Radiographic diagnosis of osteochondritis of the knee

Dr Karen Lambot

Cabinet de Radiologie
17 Cours Joseph Thierry 13001 Marseille
17 Avenue William Booth, 13012 Marseille

Radiology Department, North Hospital, Chemin de Bourrely, 13015 Marseille

Introduction

Osteochondritis dissecans of the knee is a localized alteration of subchondral bone that affects the bordering articular cartilage that may progress to instability of the fragment. The natural history of the disease may lead, in its most severe form, to loosening of the subchondral osseous fragment and liberation within the joint [1].

The juvenile form must be differentiated from the adult form. It manifests during infancy; most frequently starting at preadolescence and affects children with open physes [2]. The pathophysiology is not well elucidated, although repetitive microtrauma is known to play a major role in physically active children, especially in high-level athletes.

Radiographic diagnosis

Conventional radiographs

Technique

Most cases of osteochondritis dissecans can be diagnosed on conventional radiographs, the primary imaging modality of choice in patients complaining of knee pain [3]. Along with the classic anteroposterior and lateral views, complementary views may be useful, such as a tunnel view, where the beam is directed with a certain inclination relative to the film thereby optimally visualizing the posterior aspect of the femoral condyles, a frequent location of these lesions (figure 1) [2]. A tunnel view is more easily realized than the Schuss view, in which the patient must be placed in a standing position, sometimes difficult to perform in children.

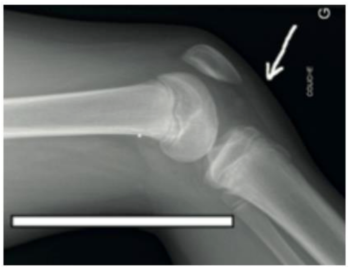

***Figure 1**: Tunnel view*

Location and diagnosis

On lateral views of the knee, the majority of these lesions are located within the subchondral bone at the level of the medial femoral condyle and situated between two lines: The line first is extended anteriorly relative to the intercondylar roof (Blumenstaat line); The second is extended distally from the posterior cortex of the distal femoral diaphysis (figure 2) [4].

***Figure 2:** Locations of osteochondral lesions on a lateral radiograph of the knee.*

On anteroposterior radiographs of the knee, osteochondral lesions are most often located on the medial femoral condyle (80% of cases). The most frequent and classic location is the lateral (intercondylar) aspect of the medial femoral condyle, followed by the extended classic and inferocentral locations (figures 3 and 4), and finally the lateral condyle (20% of cases) [2].

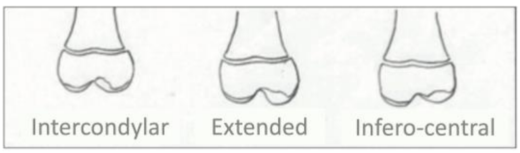

***Figure 3:** Usual locations of osteochondral lesions on anteroposterior radiographic views of the knee.*

Figure 4: *Anteroposterior and lateral radiographs of the knee. Stage 3 extended intercondylar osteochondritis dissecans at the level of the middle third of the medial femoral condyle (arrow).*

The lesions may be divided into 4 stages based on a simplified radiographic classification (figures 4 and 5) [5]:

- Stage 1: lacunar lesions with radiolucent recess.
- Stage 2: nodular structure with condensed osseous sequestrum that remains at the same level as the condyle.
- Stage 3: Sleigh-bell aspect with condensed sequestra that are often dislodged from the bony surface of the condyle.
- Stage 4: Intra-articular loose body.

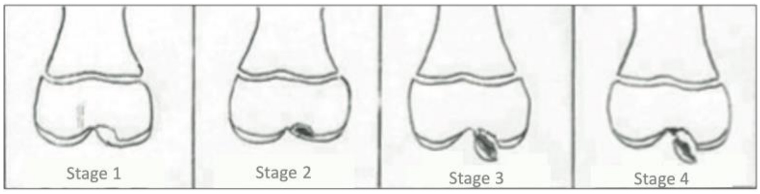

Figure 5*: Radiographic classification of osteochondritis dissecans into 4 stages.*

Conventional radiographs are a reliable method for situating the lesion (differentiating medial and lateral condylar lesions) and measuring its size. When the fragment is ossified, the reliability of conventional radiographs for the evaluation of fragmentation, displacement, central radiographic density, borders, and contours is moderate to good. However, reliability decreases when it comes to estimating the radiographic density of the surrounding borders and epiphyseal bone [6].

There is no consensus on the radiographic characteristics used to monitor the healing process of osteochondral lesions. In fact, even a general definition of radiographic healing is lacking [3]. Despite these limitations, conventional radiographs have excellent reliability for the global evaluation of these lesions [7].

Finally, conventional radiographs may also be used to assess skeletal maturity and rule out other bone lesions [2,6].

Arthro-scan

An arthro-scan is an imaging technique consisting in a fluoroscopy-guided injection of contrast material within the joint. A CT-scan is then undergone which visualizes the surface of the articular cartilage. In the context of osteochondritis, an arthro-scan may demonstrate the partially detached character of an osteochondral fragment. It is more frequently utilized in adults than children owing to its high radiation exposure. It is often substituted with an MRI: a powerful, non-invasive and radiation-free imaging modality.

MRI

Technique

The evaluation of child with a painful knee using MRI generally requires a T1-weighted sequence – most often sagittal views – and sequences with high sensibility to bony anomalies, especially bone edema, such as fat saturation proton density (or T2-weighted images) images with sagittal, coronal, and axial views.

Location and diagnosis

On sagittal views, if the femoral condyle is divided into 3 parts, 1/3 of osteochondral lesions are located at the middle third, 1/3 at the posterior third, and 1/3 between the middle and posterior thirds [2].

On coronal views, utilizing a similar division system, the majority of lesions are located at the intercondylar notch and the middle third of the femoral condyle (73%) [2].

In patients with early disease and a stable lesion, there is visible hypertrophy of the epiphyseal cartilage at the level of the osteochondral fragment. These alterations may be visualized on both MRI and histology [2,8,9].

The secondary physis, which is spherical in nature and responsible for the growth of the epiphysis, undergoes a process of circumferential enchondral ossification, similar to that of the primary physis which is responsible for the longitudinal growth of long bones. This secondary physis is clearly identified on MRI of skeletally immature children as a thin line with increased signal intensity, an aspect similar to that of the primary physis. Some authors describe an interruption of the secondary physis at the level of the osteochondral lesion, whereas it remains continuous at the sane portion of the femoral condyle or the contralateral condyle (figure 6) [2].

Figure 6*: Coronal fat saturation proton density images. Primary and secondary physes (black arrows); osteochondritis dissecans with interruption of the secondary physis (white arrow).*

Bone edema of the epiphysis is frequently found in children with osteochondritis dissecans and is generally isolated to the subchondral bone or deeper (figure 7) [2,8,10].

Upon histological examination, no necrosis or inflammation is found [8]. This could be the reflection of repetitive micro-trauma or a direct impact during physical activity and may be in relation with the pain described by the patient [2].

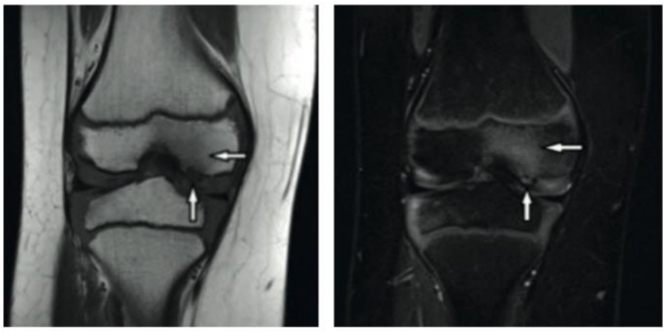

Figure 7*: T1-weighted image (left) and fat saturation T2-weighted image (right); osteochondritis dissecans (vertical arrow) and deep edema of epiphyseal bone (horizontal arrow).*

Instability of the lesion

The classic signs of instability of the osteochondral fragment described in adults are sensitive (100%) but non-specific (11%) in children [11]. As a result, revised criteria were described for the juvenile form with the addition of 3 secondary signs that, when combined, increase specificity to 100% [12]:

- High T2 signal intensity rim: indicating instability only if it has the same signal intensity as adjacent joint fluid, most often appearing as a fluid-filled cleft between the osteochondral fragment and the underlying bone (figure 8) [8], not to be confused with certain clefts with high T2 signal intensity that correspond to fibro-vascular tissue [13];
- Outer rim of low T2 signal intensity: may represent organized fibrous tissue or sclerotic bone at the bone-fragment interface (figure 8) [8];

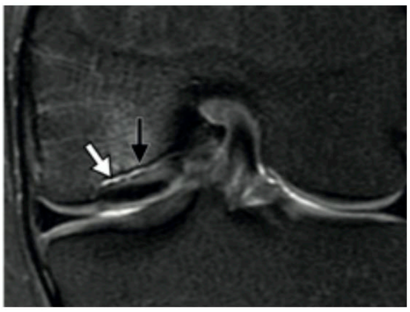

Figure 8*: Coronal fat saturation T2 image. Signs of instability: High T2 signal intensity rim surrounding the osteochondral lesion with similar signal intensity to adjacent joint fluid (white arrow) and outer rim of low T2 signal intensity (black arrow).*

- Multiple breaks in the subchondral bone plate on T2 images: may indicate a larger degree of disorganization at the bone-cartilage interface with extensive replacement with fibro-vascular tissue (figure 9) [8].
- Cysts surrounding the lesion: indicating instability only if they are multiple or single with a diameter >5mm (figure 9) [3,4,12].

Figure 9*: Sagittal fat saturation T2 image. Signs of instability: Multiple breaks in the subchondral bone plate (arrowhead) and single cyst measuring >5mm in diameter (curved arrow).*

However, MRI criteria of instability are absent in most lesions [12].

In symptomatic unstable lesions, fragment characteristics on MRI will guide surgical management depending on the estimated viability of the fragment. An unstable fragment is deemed non-viable or irreversible when it is purely cartilaginous (lack of subchondral bone), is composed of multiple pieces, or presents a loss or damage of articular cartilage [3].

Differential diagnosis: normal variants of femoral condyle ossification.

Differentiating between typical development and early osteochondritis dissecans is not always a simple task, especially if the child complains of non-specific knee pain [2,14]. Demographically, normal ossification precedes the age of appearance of osteochondral lesions, which are more frequently encountered in adolescence [14]. Jan et al. reported that age is an important factor when differentiating between these two entities, since variations in ossification do not appear in girls older than 10 years of age and in boys older than 13. Furthermore, osteochondritis dissecans is generally not seen in children younger than 8 years of age. Moreover, if the growth plate is almost fused and the lesion extends toward the intercondylar region, then an ossification variant is less probable [10]. Distinguishing between typical development and osteochondral lesions is often possible on MRI [14], with signs of normal variants of ossification including signal intensity anomalies located exclusively at the posterior inferocentral condyle, an intact articular cartilage, accessory ossification centers (sometimes visible as spiculations), absence of bone edema, and no intercondylar extension in the coronal plane (figure 10) [2,3,14].

Figure 10*: Sagittal T1 image. Variant of normal ossification (arrow).*

Finally, the continuity of the secondary physis may also differentiate between normal ossification variants and osteochondral lesions [2].

If an osseous defect of the femoral condyle is considered as a normal ossification variant, surveillance with follow-up imaging is generally not indicated, except if the pain persists [14].

Conclusion

The radiographic diagnosis of osteochondritis of the knee is made most often on anteroposterior and lateral radiographs. These radiographs are indicated when a patient presents with knee pain, which is sometimes chronic and ill-localized. Radiographs are used to determine the location of the lesion, its extension, and the radiographic stage. MRI further confirms the diagnosis, allows the analysis of the articular cartilage, and displays signs of instability. The main differential diagnosis of osteochondritis dissecans of the knee is a normal ossification variant of the femoral condyle and depends on the clinical scenario, notably the age of the child, the location of the lesion, and its characteristics on medical imaging.

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