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Journal
Seminars in Musculoskeletal Radiology, 18(05)

ISSN
1089-7860

Authors
Ghahremani, Shahnaz
Griggs, Rachel
Hall, Theodore
et al.

Publication Date
2014-11-01

DOI
10.1055/s-0034-1389268

Peer reviewed

Osteochondral Lesions in Pediatric and Adolescent Patients

Shahnaz Ghahremani, MD[1] Rachel Griggs, MD[1] Theodore Hall, MD[1] Kambiz Motamedi, MD[2] M. Ines Boechat, MD[1]

[1] Pediatric Imaging Section, Department of Radiological Sciences, David Geffen School of Medicine at UCLA
[2] Musculoskeletal Imaging Section, Department of Radiological Sciences, David Geffen School of Medicine at UCLA, Los Angeles, California

Address for correspondence Shahnaz Ghahremani, MD, Pediatric Imaging Section, Department of Radiological Sciences, David Geffen School of Medicine at UCLA, Los Angeles, CA 90095 (e-mail: sghahremani@mednet.ucla.edu).

Semin Musculoskelet Radiol 2014;18:505–512.

Abstract

Osteochondral lesions are acquired, potentially reversible injuries of the subchondral bone with or without associated articular cartilage involvement. Injury results in delamination and potential sequestration of the affected bone. Although an association with mechanical and traumatic factors has been established, the etiology remains poorly understood. These lesions commonly occur in the knee; articular surfaces of the elbow, ankle, hip, and shoulder are also affected. Osteochondral lesions are relatively common in children and adolescents, and the incidence is increasing. Prognosis of these lesions depends on stability, location, and size of the lesion.

Imaging has an essential role in the diagnosis, staging, and management of osteochondral lesions. Many of these lesions are first diagnosed by plain film. MRI adds value by identifying unstable lesions that require surgical intervention. This review focuses on the clinical and imaging features of osteochondral lesions of the knee, elbow, and ankle. Imaging criteria for staging and management are also reviewed.

Keywords
- OCD
- MRI
- plain radiographs
- knee
- elbow
- talus

Several terms have been used to describe injuries to the subchondral bone and overlying cartilage. The term *osteochondritis dissecans* (OCD) is used to describe an acquired lesion of subchondral bone, thought to be secondary to repetitive mechanical or traumatic factors. The term *osteochondral defect* is the newer, preferred term for OCD because the original term was somewhat of a misnomer. The term *osteochondral fracture* is reserved for an osteochondral defect with associated disruption of the articular cartilage; in children it is usually a fatigue-type fracture of normal quality bone, subject to high repetitive stresses.[1] The term *osteochondral lesion* is used in a broader sense, encompassing OCD/osteochondral defects, osteochondral fractures, and vascular insufficiency lesions of the subchondral bone associated with etiologies such as Legg-Calvé-Perthes disease, steroid use, alcoholism, hemoglobinopathies, and lupus erythematosus, among others. This review focuses on osteochondritis-type lesions, although, where relevant, other osteochondral lesions are discussed.

The term *osteochondritis* was originally introduced by König in 1888; he hypothesized the process was the result of inflammation and therefore termed it "osteochondritis."[2] Today, the exact pathophysiology remains unclear. The most consistently associated factors are high levels of activity and frequent participation in sports.[1] Although the etiology is likely multifactorial, inflammation, familial predisposition, and vascular abnormalities are not consistently supported by the literature.[1] The knee, ankle, and elbow joints are more frequently involved, but the articular surfaces of the shoulder and hip may also be affected.[3]

OCD lesions may consist of osseous resorption and/or collapse. Injury of the overlying articular cartilage may also be seen but not necessarily. OCD may reflect bony injury without separation from the parent bone. Alternatively, OCD

Issue Theme Sports Injuries and Imaging in Children; Guest Editor, Erich Sorantin, MD, PhD

DOI http://dx.doi.org/10.1055/s-0034-1389268.
ISSN 1089-7860.

lesions can be incompletely or completely sequestered from the parent bone. Separation from the parent bone is the factor that distinguishes an unstable lesion from a stable one.

OCD is a relatively common disorder in children and adolescents, with a prevalence of 15 to 30 per 100,000; boys are affected than girls. Currently, participation in competitive sports by children at younger ages is on the rise. Simultaneously, the mean age of OCD onset is dropping, with an increasing prevalence in girls.[1,2,4]

It is not uncommon for osteochondral lesions to be detected incidentally on radiographs. Especially in this setting, where there is no known correlating clinical history or corresponding physical examination abnormality, careful attention should be paid to differentiate OCD from developmental variations of ossification.[5,6] Irregularity of the epiphyses can be seen as a normal variant or in relation to epiphyseal dysplastic disorders, which are difficult to distinguish radiographically (►**Fig. 1**). In many cases, epiphyseal irregularity can be differentiated from osteochondral lesions by clinical history or involvement of multiple joints.[5] MR characterization may be of benefit in select cases.

Diagnostic Studies

Arthroscopic evaluation can pinpoint an OCD and allow inspection of the cartilage. Arthroscopy also has the benefit of being able to diagnose and treat the condition simultaneously. Consequently, it is regarded as the gold standard for assessment of OCDs. However, imaging studies can provide valuable information regarding the size, stability, and prognosis of the lesion. Because not all lesions require surgical intervention, imaging may help the clinician tailor the management.[1] Multiple imaging modalities are used in the diagnosis of OCD including plain radiographs, bone scintigraphy, computed tomography (CT), and MR imaging with or without arthrography.

Plain radiographs are used to diagnose, characterize, and localize OCDs, rule out other osseous injuries, and evaluate skeletal maturity albeit plain film staging of arthroscopically proven lesions has been found to be unreliable.

Bone scintigraphy can assess healing of OCDs, based on correlation of scintigraphic activity of blood flow and osteoblastic activity. Quantitative technetium bone scans are performed serially, every 6 weeks, until healing is apparent. However, the isotope tracer remains in the affected area for a long time, making interpretation difficult. Currently, bone scintigraphy is not used in the management of OCD.[7] CT imaging is also usually avoided in pediatric patients due to concerns related to radiation hazard.

Numerous studies have shown that MRI is the modality of choice in the diagnosis, staging, and surveillance of OCDs.[1–3,8–10] MR arthrography is not used routinely, and use of intravenous contrast for MRI examinations is controversial.[1] MRI can accurately estimate the lesion size, status of cartilage and subchondral bone, as well as stability of the lesion, presence or absence of a loose body, extent of bone edema, and associated joint effusion.[2,3,8–11]

Although MRI is considered the imaging study of choice to determine lesion stability, it has been reported that instability can be overdiagnosed on MR imaging; these reports cite overdiagnosis when the only sign of instability on MRI is high signal intensity at the bone fragment interface.[12] Some authors believe that linear high T2 signal at the lesion interface has high accuracy in predicting instability only when accompanied by a breach in articular cartilage, seen on T1-weighted images.[1] A possible pitfall for MRI might be incomplete detection of detached fragments and loose bodies that are more easily seen on plain films.[13]

Staging of Osteochondritis Dissecans

The first classification system of OCDs was described in 1959 by Berndt and Harty, based on plain film findings of talar OCDs.[14] In this classification system, a grade 1 lesion is a depressed osteochondral fracture. A grade 2 lesion is an

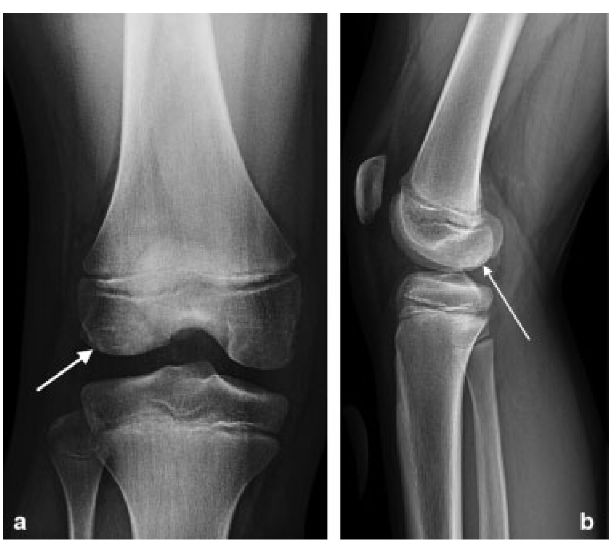

Fig. 1 (**a**) Anteroposterior and (**b**) lateral radiographs of the right knee of a 9-year-old child with irregularity on the posterior aspect of the lateral condyle (arrows).

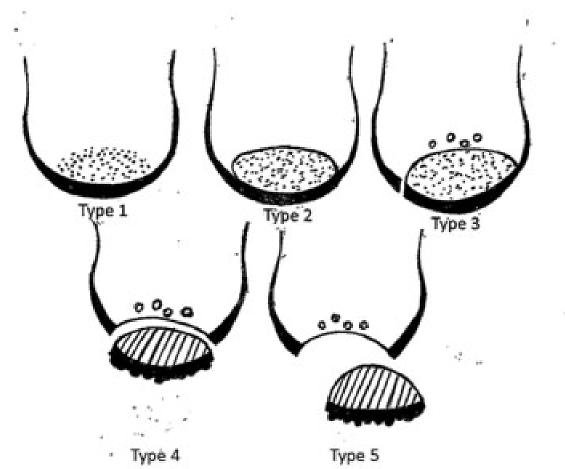

Fig. 2 The drawing illustrates the most recent staging system of osteochondritis dissecans.

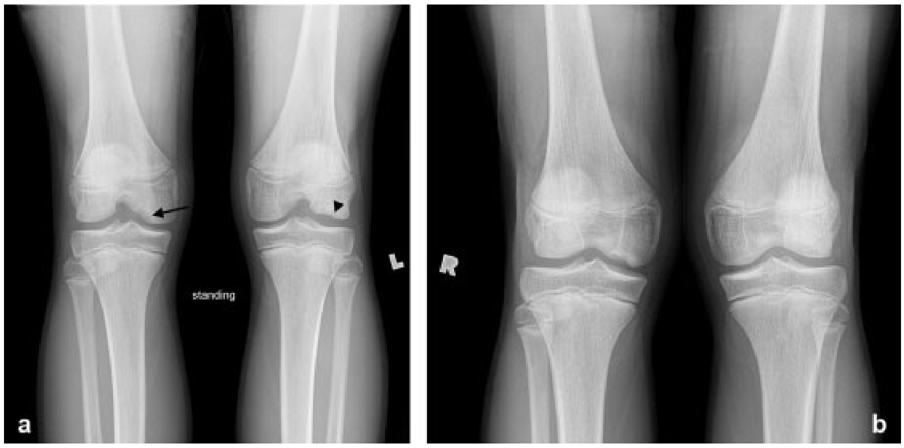

Fig. 3 (**a**) Notch view and (**b**) anteroposterior view of the bilateral knee with bilateral osteochondritis dissecans: right knee on medial condyle, weightbearing area (arrow) and left knee on the lateral condyle (arrowhead). The defects are better seen in the notch view.

osteochondral fracture attached by a bone bridge to the host bone. A grade 3 lesion is an osteochondral fracture with a detached nondisplaced fragment, and a grade 4 lesion correlates with a displaced fracture fragment.

Nelson et al were the first to classify OCD lesions based on MRI findings.[14] They used a sample of 14 patients with knee and ankle lesions and compared the MR findings with subsequent arthroscopic findings. They concluded that MR was able to accurately predict arthroscopic findings. The MRI classification system was designed to reflect the arthroscopic findings, as follows:

Grade 1: Intact cartilage with signal changes in subchondral bone
Grade 2: High signal breach of the cartilage; low signal posterior to the lesion.
Grade 3: Thin high signal rim extending behind the osteochondral fragment, indicating synovial fluid around the fragment.
Grade 4: Mixed or low signal loose body in the center of the lesion or a free bone fragment within the joint.

In 1999, the following MRI staging and classification was proposed for juvenile OCD, based on a large multicenter study.[1,2] This system considered the presence of fluid between the OCD fragment and underlying bone a sign of instability of the fragment (►**Fig. 2**).

Stage 1: Small signal change without clear fragment margins.
Stage 2: Osteochondral fragment with clear margins but no fluid between fragment and underlying bone.
Stage 3: Fluid is visible partially between fragment and underlying bone.
Stage 4: Fluid is visible completely between fragment and underlying bone, but the fragment remains in situ.
Stage 5: Fragment is completely detached and displaced (loose body).

OCD fragment size > 1 cm and cystic changes within adjacent bone are considered to be signs of instability.[15] The characteristics of an unstable OCD lesion have been mostly described in the knee and ankle, but they can be applied in the evaluation of elbow lesions as well.[16]

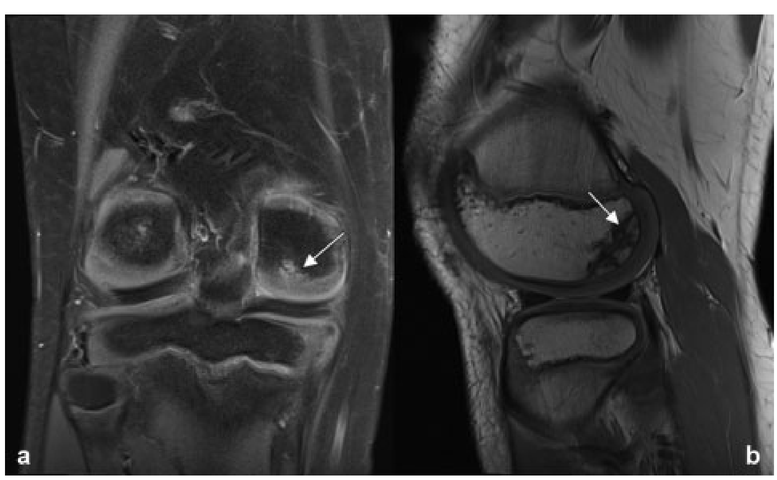

Fig. 4 (**a**) Coronal proton-density (PD) fat-saturated and (**b**) sagittal PD images of the knee in a teenager with stable osteochondritis dissecans (arrows).

Fig. 5 (**a**) Axial T2 fat-saturated and (**b**) sagittal proton-density images of the left knee in a teenager with unstable osteochondritis dissecans (arrows).

Osteochondral Lesions of the Knee

The most common site of OCD in both children and adults is the knee. Most juvenile OCDs are stable lesions that will heal without surgical intervention or long-term consequences. The presentation is generally nonspecific with poorly localized knee pain that is exacerbated by exercise or when climbing hills or stairs. Physical examination reveals antalgic gait and tenderness to palpation over the anteromedial aspect of the knee with knee flexion. This tenderness corresponds to the most common site of OCD of the knee, the lateral aspect of the medial femoral condyle.[4] Frequency of lateral femoral condyle OCD is relatively high in juvenile patients, however, and point tenderness may alternatively be demonstrated here. Bilateral knee involvement is reported in up to 25% of the cases; therefore examination of both knees is important.[1] The presence of mechanical symptoms, joint effusion, crepitus, and pain with motion may suggest instability of the lesion. Atrophy of the quadriceps muscle is an indicator of chronicity.

Initial imaging for evaluation of OCD must include anteroposterior (AP) and lateral radiographs and notch (tunnel) views. Lateral and notch views are important for visualization of the posterior femoral condyles, which are not clearly seen on the AP view (►**Fig. 3**). MRI imaging can be performed to classify a lesion previously demonstrated on plain film or to evaluate for a radiographically occult lesion. MRI is sensitive in showing the subarticular osseous defect even in the early stages of the process (►**Fig. 4**). Overlying cartilage defects and fluid signal tracking between the defect and host bone are clearly seen by MRI (►**Fig. 5**).

Osteochondral Lesions of the Elbow

Osteochondral lesions of elbow include OCD, osteochondral fractures, and Panner disease. Panner disease, or osteochondrosis of the capitellum, is a self-limiting disorder of physeal enchondral ossification. It has an insidious onset and classically occurs in children ages 4 through 8. Nonoperative treatment results in complete resolution of symptoms and radiographic findings in most patients.[9,17]

OCD is an uncommon cause of elbow pain, but these lesions should be considered in the differential diagnosis of elbow pain in throwing or tumbling athletes. As with OCD of the knee, the etiology of elbow OCD is uncertain. Most authors agree that it is an overuse injury. Athletes with capitellar OCD lesions are typically 10 to 18 years old and present with lateral elbow pain, tenderness, and swelling in the dominant elbow or in both elbows in gymnasts and weightlifters. The pain primarily occurs

Fig. 6 (**a**) Anteroposterior (AP) and (**b**) 45-degree flexion AP views of the right elbow in a teenager. The osteochondritis dissecans is more clearly seen on the oblique view (arrows).

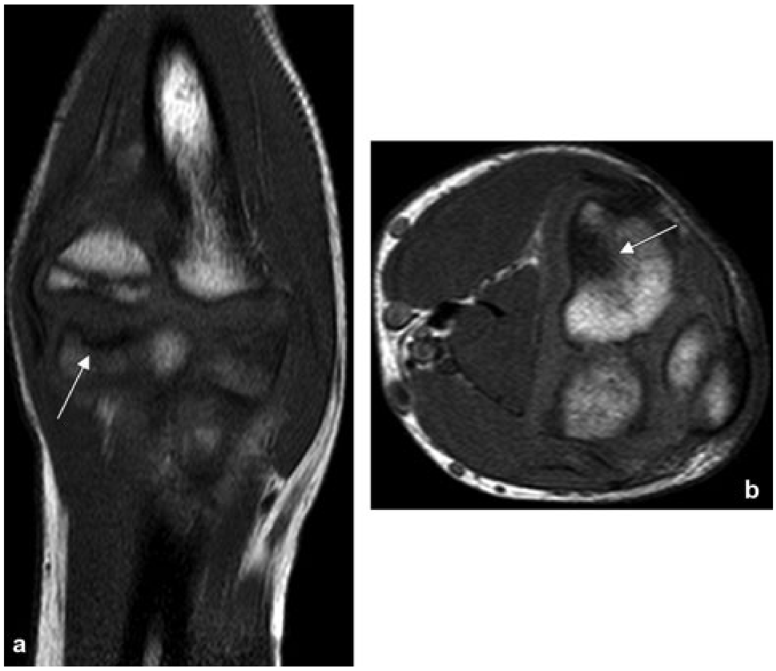

Fig. 7 (**a**) Coronal oblique and (**b**) axial T1 images of the right elbow (the same patient in Fig. 5) demonstrate a stable lesion of the capitellum (arrows).

with activity and increases over time. With advanced lesions there is limited range of motion, particularly with extension.

The most common location of OCD of the elbow is the capitellum, but disease involvement of the trochlea, radial head, and olecranon has also been reported.[16,18–20] In the case of capitellar involvement, the poorly vascularized bone is prone to ischemia in the athlete who is highly involved in activities such as pitching, throwing, or gymnastics. In these conditions, the capitellum is overstressed in the valgus position.[7,16] Similarly, limited blood supply to the trochlea, in particular to the lateral aspect of the bone, predisposes the patient to OCD.[18]

Plain radiography should be the first imaging study in any suspected case. However, early lesions may be missed on plain films. MRI is more accurate than plain radiography or CT in delineating the size of OCD and the presence of a loose body,[9] which are important prognostic factors.

The most common location for a capitellar OCD lesion is the anterolateral aspect of the bone. Flattening of the capitellar subchondral bone is the earliest radiographic sign of OCD. This is best seen on AP radiograph of the elbow taken at 45 degrees of elbow flexion (►**Fig. 6**). A pseudodefect of the capitellum, seen in the posterior aspect of the bone, should not be mistaken for an OCD. Pseudodefects are related to lack of articular cartilage coverage; this region is referred to as the "posterior bare area."[7] On MRI, early capitellar OCD presents as focal T1 low signal intensity in the anterior capitellum, with or without change in T2 signal, associated with flattening of the subchondral bone (►**Fig. 7**). Late-stage lesions may present as an osteochondral fragment with a T2 high signal rim (►**Fig. 8**).

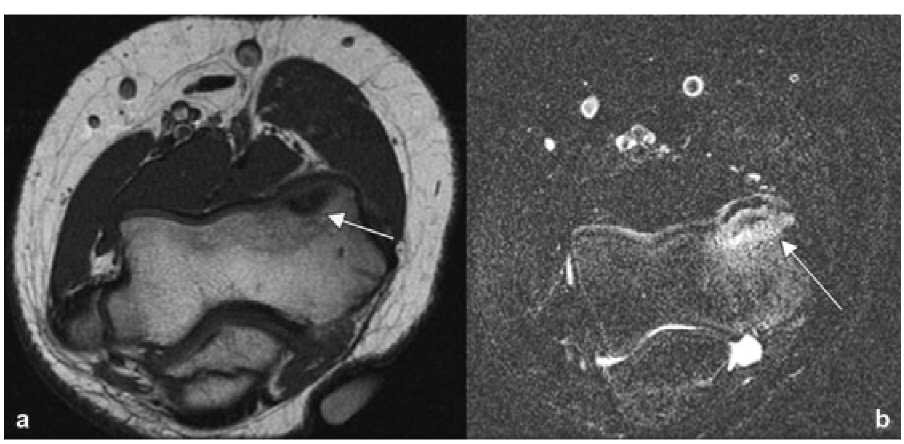

Fig. 8 (**a**) Axial T1 and (**b**) axial fat-saturated T2 images of the right elbow of a teenager with an unstable osteochondritis dissecans of the capitellum (arrows).

Fig. 9 (**a**) Anteroposterior and (**b**) oblique radiographs of the left ankle in a teenager with osteochondral fracture of the medial aspect of the talar dome (arrows).

In the trochlea, OCD appears as a well-circumscribed defect along the lateral articular trochlear surface that may mimic a pseudo-intercondylar notch.[19] Lateral trochlear lesions have the classic imaging appearance of OCD and are well circumscribed, whereas medial trochlear lesions show chondral fissuring, subchondral osseous pitting, and surrounding edema signal.[7]

Osteochondral Lesions of the Ankle

Osteochondral lesions of the ankle include OCD and osteochondral fractures. The most common bone involved is the talus. First described by Kappis in 1922, the medial and lateral aspects of the talar dome are equally affected.[20,21] Central lesions occur occasionally.[20] When the mechanism of injury is ankle inversion, a medial lesion will result from compression of the medial talar dome by the tibia, which is secondary to spiraling or shortening of the collateral ligaments. If the foot is dorsiflexed, a lateral lesion will result from compression by the fibula. The medial lesions are posterior, and the lateral lesions are more anterior.[21]

Osteochondral fractures generally present with an acute history of trauma. The first sign of a talar OCD, however, may be a sprained ankle that does not improve. Patients with loose bodies related to OCD may present with pain, stiffness, and locking.

The talar dome is predominantly covered by articular cartilage and thus has a limited ability to repair. Therefore, early and accurate diagnosis is important for preserving optimal function of the ankle. It is also important to determine the correct staging of the cartilage lesion because treatment options are stage dependent.[8] Delayed detection or management of an OCD may lead to osteoarthritis as a result of altered joint mechanics.

Radiographic examination of the ankle includes AP, lateral, and oblique views that may reveal lucency at the site of the lesion (►**Fig. 9**). MRI clearly delineates talar OCD and is valuable in staging the lesion (►**Fig. 10a-c**). As previously

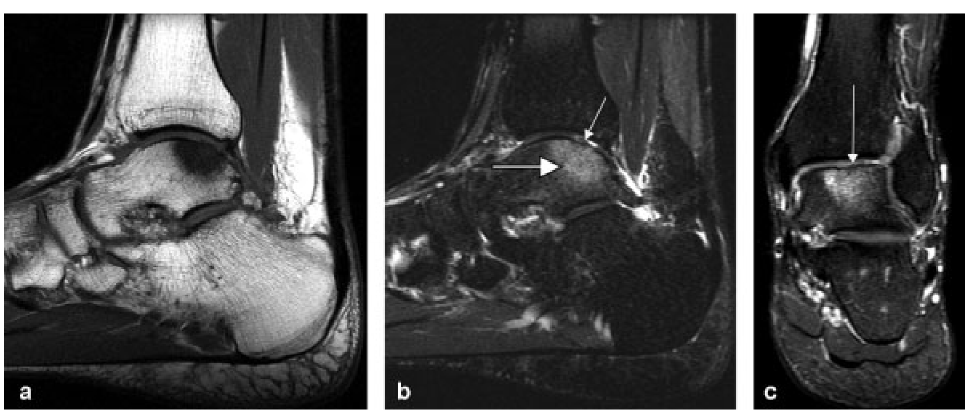

Fig. 10 (**a**) Sagittal T1 and (**b**) inversion recovery images of the ankle in a young patient with stable osteochondritis dissecans (OCD) of the posterolateral aspect of the talar dome (arrow) with peripheral edema (thick arrow). (**c**) Coronal inversion recovery image of the left ankle in a young patient with stable OCD (arrow) of the posterolateral aspect of the talar dome.

Fig. 11 (**a**) Coronal, (**b**) sagittal, and (**c**) axial computed tomography images of the ankle with an unstable osteochondritis dissecans at the lateral aspect of the talar dome; loose fragments are present (arrows).

mentioned, CT scan is rarely used in younger patients but is useful in evaluating unstable lesions with loose bodies (►**Fig. 11**).

Management of Osteochondral Lesions

Most authors believe treatment of OCD lesions should be based on skeletal maturity and lesion stability. Nonoperative management is the first-line treatment for stable OCD lesions in children. Surgery is usually indicated for unstable lesions or stable lesions that fail nonoperative treatment. Patients with unstable lesions, loose bodies, torn menisci, or other intra-articular injuries undergo surgical treatment.[1,4,17,22]

Fig. 12 (**a**) Anteroposterior and (**b**) lateral radiographs of the knee of the patient in Fig. 3, status post drilling and pinning. The follow-up examination and plain films (not shown) after removal of the pins demonstrated a favorable outcome.

Surgical treatment options include drilling, bone grafting, fixation, alignment procedures, and debridement. These procedures are frequently performed arthroscopically. Drilling has been shown to induce migration of inflammatory factors and stem cells, which leads to revascularization and healing (►**Fig. 12**). If the overlying cartilage is unstable, debridement of fibrous tissue between the lesion and parent bone is indicated, and bone grafting should be considered. Bioabsorbable implants, osteochondral autograft plugs, and autologous chondrocyte implants may also be used in lieu of bone grafting.[1,17,23] Very large or fragmented OCD lesions are not amenable to fixation, owing to poor cartilage quality or incongruence. In this setting, open reduction is necessary; the fragment should be removed and the donor site debrided. Autologous chondrocyte transplantation is used for large defects with good to excellent results.[24,25]

Conclusions

Osteochondral lesions are commonly encountered in the evaluation of pediatric joints. It is important to recognize this entity and understand its natural history. Although plain film diagnosis is most efficient, MRI plays an important role in the evaluation of this condition. MR staging classifications have been developed to parallel surgical criteria. Accurate and timely imaging diagnosis of this process can mitigate potential complications and prevent unnecessary surgery.

Acknowledgments
We sincerely thank Dr. Ehsan Saadat and Ms. Claire Isidro. They were extremely helpful in the editing and final construction of this article.

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