Clinical Cartilage Imaging

MRI Assessment of Articular Cartilage Repair

Darshana Sanghvi, M.D., D.N.B.
Kokilaben Dhirubhai Ambani Hospital, Mumbai, India

Introduction

Articular cartilage lesions in the young population predispose to the development of precocious osteoarthritis. Poor healing of cartilage damaged by trauma or degeneration has been ascribed to avascularity. Cartilage lesions are associated with significant morbidity, including lifestyle restrictions, especially in individuals engaged in sports. The past decade has seen the evolution of a number of sophisticated surgical repair procedures for the treatment of isolated, focal traumatic or degenerative cartilage lesions. The evolution of these surgeries has created the need for accurate, non-invasive assessment of the repair tissue. The current generation of MR magnets and dedicated pulse sequences allow for structural and biochemical assessment of the repair tissue. This information is useful for prognostication and for comparing the effectiveness of various types of surgical procedures.

Articular cartilage repair procedures

The bone marrow stimulation surgeries include microfracture technique, drilling and abrasion arthroplasty. The goal of all of these procedures is to expose the pluripotential stem cells in the subchondral bone which then migrate to the site of the chondral lesion. A fibrin clot is formed at the site of the microfractures or drilling, which serves as a scaffold for the formation of fibro cartilaginous repair tissue. Osteochondral autologous transfer (OATS) technique or mosaicplasty involves the removal of osteochondral plugs from the non-weight-bearing part of the joint, often the trochlea. The plugs are then transferred to the chondral lesion along the weight-bearing part of the articular surface. It thus transplants autologous hyaline tissue to...
the articular lesion. The osteochondral plugs should be perpendicular to the articular chondral defect. Autologous chondrocyte implantation (ACI) technique involves transplanting chondrocytes harvested and replicated from a non-weight-bearing part of the articular surface into the lesion at the weight-bearing site. In the initial part of this two stage procedure, the chondrocytes are harvested and cultured in vitro for approximately five weeks. In the second part of the procedure, the harvested chondrocytes are injected into the articular chondral lesion and covered with a periosteal flap.

**MRI assessment**

The aim of imaging is to examine the success of surgery and assess the quality of the repair tissue.

In a successful mosaicplasty procedure, the cartilage caps of plugs should be flushed with the adjacent native cartilage. The aim is to have the plugs placed perpendicular to the articular surface. MRI after the mosaicplasty procedure involves assessment of graft incorporation, graft congruity and examination of the repair tissue characteristics. The donor site may also be assessed. In the first four weeks after the procedure, the plugs and surrounding marrow have altered marrow signal. By 12 months, the plugs and the surrounding marrow return to normal fatty marrow signal (Fig. 1). Persistent edema like subchondral bone marrow signal and cyst formation indicates graft failure and poor incorporation.

The MOCART (MR observations of cartilage repair tissue) system (Table 1) is an efficient scoring method for consistent reporting of the radiological features of autologous chondrocyte implants and has impressive interobserver reproducibility. MOCART scoring may be useful for objective follow-up of articular carti-

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<th>The 8 parameters assessed by the MOCART scoring system.</th>
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<tr>
<td>1</td>
<td>Degree of defect repair and defect filling</td>
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<td>2</td>
<td>Integration with border zone</td>
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<td>3</td>
<td>Quality of repair tissue surface</td>
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<td>5</td>
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<td>Status of subchondral lamina</td>
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<td>7</td>
<td>Integrity of subchondral bone</td>
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<td>8</td>
<td>Presence of complications (adhesions and effusion)</td>
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The MOCART scoring may be useful for objective follow-up of articular carti-

1 An 18-year-old was involved in a motorcycle accident. (1A) Frontal knee radiograph shows flattening of the articular surface of the lateral femoral condyle (arrow). (1B) Corresponding coronal MR STIR image shows a traumatic osteochondral lesion of the lateral femoral condyle. (1C) The biopsy site from the non-weight-bearing part of the lateral femoral condyle is seen in the transaxial image. (1D and 1E) Sagittal DESS and coronal T2w images show the biopsy site (dotted arrow) from the non-weight-bearing lateral femoral condyle and the site of the graft (solid arrow). There is excellent congruity of the osteochondral plugs with the parent bone. The patient remained symptom free at one year clinical follow up.
2 Post ACI follow up MRI shows satisfactory fill of the lesion. The articular surface of the graft is smooth. The signal is similar to native cartilage. There is no defect between the graft and parent bone, no subchondral marrow edema, adhesions or effusion.

3 Sagittal PD-weighted images of the knee joint (3A) – unstable osteochondritis dessicans of the medial femoral condyle. (3B) Post ACI MRI shows adequate fill by the graft (arrow).

4 15-year-old girl with first episode of patellar dislocation. (4A) Axial STIR MR images show trochlear dysplasia with marrow contusions at patellar apex and outer aspect of lateral femoral condyle and also a large osteochondral defect at the patellar apex (arrow). The corresponding osteochondral fragment is seen in the lateral patellofemoral recess (arrow). (4B) In the first stage of surgery, arthroscopic loose body removal was done with cartilage biopsy. Left knee open ACI (stage 2) was done for the patellar osteochondral defect. (4C) Follow up MRI showed graft hypertrophy. The patient had mechanical symptoms after surgery.
Cartilage repair, as it allows prospective multicenter studies in which results of cartilage repair surgeries are compared [1]. An additional advantage over arthroscopy for post operative assessment is the ability of MRI to demonstrate subchondral marrow. The margins of the repair tissue should be continuous [2] and have equivalent thickness when compared with adjacent native cartilage and the articular surface should be even (Figs. 2, 3).

Adverse events after ACI include graft failure, which is the commonest, followed by delamination, tissue hypertrophy and local infection. Two common complications of the ACI technique are graft hypertrophy and delamination. Graft hypertrophy (Figs. 4, 5) may occur 3 to 7 months after autologous chondrocyte implantation and has been reported as a complication in 10% to 63% of cases [3–5]. Delamination refers to separation of the graft from the parent bone. It appears as a linear fluid signal undermining the graft. When significant, both delamination and graft hypertrophy may require repeat surgery, either debridement in the case of hypertrophy or repeat ACI in both cases.

Conclusions

Articular cartilage injury is frequent, documented in almost 63% of arthroscopies [6]. It is even more common in conjunction with ACL tears; about 79% of patients with ACL deficient knees have chondral lesions of varying severity [7]. The introduction of novel cartilage repair procedures that transplant hyaline cartilage to the injured area or have the potential to form hyaline-like repair tissue, has lead to an increased requirement for a non-invasive but accurate technique to assess the outcome of such repair surgeries. MR imaging is currently the optimal technique for such assessment [8]. The ability of MR imaging to directly depict subchondral bone and bone marrow represents an advantage over arthroscopy MRI is also accurate for examination of the repair tissue and its interface with parent cartilage and complications of repair surgeries such as graft hypertrophy and delamination.

Acknowledgement for arthroscopy images:
Dr. Dinshaw Pardiwala, M.S., Consultant Arthroscopy and Sports Medicine, Kokilaben Dhirubhai Ambani Hospital, Mumbai, India.

References

Contact
Darshana Sanghvi, M.D., D.N.B.
Kokilaben Dhirubhai Ambani Hospital
Mumbai
India
sanghvidarshana@gmail.com