or complete resurfacing of a single compartment of a joint with metal or polyethylene, but these treatments are beyond the scope of this article. Patient compliance with a proper rehabilitation regimen is necessary to ensure a good outcome. A basic algorithm for these various procedures is shown in **Fig. 1**.

Bone Marrow Stimulation

Marrow stimulation techniques are probably the most common surgeries for chondral defects, with microfracture being the most common of these. The goal of stimulation procedures is to promote bleeding that forms a clot, which then fills the chondral defect with pluripotent cells derived from bone marrow. Cytokines are released, stimulating the formation of fibrocartilage within the lesion.[16] However, fibrocartilage does not have the same biomechanical properties as native hyaline cartilage, so this repair may be less durable.

Early marrow stimulation procedures removed the subchondral bone plate altogether. These procedures were then replaced by abrasion arthroplasty, a less invasive subchondral bone plate debriding technique. As time progressed, less invasive procedures were favored, such as subchondral bone drilling and microfracture. Although drilling and microfracture are similar, historically, drilling was theoretically believed to have a higher risk of tissue necrosis. However, a recent study in a rabbit model showed more osteocyte necrosis with microfracture than with microdrilling.[17]

Microfracture is appealing because it can be performed arthroscopically, is therefore relatively noninvasive, and has low morbidity. In this procedure, the chondral lesion is first debrided to sharp, stable margins, and an awl is then used to create 1-mm to 2-mm holes in the subchondral bone plate approximately 3 to 5 mm apart across the entire lesion area (**Fig. 2**, Video 1).[16] The recovery and rehabilitation time for microfracture is the same as for cartilage repair surgeries for small lesions (<4 cm^2): 6 weeks on crutches with partial weight bearing and continuous passive motion for 6 to 8 hours daily. No inline running for 6 to 9 months and no pivoting sports for 1 year are advised.