Articular Cartilage Injuries of the Knee

Evaluation and Treatment Options

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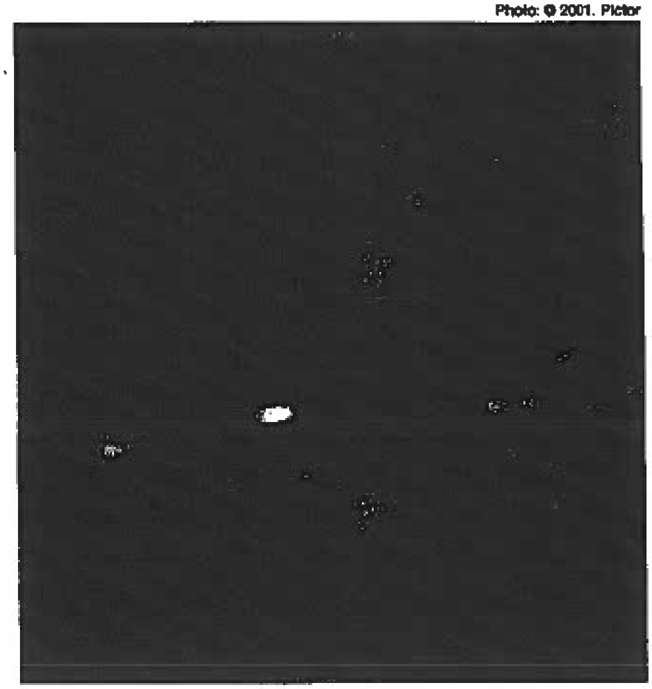
IN BRIEF: Articular cartilage defects of the knee can be very debilitating, and diagnosis can be difficult because the symptoms are often nonspecific. Routine MRI scans, despite vast improvement in detection techniques, are often not sensitive or specific enough, especially for low-grade lesions. Therefore, articular cartilage injuries of the knee are often a diagnosis of exclusion requiring a thorough history, a good physical exam, and a high index of suspicion. Treatment of these injuries is still evolving, but new treatment options, including autogenous chondrocyte implantation, look promising, and long-term outcomes, while not yet complete, look encouraging.

The exact incidence of localized articular cartilage lesions of the knee is unknown, but chondral defects have been reported in up to 63% of knee arthroscopies.[1] While the cause of articular cartilage injuries of the knee remains largely hypothetical, it depends on patient age and activity level.[2-4] Throughout the late teen years and into early adulthood, a common cause of cartilage injuries of the knee is direct trauma. The mechanism is a sudden twist and pivot that shears off or damages a portion of the cartilage surface.

Ligament injuries are another significant contributor to cartilage injuries. A frequently seen example is an anterior cruciate ligament (ACL) tear[4] that damages the supporting bone beneath the articular cartilage. This leads to gradual thinning and possible degeneration of the overlying cartilage.

One common osteoarticular defect of the joint surface is osteochondritis dissecans (OCD),[5] usually seen at the far lateral aspect of the medial femoral condyle and the central region of the lateral femoral condyle. In patients with OCD in which the underlying subchondral bone collapses, the overlying articular cartilage may slough off, and the patient develops a focal area of arthritis.



For CME credit, see page 97

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To check for signs of quadriceps atrophy, measure the patient's thigh circumference 15 cm proximal to the superior pole of the patella. A difference of more than 1 cm compared with the patient's other leg suggests atrophy.

With current technology, cartilage lesions cannot be resurfaced for most patients, but recent treatment advances have made it possible for some patients.

Injury Classification

The Outerbridge articular cartilage lesion classification system[7] is used to grade cartilage lesions of the knee. This four-grade system is based on arthroscopic evaluation. Grade 1 and 2 lesions are considered low grade and involve softening or fissuring of the articular cartilage surface that does not extend to the underlying bone. Low-grade lesions do not heal well and frequently lead to further cartilage damage. Grades 3 and 4 are considered high-grade, full-thickness lesions that have very little cartilage remaining or that expose the underlying bone surface.[8] Localized grade 4 lesions are relatively rare. We will discuss primarily the diagnosis and treatment of high-grade localized articular cartilage lesions of the knee.

It is generally believed that lesions larger than 2 cm in diameter are more likely to be symptomatic and degenerate further. Some smaller lesions, however, may become symptomatic and progress in size. Contained lesions, which are generally smaller, high-grade lesions, are relatively well protected from rapid degeneration because the exposed bone surface remains insulated from the opposing articular surface by a surrounding margin of intact cartilage.

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Diagnosing Cartilage Injuries

The patient's history is vital to diagnosing a knee injury.[9] Frequently, the patient's complaints include swelling of the joint with activity. He or she may have functional limitations in activities such as walking or running, squatting, ascending or descending stairs, or performing repetitive assembly line maneuvers. Because many of these resemble symptoms of meniscal tears, differentiating between articular cartilage damage and meniscal tears can be difficult.

After a thorough history, a good physical exam is essential. The physician should first assess for an effusion. Thigh atrophy may also exist if the lesion has been present for several months or longer. Note the overall tone of the quadriceps muscles and check for signs of quadriceps atrophy by measuring the thigh circumference 15 cm proximal to the superior pole of the patella. A difference of more than 1 cm compared with the patient's other leg is considered positive for thigh atrophy.

Next, the patellofemoral joint is examined as the patient lies supine with the knee in full extension. A patient may have an irritated suprapatellar plica, especially if the symptoms have been long-standing. The snap test is performed by resting the examiner's hand over the patella while the index finger rolls over the plica. The test is positive if rolling pressure from the index finger elicits pain or discomfort.

After examining the plica with the snap test, the knee is flexed to 45° to assess for patellofemoral crepitation that may indicate underlying articular cartilage damage. Patellofemoral crepitation can be assessed while simultaneously checking for lateral patellar apprehension. Having the patient completely relax the lower extremity allows good assessment of medial and lateral patellar motion in the trochlear groove. Patellofemoral crepitation with passive motion may not always be caused by articular cartilage defects; in fact, it is most commonly caused by a knee effusion and the loss

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of the normal, near-frictionless motion of intra-articular structures with normal synovial fluid.

Assessment of joint-line pain and crepitation are possibly the most specific tests to identify articular cartilage injuries of the knee. Examination of the medial compartment for possible cartilage injuries is similar to that for a possible valgus knee injury. With the patient's knee flexed approximately 30°, the physician places the fingers of one hand over the medial joint line while the other hand applies a valgus stress to the knee via the ankle (figure 1). The examiner slides the fingers anteriorly and posteriorly along the joint line while applying a valgus stress and feels for intra-articular crepitation. If the exam is painful, the patient is asked if the pain feels superficial or deep and if the maneuver reproduces symptoms.

In the same position, to test for lateral compartment cartilage defects, the examiner applies a varus stress to the knee. Normal crepitation may be felt under the iliotibial band, so it is important to place one's fingers anterior and posterior to the iliotibial band at the joint line. It can be extremely difficult to differentiate joint-line crepitation caused by an articular cartilage lesion from an isolated or concurrent meniscal tear.

Knee stability is tested to identify underlying ligament injuries that may be contributing to articular cartilage defects.[9] First, the Lachman's test is performed to assess for the possibility of an ACL tear. The physician should also assess for any increased joint-line opening with valgus and varus stress that could indicate a medial collateral ligament complex injury or posterolateral corner injury. When examining a patient for ligament laxity, remember that underlying degenerative disease of a compartment may cause "pseudolaxity," allowing the joint to actually collapse on the contralateral arthritic compartment, thus giving the false sense of an ipsilateral collateral ligament injury. Assessment of the posterior cruciate ligament is performed with the posterior sag sign, quadriceps active test, and posterior drawer test.[9] The clinician may also use rotational testing of the knee (posterolateral drawer test, pivot shift, and reverse pivot shift tests) to further characterize possible ligament injuries.[9]

Figure 1: ©2001. Terry Boles

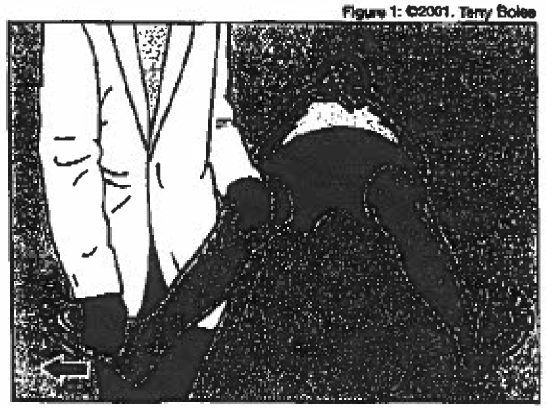

FIGURE 1. Valgus stress test. The patient is supine with the affected knee flexed 30°. The examiner places a hip against the lateral aspect of the patient's thigh and places the fingers of one hand over the medial joint line. Grasping the patient's foot or ankle, the examiner applies a valgus stress and assesses for intra-articular crepitation and the degree of medial joint-line opening.

Radiographic Imaging

Plain radiographs are useful for diagnosing severe cartilage injuries but are marginally useful for detecting localized articular cartilage lesions of the knee. Increasingly severe degrees of radiographic osteoarthritis have been associated with higher risks of dysfunction and symptoms.[2] Attempts should be made to obtain all knee anteroposterior (AP) radiographs with the patient standing. The standard series includes a standing AP view, a lateral view with the knee flexed 35°, and a 45° patellar sunrise view. Lateral radiographs may indicate OCD or impaction fractures of the femoral condyles. If an area looks suspicious for OCD, an intercondylar notch view should also be obtained.

Evidence of joint-line narrowing, caused by decreased thickness of the articular cartilage of that portion of the knee, may indicate advanced articular cartilage injury. If evidence of joint-line narrowing is seen on the AP x-ray or asymmetrical alignment is noted clinically, a full-length standing radiograph can be obtained. When assessing the full-length view, a line should be drawn from the center of the hip to the center of the ankle to determine where this line crosses the knee; any deviation, either medially or laterally to the tibial spines, indicates an underlying genu varus or valgus deformity. The ideal mechanical axis is through the center of the knee joint between the tibial spines.

In most cases of localized articular cartilage lesions of the knee, however, plain radiographs will be normal.

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Figures 2-4: Courtesy of Hollis M. Fritts, MD

FIGURE 2. T1-weighted fat-suppressed 3-D, spoiled gradient-echo MRI, sagittal view of the knee. A small, full-thickness defect of articular cartilage (curved arrows) can be seen as low signal intensity of joint fluid interrupting the cartilage.

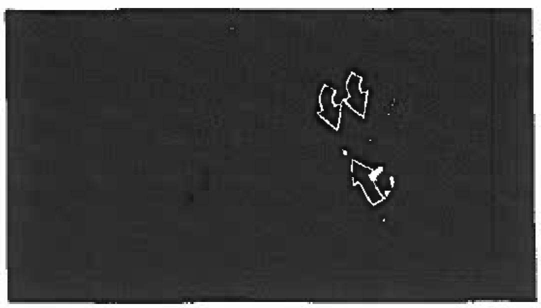

FIGURE 3. Fast spin-echo MRI of a chondral flap tear (straight arrow) in a young man who had lateral knee pain and mechanical symptoms. T2-weighted sagittal image shows increased signal intensity of joint fluid (curved arrows) that interrupts and undermines an unstable chondral flap tear.

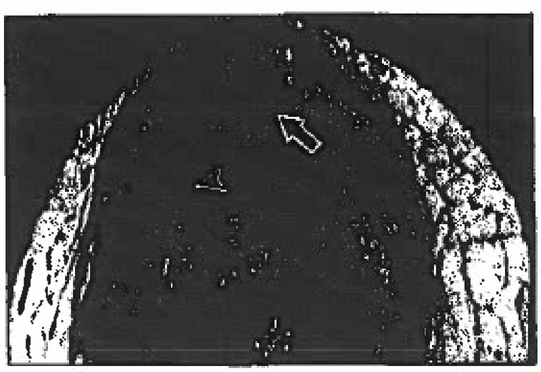

FIGURE 4. Axial view, fat-suppressed fast spin-echo MRI of patellar dislocation injury. Full-thickness chondral fracture (arrow) of the medial patellar facet is seen as an area of abnormal increased signal intensity. Bone contusion edema of the subjacent marrow (arrowhead) involving the lateral femoral epicondyle was caused by impaction of the patella against the epicondyle at the time of injury.

MRI as a Tool for Detecting Cartilage Damage

Magnetic resonance imaging (MRI) scans using special cartilage imaging techniques have proven to be very useful in diagnosing cartilage injuries of the knee.[10] MRI of articular cartilage lesions is best performed using high–magnetic-field-strength (1.5 or 3.0 Tesla) scanners. Higher field strength results in higher signal-to-noise ratio, enabling thinner slice and higher spatial resolution imaging, both of which are key factors for optimal articular cartilage visualization. Lower–field-strength scanners, such as 0.2 Tesla in-office scanners, are not yet reliable for detecting articular cartilage lesions.

Many MRI techniques have been used with variable success to help assess articular cartilage. One technique that is sensitive and specific for cartilage pathology is T1-weighted, fat-suppressed, three-dimensional, spoiled gradient-echo imaging[11] (figure 2). However, this technique requires a relatively long imaging time and is not useful for evaluating injuries to the menisci, ligaments, soft tissues, or bone. Therefore, in the clinical setting, standard spin-echo techniques are used to visualize other structures, and this will further prolong imaging time.

In our experience, high–field-strength fast spin-echo imaging is a clinically useful, efficient, and reliable technique for detecting cartilage defects and is also excellent for visualizing menisci, ligaments, soft tissues, and bone. Potter et al[12] evaluated 88 knees with high–field-strength fast spin-echo MRI and correlated the findings with subsequent surgical arthroscopy. For detecting knee chondral defects, they reported a sensitivity of 87%, specificity of 94%, and accuracy of 82%.

Typically, the sequence for fast spin-echo imaging includes sagittal, coronal, and axial planes (figures 3 and 4). A T2-weighted, fat-suppression sequence is also routinely performed in the coronal or axial planes for sensitive detection of fluid and bone marrow edema.

MRI arthrography employs routine and fat-suppression techniques after fluoroscopically guided intra-articular injection of a dilute gadolinium solution. It is accurate in detecting articular cartilage abnormalities, but it has not been proven more accurate than the high-resolution, fast spin-echo technique. Its advantage over routine MRI in the evaluation of OCD (figure 5) and autogenous cartilage implants is that it is possible to extend contrast into the bone or between

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bone and the articular cartilage or implant when no effusion in the knee is present (figure 6). Typical techniques for MRI arthrography include routine fast spin-echo imaging (as noted above) in sagittal and coronal planes, as well as the axial plane if evaluation of the patellofemoral joint is desired.

Criteria for Surgical Treatment

Patients who do not respond to a standard treatment program of exercise, weight loss, and activity modification, or who have incomplete relief from arthroscopic debridements, are suitable candidates for surgical referral. The natural history of articular cartilage lesions of the knee is still not well understood.[13] The main criteria for recommending treatment for a patient with an articular cartilage defect of the knee include lesion size, lesion location, extremity alignment, and ligament injury. All of these factors influence treatment and successful outcome.[5] In essence, the following criteria can be viewed as exclusionary criteria for the surgical treatment techniques that follow.

Size of the lesion has a significant influence on the patient's symptoms and functional activities. Because lesion size is important to prognosis, clinicians have described several ways to classify the size. One commonly used system[14] divides lesions into four groups: smaller than 1 cm^2, 1 to 2 cm^2, 2 to 10 cm^2, and larger than 10 cm^2. The size of the lesion must be determined before making further recommendations. An osteochondral lesion may be sized on plain radiographs when it involves the underlying bone (recognizing that radiographs have approximately a 15% magnification). Less severe articular cartilage lesions (those restricted to the cartilage itself and not involving underlying bone) can often be sized on specialized MRI scans. Despite significantly improved detection with MRI, the gold standard for measuring these lesions remains surgical arthroscopic evaluation.

Location of the articular cartilage lesion affects the long-term prognosis and available treatment options. It is important to recognize whether the lesion is localized or involves more than one location. If "kissing lesions" are present on opposing articular cartilage surfaces (patella and femur or femur and tibia), the prognosis is more guarded. Lesions isolated to the femoral condyles, with no corresponding arthritis on the opposing cartilage surfaces, have the best prognosis. Lesions of the patella and tibial plateau have a generally poor prognosis and few available interventional treatments.

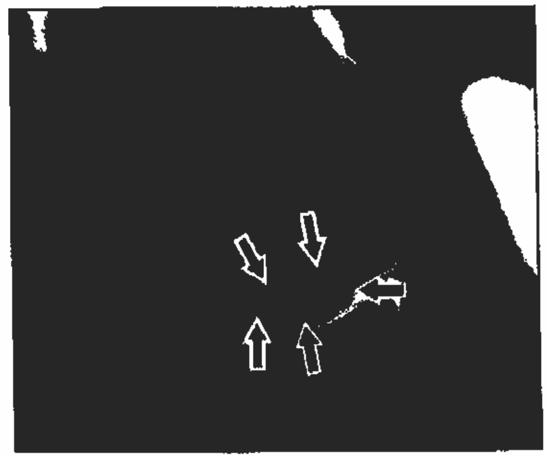

FIGURE 5. Sagittal fat-suppression T1-weighted MRI of an unstable osteochondritis dissecans (OCD) lesion of the medial femoral condyle. Note high signal intensity of the gadolinium contrast (open arrows) extending from the joint through the chondral interruption and beneath the unstable OCD lesion (red arrows).

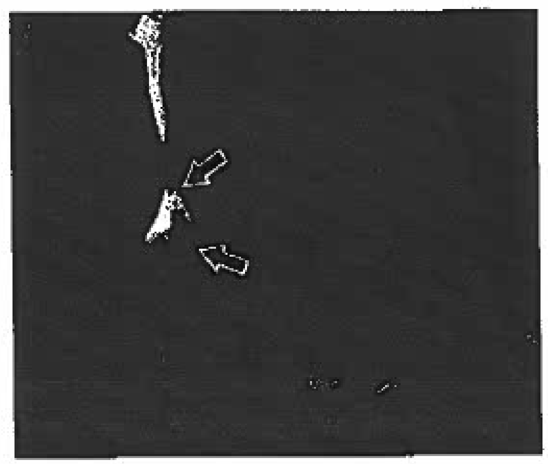

FIGURE 6. Sagittal, proton-density MRI gadolinium contrast arthrogram of an adolescent boy reveals a displaced OCD lesion of the femoral trochlea (arrows).

Extremity malalignment—either a genu valgus or varus deformity, with the cartilage lesion located on the side of the malalignment—needs correction of the mechanical axis prior to treatment for the articular cartilage defect. Symptomatic patients who have knee malalign-

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ment and an underlying localized distal femoral articular cartilage defect, or kissing lesions on the side of the malalignment, may be candidates for an osteotomy.[4]

Concurrent ligament injury that causes knee instability needs to be corrected before treatment for an articular cartilage defect.[1] About 3 to 4 months after reconstruction of the cruciate ligaments, medial collateral ligament complex, or posterolateral corner of the knee, the knee is assessed to make sure that the ligament reconstruction has succeeded before recommending a cartilage repair. The time interval between ligament reconstruction and articular repair is surgeon-specific but generally depends on the type of additional reconstruction needed.

Current Treatment Options

Arthroscopic joint debridement is generally indicated for patients who have small articular cartilage lesions (<1 cm^2) or kissing lesions. These patients must be assessed for symptoms after debridement, and they need to be enrolled in a postoperative rehabilitation program. Patients with simple arthroscopic debridement frequently do not respond as well to the procedure as do patients who undergo concurrent arthroscopic procedures, such as partial meniscectomies or removal of loose bodies, during cartilaginous debridement. If symptoms persist beyond initial treatment, further evaluation and treatment of the articular cartilage defect may be required.[1]

Microfracture, an arthroscopic technique, may be used in some cases to stimulate scar tissue (fibrocartilage) formation over a localized cartilage defect of the femoral condyles.[15] A sharp instrument, such as an awl or surgical wire, is used to create a hole in the supporting bone plate (subchondral bone). It is hypothesized that some of the underlying stem cells in the bone marrow will adhere to the microfracture and differentiate into a fibrocartilage or cartilage-like material. This technique works best in patients who are younger than 30 who have lesions that are smaller than 1 to 2 cm^2. It is important to monitor these patients over time. Patients may initially do very well and then have symptom recurrence a few years later once the fibrocartilage covering of the articular cartilage defect wears off.[16] The long-term success rate of this procedure is unknown.

Osteotomy is used to correct mechanical alignment. The principle behind the osteotomy is to shift weight bearing from the region that contains the articular cartilage defect to the compartment of the knee that has normal cartilage. Orthopedic surgeons use a variety of measurement techniques to decide the precise amount of correction needed.

The most common knee osteotomy site to treat genu varus is the proximal tibia. The two types of proximal tibial osteotomies are referred to as either opening or closing wedge. Specific indications or the surgeon's preferences will determine which technique is used. The opening wedge technique is especially beneficial when used with chronic ligament injuries.

Prognosis after an osteotomy depends on achieving the desired mechanical axis. A period of non–weight bearing or limited weight bearing allows the bone to heal and avoids settling of the bone at the osteotomy site.

Autogenous osteochondral transfer procedures are performed by taking plugs of normal bone and cartilage from a lesser weight-bearing area of the knee and transferring them to the area of the cartilage defect. This technique is generally reserved for lesions that are smaller than 2 cm^2.[14,15] Though small lesions can be treated arthroscopically in some instances, it is very difficult to achieve acceptable precision using arthroscopy. Larger lesions require an open arthrotomy to ensure that harvesting the donor plugs and placing them in the recipient area closely matches the normal contour of the articular cartilage surfaces. Fibrocartilage fills the donor site and the spaces around the plugs. Early follow-up of this procedure appears promising. The long-term prognosis, including the possibility of pathology at the donor and recipient sites, is unknown.

Fresh osteochondral allografts use larger cartilage and bone plugs obtained from a recently deceased donor whose knee matches the exact size of the recipient's knee.[4] Templating the size of the defects from radiographs is essential to make sure that the recipient receives the correct contour of the newly implanted cartilage. Fresh allografts should be implanted when the articular cartilage cells are still viable to maximize the chances of viability in the donor. Generally, these procedures are reserved for patients who have larger osteochondral defects (often >4 to 6 cm^2). Long-term results are good,[17] but the availability and cost of fresh osteochondral allografts have limited their use.

Autogenous cartilage implantation[4,14,16,18] is a new procedure for treating chondral lesions that uses the

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patient's own chondrocytes to grow and form a nearly normal cartilage matrix. High cost and long rehabilitation require that patients have an extensive evaluation to ensure that they will likely achieve a good functional result. All of the above criteria for size, location, joint alignment, and stability testing must be followed. The presurgical work-up for autogenous cartilage implantation also involves an arthroscopic evaluation to determine the patient's suitability.

If arthroscopy confirms that the patient has an isolated defect of the femoral condyle or trochlear groove, a biopsy of normal articular cartilage (200 to 300 mg) is obtained from a lesser weight-bearing surface of the femur. These cells are then separated from the matrix, grown to several million cells in the laboratory, and prepared to fill in the symptomatic cartilage defect. (See "Articular Cartilage Injury and Autologous Chondrocyte Implantation: Which Patient's Might Benefit?" November 2000, page 43.)

Implantation of these cells requires an open incision, similar to the incision for a total knee replacement procedure, and arthrotomy. The articular cartilage lesion is isolated, and all degenerative cartilage debrided. Scar tissue is removed from the bed of the defect. The size of the articular cartilage defect is then templated, and a matching piece of periosteum is harvested from the distal femur or the proximal tibia. The free piece of periosteum is microsutured into the edges of the defect; it is essential to obtain a watertight seal. Then, fibrin glue is placed around the edges of the suture line to further ensure that cells do not leak through the suture holes. The prepared implantation cells are then injected under the periosteal patch. The injection site is closed with a suture and fibrin glue. After transplantation, patients follow a closely regimented rehabilitation protocol. Early results with this procedure in the United States are encouraging.

Future Outlook

The treatment of articular cartilage defects of the knee has entered new frontiers. Prior to several years ago, few alternatives were available. New technological advances have allowed us to treat some of these lesions, although further follow-up is necessary to determine their long-term efficacy. Diagnosis begins with a careful history and clinical examination, including appropriate radiographic work-up. Patients who do not respond to conservative treatment or who have incomplete relief from arthroscopic debridement are suitable candidates for surgical referral. PSM

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